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To Evaluate the Potential Isolates of *L. lecanii* Against Whitefly (*Bemisia tabaci*) and Aphid (*Lipaphis erysimi)* under Natural Field Condition

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ABSTRACT: Whitefly (*Bemisia tabaci*) and mustard aphid (*Lipaphis erysimi* L.) are the most destructive insect pests infesting okra (*Abelmoschus esculentus*) and mustard (*Brassica juncea*), respectively, leading to substantial yield losses and compromising yield and oil quality of the crop. This study evaluates the field efficacy of the entomopathogenic fungus *Lecanicillium lecanii* and other bio-insecticides as environmentally sustainable alternatives to conventional chemical pesticides. Field trials were conducted across one cropping seasons to assess the impact of *L. lecanii*, neem-based formulations and other biorational products on pest incidence, population dynamics and crop yield. Results revealed that *L. lecanii* significantly reduced whitefly and aphid populations compared to untreated controls. Imidacloprid 17.8% SL were found superior treatment reduced the white fly and aphid population (80% and 85.08%) among the EPF and their combination treatment T_6 – *L. lecanii* 10% concentration observed best treatment to reduced the population 75% and 76.18% at 10th DAS for broth the insect, respectively. EPF showing comparable effectiveness to standard chemical treatments but with added benefits of environmental safety and compatibility with integrated pest management (IPM) strategies. The study underscores the potential of *L. lecanii* and similar bio-insecticides as viable tools in sustainable pest management programs for okra and mustard cultivation. Further exploration into formulation improvements and application timing may enhance efficacy and farmer adoption.

Keywords: *Lecanicillium lecanii*, whitefly, aphid, bio-insecticides, field efficacy, integrated pest management.

INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is a widely grown vegetable crop in tropical and subtropical regions, for its nutritional and economic importance. However, its cultivation is significantly hindered by a range of insect pests that adversely affect both yield and quality parameters. More than 70 insect species are known to infest okra (Sahu *et al*., 2024), among the sucking pest complex comprising aphids (*Aphis gossypii* Glov.), leafhoppers (*Amrasca biguttula* Ishida) and whiteflies (*Bemisia tabaci* Genn.) poses the greatest economic threat (Pawar *et al.*, 2023). These pests feed by extracting sap from the phloem tissues, leading to leaf curling, stunted plant growth, diminished photosynthetic efficiency, and considerable yield losses, which have been estimated at up to 17.46% (Singh *et al.*, 2023; Rajwade *et al.*, 2023).

Indian mustard (*Brassica juncea* L.), an important oilseed crop cultivated extensively in India, also experiences substantial yield reductions due to insect pest infestations, particularly during the vegetative and reproductive phases. Key insect pests affecting mustard include aphids (*Lipaphis erysimi*, *Brevicoryne brassicae* and *Myzus persicae*), sawflies (*Athalia lugens proxima*), leaf miners (*Chromatomyia horticola*), painted bugs (*Bagrada hilaris*), flea beetles (*Phyllotreta cruciferae*), and several lepidopteran defoliators such as the diamondback moth (*Plutella xylostella*), pod borer (*Crocidolomia binotalis*), hairy caterpillar (*Spilosoma obliqua*), and cabbage butterfly (*Pieris brassicae*). Among these, *L. erysimi* is recognized as the most destructive, with infestations beginning at the early vegetative stage and continuing through pod development (Patel *et al*., 2019). These aphids colonize tender plant parts and feed on phloem sap, resulting in leaf curling, crinkling, stunting, and significant losses in seed yield and oil content. Reported yield losses due to mustard aphids range between 35.4% and 91.3%, depending on varietal susceptibility and environmental conditions (Singh *et al*., 2023).

Although chemical insecticides such as Dimethoate 30EC and Imidacloprid 17.8SL have shown high efficacy against mustard aphids (Kumar *et al*., 2020; Mishra and Singh 2019), their extensive and indiscriminate use has led to multiple adverse effects. These include the development of pest resistance, resurgence of secondary pests, environmental pollution, pesticide residues in food products, and harmful impacts on non-target organisms, including pollinators and natural enemies. In response to these challenges, the use of entomopathogenic fungi (EPF) as biological control agents is gaining attention as a sustainable and eco-friendly alternative. EPF are known to infect and kill a broad spectrum of insect pests and they are compatible with integrated pest management (IPM) strategies due to their environmental safety and target specificity (Nirmalkar *et al.*, 2025). The present study aims to evaluate the field efficacy of different formulations of entomopathogenic fungi and conventional insecticides against *Bemisia tabaci* in okra and *Lipaphis erysimi* in mustard, with the objective of identifying effective, sustainable, and environmentally sound pest management options.

MATERIAL AND METHODS

A field experiment was laid out at Barrister Thakur Chhedilal, College of Agriculture and Research Station, Bilaspur (Latitude 22.078642 and Longitude 82.152328) during *Kharif* 2022-2023 in randomized block design to assess the field efficacy of most virulent isolate of *Lecanicillium lecanii* against Okra Whitefly (*Bemisia tabaci*) and Mustard Aphid (*Lipaphis erysimi*) under natural field condition. The cultivars okra variety Green wonder F_1 and mustard variety Pawan were grown in plot size of 3 × 12m and respectively with proper spacing each treatment. Good agronomic practice was followed during experiments.

Treatment details.

Treatments	Name of biopesticides/insecticides	Concentration (cfu^{-ml})	Dose (ml^{-lit})
T_1	*L. lecanii* (Ll_1) - 1.5%	($1×10^7$)	10
T_2	*L. lecanii* (Ll_1) - 5%	($1×10^8$)	10
T_3	*L. lecanii* (Ll_1) - 10%	($1×10^9$)	10
T_4	*L. lecanii* (Ll_2) - 1.5%	($1×10^7$)	10
T_5	*L. lecanii* (Ll_2) - 5%	($1×10^8$)	10
T_6	*L. lecanii* (Ll_2) - 10%	($1×10^9$)	10
T_7	*L. lecanii* 50% + *Paceliomyces* 50%	($1×10^9$)	10
T_8	*L. lecanii* 50% + *Beauveria bassiana* 50%	($1×10^9$)	10
T_9	*L. lecanii* 50% + *Metarhizium anisopliae*	($1×10^9$)	10
T_{10}	*L. lecanii* 50% + *Bacillus thuringiensis* 50%	($1×10^9$)	10
T_{11}	Imidaclorpid 17.8% SL	$80ml^{-ha}$	$0.33ml^{-lit}$
T_{12}	Untreated control		

Okra variety Green wonder F_1 was sown of 3 × 12 cm at spacing in last week of June. Standard horticultural practices were followed during experiment. All required liquid formulations were prepared in PDA broth. Insecticides Imidacloprid 17.8% SL was used as standard check and only water used for spray in control plot. Observation on whiteflies and yellow vein mosaic virus was recorded one day before and 3rd , 7th and 10th days after spraying on five randomly selected plants covering three leaves, one each from top, middle and bottom portion of the plant. The observation on population density of whitefly (*Bemisia tabaci)* recorded on 30th and 45th days after sowing on three top, middle and bottom leaves of 5 designated plants, the percent reduction over control worked out using modified Abbot's formula given by (Fleming and Ratnakaran 1985).

$P = 100 \times 1 - (Ta \times Cb) (Tb \times Ca)$

Where, P = Percentage population reduction over control

Ta = Population in treatment after spray

Ca = Population in control after spray

Tb = Population in treatment before spray

Cb = Population in control before spray

An observation was taken from 10cm top apical central shoot of inflorescence from 5 randomly selected plants of each plot. Both pre-treatment and post-treatment observation was taken for mustard aphid. Post-treatment observations were recorded after 3rd, 5th and 10th days of spray. In case of pre-treatment observation, it was taken 24 hours before spraying (Kafle, 2015). Percentage of population reduction over control was calculated using the modified Abbots formula as given by Fleming and Retnakaran (1985).

$PROC = [1-\{(Ta \times Cb) / (Tb \times Ca)\}] \times 100$

Was taken as the pre-treatment population for succeeding spray

Tb = Population in treatment before spray

Ta = Population in treatment after sprays

Cb = Population in control before spray

Ca = Population in control after spray

RESULTS AND DISCUSSION

Efficacy of *Lecanicillium lecanii* against whitefly (*Bemisia tabaci*) of Okra. Field efficacy of different formulation of entomopathogenic fungi and their combination and standard check insecticide were evaluated under natural field condition and observations was recorded at 3rd , 7th and 10th DAS, leaf infestation of white fly was recorded before spray and found statistically non-significant.

Before spray. Before spray no. of whitefly was recorded and found statistically non-significant and leaf infestation ranged from 8.17% to 9.43%.that means in all treatment the population of whitefly was almost equal.

Population of whitefly and percent reduction. Data presented on Table 1 shown the mean no. of whitefly leaf infestation was recorded maximum ($6.33^{-3leaves}$) in T_4 - *L. lecanii* (Ll_2)-1.5% followed by T_1- *L. lecanii* (Ll_1) -1.5% ($6.10^{-3leaves}$), and T_5 - (*L. lecanii* (Ll_2)- 5% ($6.00^{-3leaves}$), while least population density was recorded in T_{11} – (Imidacloprid 17.8% SL) ($2.82^{-3leaves}$). Similarly maximum mean population no. of okra whitefly leaf infestation was found in 3rd DAS ($5.81^{-3leaves}$) followed by 7th DAS ($5.32^{-3leaves}$) and least no. of whitefly ($4.42^{-3leaves}$) was recorded in 10th DAS.

Data disclose from Table 1 that the mean percent reduction of leaf infestation over control was recorded maximum 67.75% at standard check treatment T_{11} - Imidacloprid 17.8% SL followed by T_6 - *L. lecanii* (Ll_2) - 10% (62.45%) and T_3 - *L. lecanii* (Ll_1) - 10% (57.55%) while, least percent reduction of leaf infestation was recorded at T_4 - *L. lecanii* (Ll_2) (28.54%). Among the entomopathogen the mean percent reduction of leaf infestation was found maximum in T_6 - *L. lecanii* (Ll_2) -10% (62.45%). Percent reduction of leaf infestation was gradually increases from 27.32% to 40.72% and 55.69% third, seventh, and ten DAS, respectively.

3rd DAS population and percent reduction. The data presented in Table 1 shown the maximum no. of okra whitefly ($7.33^{-3leaves}$) leaf infestation was recorded 3rd day after spray in T_4 - *L. lecanii* (Ll_2) -1.5% followed by T_1 - *L. lecanii* (Ll_1) - 1.5% ($7.10^{-3leaves}$), and T_5 - (*L. lecanii* (Ll_2) - 5% ($7.00^{-3leaves}$), and least no. of whitefly ($3.03^{-3leaves}$) was recorded in T_{11} - Imidacloprid 17.8% SL ($3.03^{-3leaves}$) respectively T_3 and T_6 found at par with each other.

Data on percent reduction of whitefly infestation was recorded 3rd days after spray from different treatments. All treatments showed significant effect to control the whitefly among the different treatments over untreated control. Table 1 revealed that after 3rd days of spray the standard check insecticide *Imidacloprid* 17.8% SL was found superior over all treatment and significantly differ with all other treatment and recorded 61.42% reduction over control treatments T_6 -*L. lecanii* (Ll_2) - 10% (57.92%) was the next effective and significantly superior over control treatments *i.e.* T_3 - *L. lecanii* 10% (49.17%), T_9 - *L. lecanii* 50%+ *Metarhizium anisopliae* 50% (45.43%), T_{10} - *L. lecanii* 50% + *Bacillus thuringiensis* 50% (43.62%), treatments for were also found significantly effective controlling whitefly population. Although T_4 - *L. lecanii* (Ll_2) - 1.5% (26.67%) was least effective compare to other treatments.

7th DAS population and percent reduction. The data presented in Table 1 shown the maximum no. ($6.33^{-3leaves}$) of okra whitefly leaf infestation was recorded 7th day after spray in T_4 - *L. lecanii* (Ll_2) - 1.5% followed by T_1- *L. lecanii* (Ll_1) -1.5% ($6.10^{-3leaves}$), T_5 - *L. lecanii* (Ll_2) - 5% ($6.00^{-3leaves}$), and least no of whitefly population was recorded in T_{11} -Imidacloprid 17.8% SL ($3.43^{-3leaves}$), respectively treatments T_3, T_6, T_8, T_9 and T_{10} at par with each other.

Data on percent reduction of whitefly infestation was recorded 7th days after spray from different treatments. All treatments showed significant effect to control the whitefly among the different treatments over untreated control. Table 1 revealed that after 7th days of spray the standard check insecticide Imidacloprid 17.8% SL was found superior over all treatment and significantly differ with all other treatment and recorded 61.85% reduction over control. T_6 - *L. lecanii* (Ll_2) -10% (54.44%) was the next best effective and significantly superior over control. Treatments *i.e.* T_3 - *L. lecanii* (Ll_1) -10% (54.22%), T_8 - *L. lecanii* 50%+ *Beauveria bassiana* 50% (52.97%), T_9 - *L. lecanii* 50%+ *Metarhizium anisopliae* 50% (49.63%), treatments for were also found significantly effective controlling whitefly population. Although T_4 - *L. lecanii* (Ll_2) - 1.5% (29.96%) was least effective compare to other treatments.

10th DAS population and percent reduction. The data presented in Table 1 shown the maximum no. ($5.33^{-3leaves}$) of okra whitefly leaf infestation was recorded 10th day after spray in T_4 - *L. lecanii* (Ll_2) -1.5% followed by T_1 - *L. lecanii (Ll1)* -1.5% ($5.10^{-3leaves}$), T_5 - *L. lecanii* (Ll_2) - 5% ($5.00^{-3leaves}$), and least no of whitefly was recorded in T_{11} - Imidacloprid 17.8% SL ($2.00^{-3leaves}$), respectively T_3, T_6,T_7, T_8 T_9 and T_{10} found at par with each other.

Data on percent reduction of whitefly infestation was recorded at 10th days after spray from different treatments. All treatments showed significant effect to control the whitefly among the different treatments over untreated control. Table 1 revealed that after 10th days of spray the standard check insecticide Imidacloprid 17.8% SL was found superior over all treatment and significantly differ with all other treatment except T_6 and recorded 80.00% reduction over control. Followed by T_6 - *L. lecanii* (Ll_2) - 10% (75.00%) was the next effective and significantly superior over control. Treatments *i.e.* T_3 - *L. lecanii* 10% (69.33%), T_8 -*L. lecanii* 50%+*Beauveria bassiana* 50% (67.00%), T_9 - *L. lecanii* 50% +*Metarhizium anisopliae* 50% (61.00%), and T_{10} - *L. lecanii* 50%+ *Bacillus thuringiensis* 50% (60.00%), treatments for were also found significantly effective controlling aphid population. Treatments T_6 and T_3, T_3 and T_8, T_8, T_9 and T_{10} found at par with each other's means this treatment showed equally effective against white fly population. Although T_4 - *L. lecanii* (Ll_2) -1.5% (46.67%) was least effective compare to other treatments.

Similar trends were also found by Urkude *et al*. (2024) that The highest percent reduction of leaf infestation 85.66% recorded by Imidachloprid 17.8% SL + *L. lecanii* 50% and among bio-pesticide highest reduction observed in treatment *Beauveria bassiana* 50% + *L. lecanii* 50% (76.18%) against whitefly of moongbean. Other workers also works on different insects pests using *L. lecanii*, combination of bio-pesticides and insecticides Verma *et al*. (2023) works on field efficacy of *L. lecanii* against leaf folder and rice stem borer in Rajeshwari and Zinco rice and find the highest percent reduction of leaf infestation 98.7 % recorded by Indoxacarb and Novaluron. Among bio-pesticide highest reduction observed in treatment *Beauvaria bassiana*-10% (84.9%) followed by *L. lecanii*-10% (81.2%)

Similar results also find many works *i.e.* Sarkar *et al.* (2016); Hemadri *et al*. (2016) that evaluate the efficacy of different bio-pesticides against sucking pests of okra. The treatments *viz*., *Lecanicillium lecanii* and Imidacloprid 17.8% SL. Among them best performance of insecticides against whitefly was recorded in Imidacloprid treated plots with lowest mean population of whitefly (3.91 whitefly/15 leaves) followed by karanjin (4.16 whitefly/15 leaves). Similar result also found by Janghel and Rajput (2013); Halder *et al*. (2021) that the efficacy of *L. lecanii* against whitefly (*Bemisia tabaci)*. Maximum reduction was recorded in

V. lecanii 84.20% followed by *M. anisopliae*, 82.91% whitefly population reduction**.**

Efficacy of *Lecanicillium lecanii* against Aphid (*Lipaphis erysimi*) of Mustard. Field efficacy of different formulation of entomopathogenic fungi and their combination and standard check insecticide were evaluated under natural field condition and observations was recorded at 3^{rd}, 5^{th} and 10^{th} DAS leaf infestation of aphid was recorded before spray infestation ranges from 28.00 to 28.87.Population density of mustard aphid was recorded before spray and found statistically non-significant and infestation ranged from 28.00% to 28.87%.

Population of Aphid and percent reduction. Data presented on Table 2 shown the mean population density of mustard aphid infestation was recorded maximum (27.84%) in T_4 - *L. lecanii* (Ll_2)-1.5% followed by T_1 - *L. lecanii* (Ll_1) - 1.5% and (26.73%), T_5 - *L. lecanii* (Ll_2)- 5% (25.11%), and least population density (9.62%) was recorded in T_{11} - (Imidacloprid 17.8% SL), all the other treatment were showed significant different with each other. Similarly maximum mean population density of mustard aphid infestation was found in 3^{rd} DAS (22.13) followed by 5^{th} DAS (19.69) and least population density (18.06) were recorded in 10^{th} DAS. Data disclose from table that the mean percent reduction over control was recorded maximum 70.41 % at standard check treatment T_{11}-Imidachloprid 17.8% SL followed by T_6 - *L. lecanii* (Ll_2) -10% (64.08%) and T_3 - *L. lecanii* (Ll_1) - 10% (56.68%) while, least percent reduction over control was recorded 12.86% at T_4- *L. lecanii* (Ll_2) - 1.5%. Among the entomopathogen the mean percent reduction over control was found maximum at T_6 - *L. lecanii* (Ll_2) -10% (64.08%). Percent reduction was gradually increases from 28.90% to 35.99% and 46.37% at third, fifth and ten DAS, respectively.

3^{rd} DAS population and percent reduction. The data presented in Table 2 that the population density of mustard aphid infestation was recorded at 3^{rd} days after spray and found maximum (29.07%) in T_4- *L. lecanii* (Ll_2) -1.5% followed by T_1- *L. lecanii* (Ll_1) -1.5% and (27.40%), T_5 - *L. lecanii* (Ll_2) - 5% (26.00%), and least no. of whitefly was recorded in T_{11} - Imidacloprid 17.8% SL (15.07%). respectively T_3, T_6, T_8, and T_{11} found at par with each other.

Data on percent reduction of aphid infestation was recorded 3^{rd} days after spray from different treatments. All treatments showed significant effect to control the aphid population among the different treatments over untreated control. Table 2 revealed that after 3^{rd} days of spray the standard check insecticide Imidacloprid 17.8% SL was found superior over all treatment and significantly differ with all other treatment expect T_9 - (52.46%) and recorded 55.15% reduction over control. T_6 - *L. lecanii* (Ll_2) 10% (51.01%) was the next effective by treatments T_9 - (52.46%) and significantly superior over control. Treatments T_9 and T_6 showed significantly at par with each other. treatments *i.e.* T_3 - *L. lecanii* (Ll_2) - 10% (40.79%), T_9 - *L. lecanii* 50% + *Metarhizium anisopliae* 50% (52.46%), and T_8 - *L. lecanii* 50% + *Beauveria bassiana* 50% (46.90%), were also found significantly effective controlling aphid population over control. Although T_4- *L. lecanii* 1.5% (7.46%) was least effective compare to other treatments.

5^{th} DAS population and percent reduction. The data presented in Table 2 that the population density of mustard aphid infestation was recorded at 5^{th} days after spray and found maximum (28.07%) in T_4 - *L. lecanii* (Ll_2) -1.5% followed by T_1 - *L. lecanii* (Ll_1) -1.5% (27.07%), and T_5 - *L. lecanii* (Ll_2) - 5% (25.00%),while least population density was recorded in T_{11} - Imidacloprid 17.8% SL (8.80%). respectively T_3 and T_6 found at par with each other

Data on percent reduction of aphid infestation was recorded 5^{th} days after spray from different treatments. All treatments showed significant effect to control the aphid among the different treatments over untreated control. Table 2 revealed that after 5^{th} days of spray the standard check insecticide Imidacloprid 17.8% SL was found superior over all treatment and significantly differ with all other treatment and recorded 71.01% reduction over control. T_6 - *L. lecanii* (Ll_2) 10% (6.06%) was the next best effective treatments and significantly superior over control. Treatments *i.e* T_3 - *L. lecanii* (Ll_2) - 10% (59.55%), T_9 - *L. lecanii* 50%+ *Metarhizium anisopliae* 50% (51.65%), and T_8 - *L. lecanii* 50% + *Beauveria bassiana* 50% (45.25%), were also found significantly effective controlling aphid population. Although T_4 - *L. lecanii* (Ll_2)-1.5% (7.48%) was least effective compare to other treatments. All treatments showed significantly differ with each other.

10^{th} DAS population and percent reduction. The data presented in Table 2 that the population density of mustard aphid infestation was recorded at 10^{th} days after spray and found maximum (26.40%) in T_4 - *L. lecanii* (Ll_2) -1.5% followed by T_1 - *L. lecanii* (Ll_1) - 1.5% (25.73%), and T_5 - *L. lecanii* (Ll_2) - 5% (24.33%), while least population density was recorded in T_{11}- Imidacloprid 17.8% SL (5.00%). Respectively T_6 found at par with T_{11}.

Data on percent reduction of mustard aphid infestation was recorded at 10^{th} days after spray from different treatments. All treatments showed significant effect to control the mustard aphid among the different treatments over untreated control. Table 2 revealed that after 10^{th} days of spray the standard check insecticide Imidacloprid 17.8% SL was found superior over all treatment and significantly differ with all other treatment and recorded 85.08% reduction over control followed by T_6 - *L. lecanii* (Ll_2) 10% (76.18%) was significantly at par with each other. T_3 - *L. lecanii* (Ll_1) - 10% (70.32%) was the next best effective and significantly superior over control. Treatments *i.e*. T_9 - *L. lecanii* 50% + *Metarhizium anisopliae* 50% (59.45%), T_8 - *L. lecanii* 50% + *Beauveria bassiana* 50% (57.15%), T_7 - *L. lecanii* 50%+ *Paceliomyces* 50% (51.54%), and T_{10} - *L .lecanii* 50% + *Bacillus thuringiensis* 50% (48.43%) were also found significantly effective treatments for controlling aphid population. Although T_{4-} *L. lecanii* (Ll_2) - 1.5% (23.64%) was least effective compare to other treatments. T_9 and T_8, T_8 and T_7, T_7 and T_{10} showed non significant differ with each other, that means this treatment showed at par with each other.

Various researchers worked on the entomopathogenic fungi against the mustard aphid (*Lipaphis erysimi)* and found that *Verticillium lecanii* was effective in controlling the aphid population by 75.79% researchers Singh *et al*. (2008), Parmar *et al*. (2008); Janu *et al*. (2011); Kafle (2015); Kekan *et al*. (2022) also find similar trends of results.

Table 1: Efficacy of *Lecanicillium lecanii* against whitefly (*Bemisia tabaci*) of Okra.

Treatments	Dose (ml g^{-1})	cfu ml^{-1lit}	BS	No. of whiteflies$^{-3leaves}$			Mean	% reduction of leaf infestation over control			Mean
				3DAS	7DAS	10DAS		3DAS	7DAS	10DAS	
T_1- *L. lecanii* (*Ll*$_1$) - 1.5%	10	(1×10^7)	8.17	7.10 (15.44)	6.10 (14.22)	5.10 (13.02)	6.10	11.25 (19.57)	31.55 (34.13)	49.00 (44.40)	32.34
T_2- *L. lecanii* (*Ll*$_1$) - 5%	10	(1×10^8)	8.37	6.70 (14.98)	5.60 (13.66)	4.57 (12.33)	5.62	16.25 (23.64)	37.78 (37.89)	54.33 (47.47)	41.12
T_3 - *L. lecanii* (*Ll*$_1$) - 10%	10	(1×10^9)	8.80	4.07 (11.57)	4.10 (11.61)	3.07 (10.08)	3.51	49.17 (44.49)	54.22 (47.41)	69.33 (56.35)	57.55
T_4- *L. lecanii* (*Ll*$_2$) -1.5%	10	(1×10^7)	8.17	7.33 (15.70)	6.33 (14.57)	5.33 (13.34)	6.33	9.00 (17.42)	29.96 (33.16)	46.67 (43.06)	28.54
T_5 - *L. lecanii* (*Ll*$_2$) - 5%	10	(1×10^8)	8.80	7.00 (15.32)	6.00 (14.15)	5.00 (12.92)	6.00	12.50 (20.65)	33.33 (35.09)	50.00 (44.98)	31.94
T_6 - *L. lecanii* (*Ll*$_2$) -10%	10	(1×10^9)	8.47	3.37 (10.55)	4.00 (11.47)	2.50 (9.06)	3.52	57.92 (49.53)	54.44 (47.55)	75.00 (60.05)	62.45
T_7 - *L. lecanii* 50% + *Paceliomyces*	10	(1×10^9)	8.38	6.37 (14.60)	5.40 (13.35)	4.40 (11.99)	5.39	20.42 (26.75)	40.00 (39.17)	56.00 (48.56)	38.80
T_8 - *L. lecanii* 50% + *Beauveria bassiana* 50%	10	(1×10^9)	8.53	5.13 (13.06)	4.23 (11.86)	3.30 (10.35)	4.22	35.83 (36.75)	52.97 (46.68)	67.00 (55.16)	51.93
T_9 -*L. lecanii* 50% + *Metarhizium anisopliae* 50%	10	(1×10^9)	9.07	5.60 (13.65)	4.53 (12.27)	3.83 (11.09)	4.66	30.00 (33.14)	49.63 (44.76)	61.00 (51.78)	46.87
T_{10}-*L. lecanii* 50% + *Bacillus thuringiensis* 50%	10	(1×10^9)	8.83	6.07 (14.20)	5.13 (13.09)	4.00 (11.53)	5.07	24.17 (29.40)	42.96 (40.93)	60.00 (50.74)	42.37
T_{11} – Imidacloprid 17.8 % SL	80ml^{-ha}	0.33ml^{-lit}	8.45	3.03 (9.94)	3.43 (10.65)	2.00 (7.95)	2.82	61.42 (51.58)	61.85 (51.85)	80.00 (63.90)	67.75
Untreated control			9.43	8.00 (16.42)	9.00 (17.45)	10.0 (18.42)	9.00	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00
Mean			**7.20**	**5.81**	**5.32**	**4.42**		**27.32**	**40.72**	**55.69**	
CD			**NS**	**1.82**	**1.93**	**2.20**		**3.45**	**5.02**	**7.32**	
CV%			**NS**	**7.76**	**8.58**	**10.92**		**6.88**	**7.71**	**9.01**	

Data given in parenthesis shows arcsine percentage transformation DAS- Days after spray; BS- Before spray; NS –non significance

Table 2: Efficacy of *Lecanicillium lecanii* against Aphid (*Lipaphis erysimi*) of Mustard.

Treatments	Dose (ml g^{-1})	cfu ml^{-1}	BS	Aphid population/ cm^2			Mean	% reduction over control			Mean
				3 DAS	5 DAS	10DAS		3 DAS	5 DAS	10DAS	
T_1 - *L. lecanii* (*Ll*$_1$) - 1.5%	10	(1×10^7)	28.73	27.40 (31.54)	27.07 (31.33)	25.73 (30.47)	26.73	12.76 (20.90)	10.78 (19.12)	21.66 (27.11)	15.06
T_2 - *L. lecanii* (*Ll*$_1$) – 5%	10	(1×10^8)	28.20	24.13 (29.40)	23.47 (28.95)	20.80 (27.11)	22.80	23.10 (28.69)	22.62 (28.31)	38.30 (38.19)	28.00
T_3 - *L. lecanii* (*Ll*$_1$) – 10%	10	(1×10^9)	28.60	15.27 (22.96)	12.27 (20.48)	10.00 (18.41)	12.51	40.79 (39.66)	59.55 (50.49)	70.32 (57.23)	56.88
T_4 - *L. lecanii* (*Ll*$_2$) - 1.5%	10	(1×10^7)	28.33	29.07 (32.60)	28.07 (31.97)	26.40 (30.90)	27.84	7.46 (15.81)	7.48 (15.35)	23.64 (29.05)	12.86
T_5 - *L. lecanii* (*Ll*$_2$) – 5%	10	(1×10^8)	28.73	26.00 (30.64)	25.00 (29.66)	24.33 (29.19)	25.11	19.79 (26.40)	28.46 (32.16)	27.83 (31.81)	25.36
T_6 - *L. lecanii* (*Ll*$_2$) – 10%	10	(1×10^9)	28.47	18.57 (25.43)	10.60 (18.98)	8.03 (16.45)	12.40	51.01 (45.56)	65.06 (53.74)	76.18 (60.76)	64.08
T_7 - *L. lecanii* 50% + *Paceliomyces* 50%	10	(1×10^9)	28.00	22.67 (28.30)	19.33 (26.06)	16.37 (23.82)	19.46	26.83 (31.18)	36.28 (37.01)	51.54 (45.85)	38.21
T_8 - *L. lecanii* 50% + *Beauveria bassiana* 50%	10	(1×10^9)	28.33	17.93 (25.03)	16.60 (24.02)	14.37 (22.17)	16.30	42.90 (40.87)	45.25 (42.24)	57.15 (49.17)	48.43
T_9 - *L. lecanii* 50% + *Metarhizium anisopliae* 50%	10	(1×10^9)	28.80	15.00 (25.03)	14.67 (22.50)	13.67 (21.68)	14.44	52.46 (46.39)	51.65 (45.92)	59.45 (50.43)	54.52
T_{10} - *L. lecanii* 50% + *Bacillus thuringiensis* 50%	10	(1×10^9)	28.53	23.07 (28.67)	20.07 (26.60)	18.40 (25.37)	20.51	26.59 (31.02)	33.83 (35.53)	45.38 (42.32)	35.26
T_{11} - Imidacloprid 17.8 SL	80ml^{-ha}	0.33ml^{-lit}	28.87	15.07 (22.74)	8.80 (17.20)	5.00 (12.86)	9.62	55.15 (47.93)	71.01 (57.45)	85.08 (67.35)	70.41
Untreated control			28.47	31.40 (34.06)	30.33 (33.40)	33.73 (35.49)	31.82	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	
Mean			**28.50**	**22.13**	**19.69**	**18.06**		**29.90**	**35.99**	**46.37**	
CD			**N/S**	**3.13**	**3.75**	**4.09**		**2.97**	**4.25**	**6.05**	
CV%			**N/S**	**6.60**	**8.49**	**9.81**		**5.60**	**7.17**	**8.54**	

Data given in parenthesis shows arcsine percentage transformation DAS- Days after spray; BS- Before spray; NS –non significance

Similar trends were also found by Urkude *et al.* (2024) that they works against the aphid of french bean and observed highest percent reduction of leaf infestation 92.08% recorded in Imidachlorpid 17.8% SL and among bio-pesticides highest reduction observed in treatment *L. Lecanii* (25%) + *Beauveria bassiana* (25%) + Imidachloprid 17.8% SL 50% (82.08%). Similar result also interpreting by Kumar *et al.* (2007) against mustard aphid (*Lipaphis erysimi)* and found that Imidacloprid 17.8% SL@ 0.0178% was found most effective (99.6%) followed by oxydemeton methyl 0.025%, monocrotophos 0.036%, dimethoate 0.03%, chloropyriphos 0.05%, malathion 0.05%, endosulfan 0.07%, cypermethrin 0.01% and neemarin.

CONCLUSIONS

On the basis of present study we concluded that Imidacloprid 17.8% SL were found superior treatment to reduced the white fly and aphid population (80% and 85.08%), respectively and among the EPF and their combination treatment T_6 – *L. lecanii* 10% concentration observed best treatment to reduced the population 75% and 76.18% at 10th DAS for whitefly and mustard aphid, respectively.

FUTURE SCOPE

— Large scale screening of soil sample and to collect insect's cadavers from different pest of Chhattisgarh.
— Molecular identification of isolated pathogens.
— Different physical characterization was needed to know the difference among the pathogens.

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Conflicts of Interest. None.

REFERENCES

Fleming, R. and Ratnakaran (1985). Evaluating single treatment data using Abbot's formula with modification. *J. of Economic Entomology, 78,* 1-179.

Halder, J., Divekar, P. A. and Rani, A. T. (2021). Compatibility of entomopathogenic fungi and botanicals against sucking pests of okra: an ecofriendly approach. *Egyptian Journal of Biological Pest Control*, 31- 30.

Hemadri, T., Kumar, L. V., Somu, G. and Maulya, M. R., Janghel, M. and Rajput, M. S. (2016). Efficacy of bio-pesticides against whitefly *bemesia tabaci* on okra. *Plant Archives*, *16*(1), 102-104.

Janu, A., Yadav, G. S., Kaushik, H. D. and Jakhar, P. (2011). Bioefficacy of *Verticillium lecanii* and *beauveria bassiana* against mustard aphid, *lipaphis erysimi* under field conditions. *Plant Archives*, *18*(1), 288-290.

Kafle, K. (2015). Management of mustard aphid *Lipaphis erysimi* (kalt.) (homoptera: aphididae). *International of Applied Science and Biotechnology*, *3*(3), 537-540.

Kekan, A. M., Gurav S. S., Sanap, P. B. and Panchare, A. M. (2022). Efficacy of different biopesticides against sucking pests infesting okra (*Abelmoschus esculentus* L. Moench). *International Journal of Pharmaceutical Research and Applications, 7,* 486-489.

Kumar, A., Jandial, V.K. and Parihar, S. B. S. (2007). Efficacy of different insecticides against mustard aphid, *Lipaphis erysimi* (Kalt.) on mustard under field conditions, *International Journal of Agriculture Science*, *3*(2), 90-91.

Kumar, A., Yadav, S., Kumar, Y., and Yadav, J. (2020). Evaluation of different botanicals for the management of mustard aphid, *Lipaphis erysimi* (Kaltenbach). *Journal of Oilseed Brassica, 11*(1), 42–48.

Mishra, V. K. and Singh, N. N. (2019). Efficacy of insecticides against mustard aphid *Lipaphis erysimi*. *Indian Journal of Entomology*, *81*(2), 343–347.

Nirmalkar, V. K., Lakpale, N., Singh, H. K. and Tiwari, R. K. S. (2025). Mechanism of pathogenesis and biology of entomopathogenic fungi: a novel biological insect management system. Sustainable Agriculture and Biodiversity: Innovations and Insights: Narendra Publishing House, Delhi, India. 182–194

Parmar, G. M., Kapadia, M. N. and Davda B. K. (2008). Bioefficacy and cumulative effect of *Verticillium lecanii* (Zimmerman) viegas against *Lipaphis erysimi* (Kaltenbach) on mustard. *International Journal of Agriculture Science*, *4*(1), 204-206.

Patel, S., Singh, C. P. and Yadav, S. K. (2019). Monitoring of insect-pest complex on rapeseed-mustard at Pantnagar. *Journal of Entomological Research*, *43*(1), 73-76.

Pawar, D. M., Kumar, S. and Golvankar, G. (2023). Population Dynamics of Aphids Infesting Okra with different Sowing Dates. *International Journal of Theoretical and Applied Sciences*, *15*(1), 47-50.

Rajwade, H., Verma, P., Nirmalkar, V. K. and.Tiwari, R. K. S. (2023). Efficacy of entomopathogenic fungi *Paecilomyces* spp. against rice stem borer (*Scirpophaga incertulas* L.) and leaf folder (*Cnaphalocrocis medinalis* L.) under natural field condition. *Biological Forum- An international Journal*, *15*(5), 168-1174.

Sahu, S., Bhagat, P. K., Painkra, G. P., Painkra, K. L., Sahu, R., Jaiswal, V. K. and Miri Y. (2024). Evaluate the efficacy of biorational pesticides against the key pests of okra, *Abelmoschus esculentus* (L.) at Northern hills of Chhattisgarh. *International Journal of Advanced Biochemistry Research*, *8*(8), 542-547

Sarkar, S., Patra, S. and Samanta, A. (2016). Efficacy of different bio-pesticides against sucking pests of okra (*Abelmoschus esculentus* L. Moench). *Journal of Applied and Natural Science*, *8*(1), 333–339.

Singh, H., Baliyan, S., Singh, V. and Kumar, N. (2023). Insights into Bio-intensive Management of Aphids: A Broad Perspective. *Biological Forum – An International Journal*, *15*(1), 455-462.

Urkude, S., Nirmalkar, V. K., Kumar, D. and Tiwari, R. K. S. (2024). Bioefficacy of *Licannicillum lecanii* against aphid (*Aphid craccivora*) of French bean and white fly of green gram. *J. Soils and Crops, 33*(2), 283-288

Verma, P., Nirmalkar, V K., Rajwade, H. and Tiwari, R K S. (2023). Field efficacy of *lecanicillium lecanii* and combination of entomopathogenic fungi against rice stem borer (*Scirpophaga incertulas* L.) and leaf folder (*Cnaphalocrocis medinalis* L.) under natural field condition. *Journal of soils and crops, 33*(1), 99-105.

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