International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; SP-8(5): 33-38
www.biochemjournal.com
Received: 13-03-2024
Accepted: 19-04-2024

Hubballi Aravinda
Department of Agricultural Entomology, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka, India

GT Shruthi
Department of Agricultural Entomology, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka, India

SN Nandini
Department of Agricultural Entomology, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka, India

AN Shylesha
Principal Scientist, ICAR-National Bureau of Agricultural Insect Resources, Bengaluru, Karnataka, India

TM Shivalingaswamy
Principal Scientist, ICAR-National Bureau of Agricultural Insect Resources, Bangaluru, Karnataka, India

R Vijay
Department of Agricultural Entomology, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka, India

Corresponding Author:
Hubballi Aravinda
Department of Agricultural Entomology, University of Agricultural Sciences, GKVK, Bengaluru, Karnataka, India

A comparative study on bio-rational insecticides for managing sucking pests in okra (*Abelmoschus esculentus* L.)

Hubballi Aravinda, GT Shruthi, SN Nandini, AN Shylesha, TM Shivalingaswamy and R Vijay

DOI: https://doi.org/10.33545/26174693.2024.v8.i5Sa.1115

Abstract
Okra (*Abelmoschus esculentus* (L) Moench) is a highly popular and extensively cultivated vegetable. One of the significant challenges in okra production is the presence of sucking pests, which severely limit its growth. To combat these pests and reduce losses, farmers have been relying heavily on pesticides. Unfortunately, this excessive use of pesticides has led to problems such as resistance development, pest resurgence, and environmental contamination. To address these issues, a recent study was conducted to evaluate the effectiveness of various bio-pesticides for the eco-friendly management of sucking pests in okra cultivation. The field experiment was conducted to investigate the effectiveness of botanical and microbial pesticides against sucking insect pests of okra (*Ablemoschus esculentus* L) at ICAR-NBAIR Research Farm, Attur, Bengaluru during *Kharif*-2020. Five treatments *viz*., T_1: *Beauveria bassiana* (5 g/l), T_2: *Lecanicillium lecanii* (5 g/l), T_3: *Metarrhizium anisopliae* (5 g/l), T_4: *Bacillus thuringiensis var kurstaki* (2 ml /l), T_5: Neem oil 0.5% (5 ml/l), and T_6: water spray as control were selected by adopting RBD design. Treatments tested against leafhoppers, *L. lecanii* @ 5 g/l was found to be superior, whereas, against aphids, Neem oil @ 0.5% was found to be superior and the treatment *L. lecanii* @ 5 g/l was shown to be superior against whitefly at 3, 7, and 10 days after first and second sprays, respectively. Therefore, these treatments hold promise for use in biological control methods to manage these pest species in an eco-friendly manner.

Keywords: Okra, sucking pests, biological control**,** microbial pesticides, botanicals

Introduction

Okra (*Abelmoschus esculentus* (L) Moench) holds a prominent position as one of the most widely cultivated and consumed vegetables. It is valued not only for its calcium and iodine contents but also for the mucilaginous properties of its fruit, making it an important dietary component. Additionally, okra is rich in vitamins A, B, and C, further contributing to its nutritional benefits (Benson, 2017) [5]. However, a significant challenge faced in okra cultivation is the presence of insect pests attacking the crop at various stages of its growth. As many as 72 insect species have been recorded on okra (Pal *et al*. 2013) [18].

The most significant challenge among insect pests in okra cultivation is posed by sucking pests, which can attack the crop right from its early seedling stage to the final fruit harvesting stage. These sucking pests include the leafhopper, *Amrasca biguttula biguttula* Ishida (Hemiptera: Cicadellidae), whitefly, *Bemisia tabaci* Gennadius (Hemiptera: Aleyrodidae), aphid, *Aphis gossypii* Glover (Hemiptera: Aphididae), and mealy bug, *Phenococcus solenopsis* Tinsley (Hemiptera: Pseudococcidae) (Chaturvedani, *et al*. 2023) [8]. Their mode of feeding involves extracting sap from the leaves, resulting in weakened and unhealthy plants. Additionally, some of these sucking pests act as vectors, transmitting viral diseases to the okra plants (Rai *et al*. 2014) [21].

The significant losses caused by these pests have led to the extensive use of pesticides in okra cultivation, resulting in issues such as resistance development, pest resurgence, and environmental pollution (Sarkar 2016) [24]. In response to the environmental concerns, biological control methods have gained importance as an eco-friendly approach to manage insect pests. Utilizing various entomopathogenic microorganisms for this purpose offers advantages such as target specificity, self-perpetuity, and environmental safety.

Entomopathogenic fungi (EPF) like *Beauveria bassiana*, *Metarhizium anisopliae*, and *Lecanicillium* (=*Verticillium*) *lecanii* have been widely recognized for their efficacy in pest control over the years. Among botanical options, *Azadirachta indica*, commonly known as neem, has emerged as an essential player due to its diverse mode of action against a wide range of insect pests in both agricultural and horticultural crops (Halder *et al*. 2012; Jaleel *et al*. 2020) [10, 12].

There is a lack of substantial literature on the effectiveness of botanical and microbial insecticides in combating the sucking insect pests of okra. Thus, the current research sought to address this gap by investigating the efficacy of various entomopathogens and neem oil against the key sucking pests of okra.

Materials and Methods

The experiment was conducted at the Research Farm, ICAR-NBAIR, Attur, Bengaluru, with geographical coordinates of Latitude: 13.097221 and Longitude: 77.568291. The okra variety used for the study was Arka Nikita (IIHR), and it was sown following a randomized block design (RBD) with four replications. Each plot measured 20 X 20 m^2, and the spacing between rows and plants was maintained at 45 cm and 30 cm, respectively. The experiment was conducted during *Kharif*-2020, and all the recommended package of practices for organic farming were followed, except for plant protection measures.

The treatment details along with their concentrations were as follows: T_1: *Beauveria bassiana* (Balsamo) Vuillemin (Hypocreales: Clavicipitaceae) commercial formulation (1×10^8cfu g^{-1}) (5 g/l) NBAIR strain, T_2: *Lecanicillium lecanii* R. Zare & W. Gams (Hypocreales: Clavicipitaceae) NBAIR strain (2×10^9 cfu g^{-1}) (5 g/l) NBAIR strain, T_3: *Metarhizium anisopliae* (Metchnioff) Sorokin (Hypocreales: Clavicipitaceae) (1×10^{10} cfu g^{-1}) (5 g/l) NBAIR strain T_4: *Bacillus thuringiensis* var *kurstaki*-18,000 IU/mg (2 ml/l) from NBAIR and the commercial neem formulation like T_5: Neem oil 0.5% (5 ml/l) (purchased from pesticide shop: Neem ashirvad) and T_6: untreated control (water spray). The treatments were applied at 15 days interval starting from the seedling stage when leafhopper, aphids and whitefly infestation was observed.

Spraying was performed using a pneumatic knapsack sprayer with standard spray fluid quantity of 500 lit/ha at 35 and 55 days after sowing. Pre-treatment observations were made one day before the spray, and subsequent observations were made after 3, 7, and 10 days after spray (DAS). Leafhoppers, aphids, and whiteflies were counted from 15 randomly selected tagged plants/plots in each replication of treatment, covering the top, middle, and bottom leaves/plant, *i.e.* (Number of sucking pests/Leaves). The critical difference (CD) at 5% level of significance was worked out with the SAS program (version 9.2).

Results

The efficacy of microbial formulations and botanicals against sucking pests of Okra

The efficacy of botanical and microbial formulations against sucking pests of okra *viz*., Leafhoppers, Aphids and Whiteflies are depicted in Tables 1, 2 and 3 respectively.

Efficacy of botanical and microbial formulations against Leafhoppers, *Amrasca biguttula biguttula* (Ishida)

In case of leafhoppers, the pre-treatment count population of leafhoppers was found to range between 18.02 to 19.44 and 22.32 to 24.42 leafhoppers/plant before first and second sprays, respectively. Among all the treatments tested against leafhoppers, *Lecanicillium lecanii* @ 5 g/l was found to be superior and the maximum reduction of leafhoppers (4.60, 3.69, 4.74 and 4.96, 6.80, 5.35 leafhoppers/plant) was recorded on 3, 7, 10 days after first and second spray respectively. This was on par with the next superior treatments like, Neem oil 0.5% @ 5 ml/l (botanical) (7.46, 6.78, 8.71 and 5.53, 7.28, 7.95 leafhoppers/plant) 3, 7, 10 days after first and second spray respectively. Whereas, rest of the treatments; *Beauveria bassiana* @ 5 g/l, *Metarhizium anisopliae* @ 5 g/l and *Bacillus thuringiensis (Bt)* @ 2 ml/l showed lower pest reduction values (Fig.1 & Table.1).

Efficacy of botanical and microbial formulation against Aphids, *Aphis gossypii* (Glover)

The Aphids population during the pre-treatment count was in the range of 34.35 to 35.70 and 66.47 to 74.08 aphids /plant before first and the second spray respectively. Foliar spray of Neem oil 0.5% resulted in reduction of aphid population, with mortality of 8.09, 6.71, 6.46 and 37.33, 22.18, 24.67 aphids /plant, 3, 7, 10 days after first and second spray respectively. Among other treatments, L. *lecanii* @ 5 g/l was next superior treatment with reduction of 7.75, 7.84, 8.84 and 38.97, 21.59, 25.46 aphids /plant, 3, 7, 10 days after first and second spray respectively. Other treatments like, *B. bassiana* @ 5 g/l, *B thuringiensis (Bt)* @ 2 ml /l and *M. anisopliae* @ 5 g/l recorded lower pest reduction values (Table.2 & Fig.2).

Table 1: Efficacy of botanicals and mycopathogenic formulation against leafhoppers on Okra

Tr. No.	Treatments	1st spray (No. of leafhoppers/3 leaves)				% ROC	2nd spray (No. of leafhoppers/3 leaves)				% ROC
		PTC	3 DAS	7 DAS	10 DAS		PTC	3 DAS	7 DAS	10 DAS	
T_1	*Beauveria bassiana* (5 g/l)	18.02 (4.36)^{a}	7.80 (2.96)^{d}	7.05 (2.83)^{d}	9.90 (3.30)^{c}	64.04	23.78 (4.98)^{a}	8.49 (3.08)^{d}	10.29 (3.36)^{c}	10.55 (3.40)^{cd}	65.80
T_2	*Lecanicillium lecani* (5 g/l)	18.11 (4.37)^{a}	4.60 (2.36)^{e}	3.69 (2.16)^{e}	4.74 (2.39)^{d}	81.06	22.32 (4.83)^{a}	4.96 (2.43)^{e}	6.80 (2.78)^{d}	5.35 (2.51)^{e}	80.06
T_3	*Metarhizium anisopliae* (5 g/l)	18.65 (4.43)^{a}	12.80 (3.71)^{c}	11.68 (3.56)^{c}	13.41 (3.79)^{b}	44.95	23.37 (4.94)^{a}	12.31 (3.65)^{c}	11.23 (3.50)^{c}	12.89 (3.73)^{c}	57.53
T_4	*Bacillus thuringiensis (Bt)* (2.5 ml/l)	19.44 (4.52)^{a}	18.36 (4.40)^{b}	16.92 (4.23)^{b}	16.19 (4.15)^{b}	25.20	23.23 (4.92)^{a}	17.34 (4.28)^{b}	17.76 (4.33)^{b}	16.81 (4.22)^{b}	39.87
T_5	Neem oil (0.5%) 5 ml/l	18.98 (4.47)^{a}	7.46 (2.91)^{d}	6.78 (2.79)^{d}	8.71 (3.11)^{c}	66.66	24.07 (5.01)^{a}	5.53 (2.55)^{e}	7.28 (2.87)^{d}	7.95 (2.99)^{de}	75.79
T_6	Control (Water spray)	18.59 (4.43)^{a}	22.02 (4.80)^{a}	22.33 (4.83)^{a}	24.47 (5.05)^{a}	-	24.42 (5.04)^{a}	27.06 (5.30)^{a}	29.33 (5.51)^{a}	29.38 (5.51)^{a}	-

C.D @ 0.05%	NS	1.37	1.52	1.45		NS	1.59	1.38	1.66	
SE(m) ±	0.38	0.45	0.50	0.48		0.55	0.52	0.45	0.55	
C.V.	4.05	7.39	8.75	7.40		4.71	8.31	6.56	7.89	

[*] Values in the parenthesis are square root transformed
PTC: Pre-treatment count
DAS: Days after spray
ROC: Reduction over control

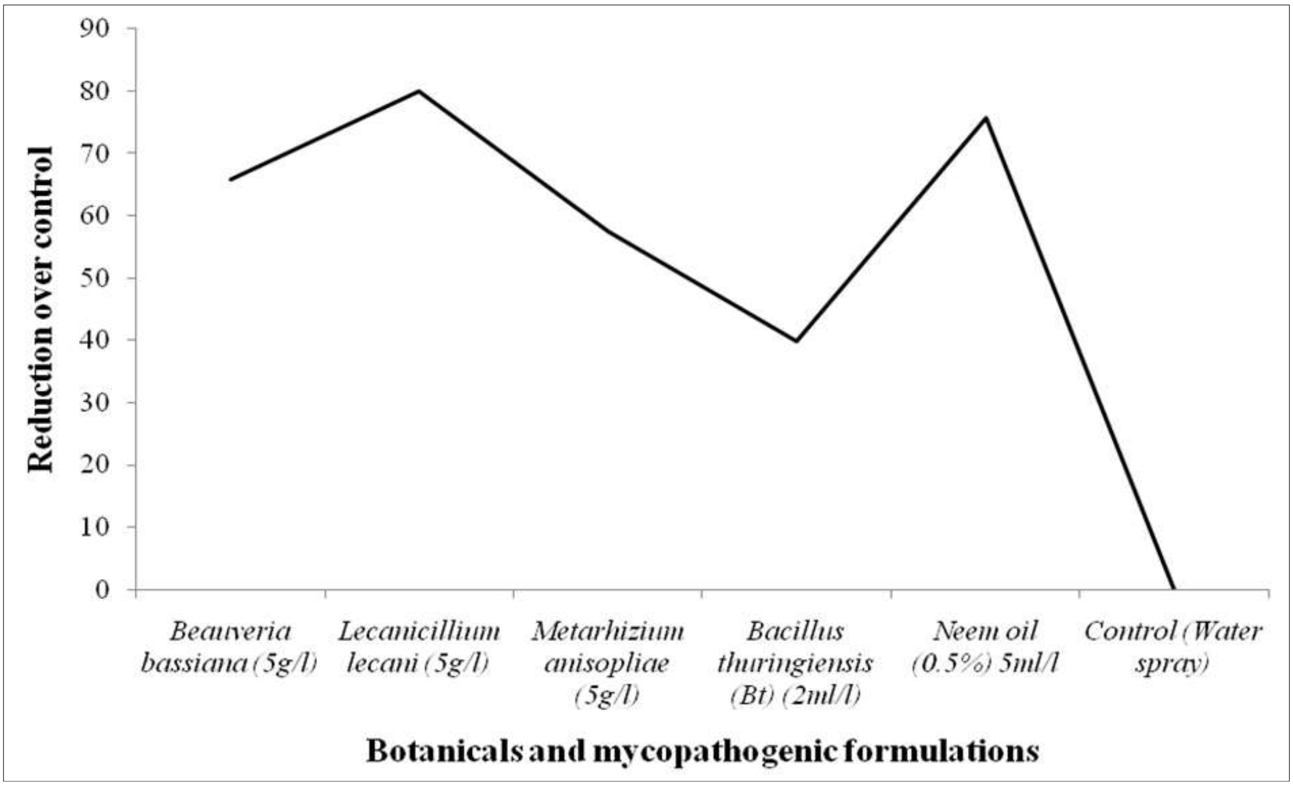

Fig 1: Efficacy of botanicals and mycopathogen formulations against leafhoppers on Okra

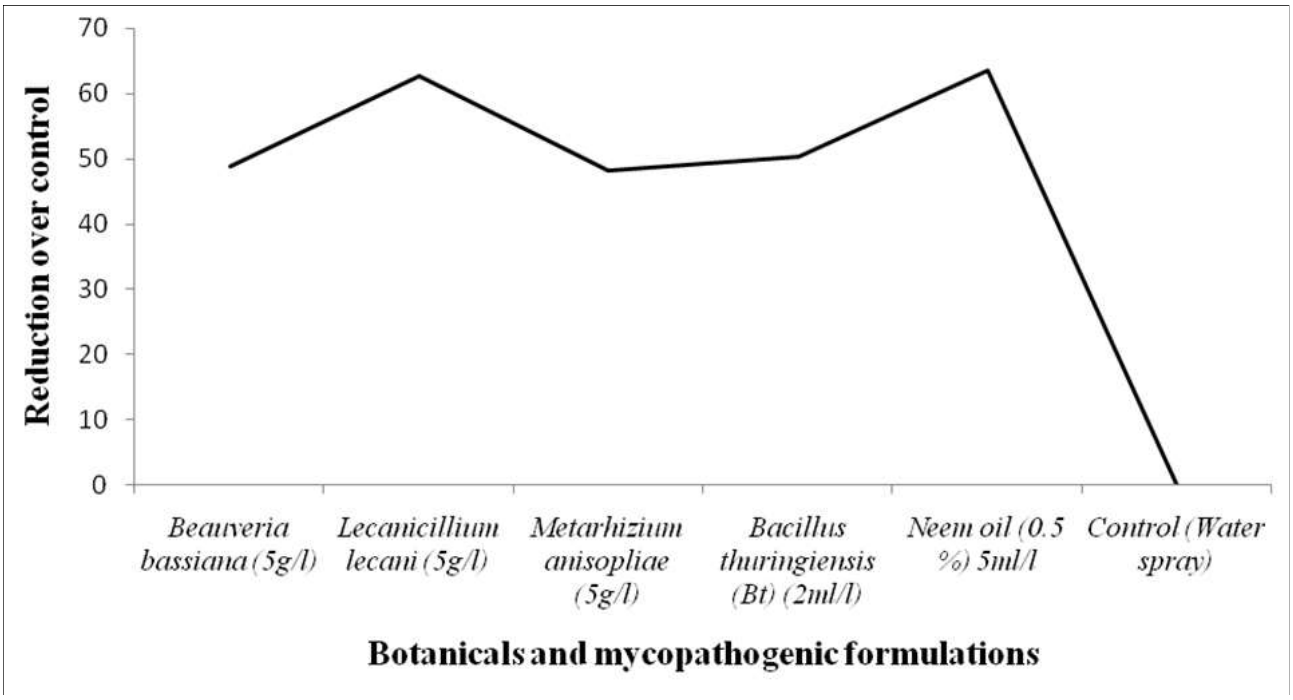

Fig 2: Efficacy of botanicals and mycopathogen formulations against aphids on Okra

Table 2: Efficacy of botanicals and mycopathogenic formulation against Aphids on Okra

Tr. No.	Treatments	1st spray (No. of Aphids/3 leaves)				% ROC	2nd spray (No. of Aphids/3 leaves)				% ROC
		PTC	3 DAS	7 DAS	10 DAS		PTC	3 DAS	7 DAS	10 DAS	
T_1	*Beauveria bassiana* (5 g/l)	34.77 (5.98)[a]	15.31 (4.04)[b]	13.27 (3.78)[c]	13.99 (3.87)[c]	49.60	72.42 (8.56)[a]	51.38 (7.23)[b]	31.98 (5.74)[b]	34.58 (5.96)[bc]	48.92
T_2	*Lecanicillium lecani* (5 g/l)	35.11 (6.01)[a]	7.75 (2.95)[c]	7.84 (2.97)[d]	8.84 (3.13)[d]	71.09	66.47 (8.21)[a]	38.97 (6.31)[c]	21.59 (4.75)[c]	25.46 (5.14)[d]	62.75
T_3	*Metarhizium anisopliae* (5 g/l)	34.53 (5.96)[a]	17.52 (4.30)[b]	17.54 (4.30)[b]	20.54 (4.64)[b]	34.18	67.45 (8.27)[a]	49.04 (7.07)[b]	33.92 (5.91)[b]	36.42 (6.12)[b]	48.29
T_4	*Bacillus thuringiensis (Bt)* (2 ml/l)	35.70 (6.06)[a]	16.60 (4.19)[b]	17.70 (4.32)[b]	19.53 (4.53)[b]	36.26	68.67 (8.34)[a]	50.85 (7.19)[b]	34.59 (5.96)[b]	29.31 (5.49)[cd]	50.31
T_5	Neem oil (0. 5%) 5 ml/l	35.59 (6.05)[a]	8.09 (3.01)[c]	6.71 (2.77)[d]	6.46 (2.73)[d]	74.84	68.40 (8.33)[a]	37.33 (6.19)[c]	22.18 (4.81)[c]	24.67 (5.06)[d]	63.55
T_6	Control (Water spray)	34.35 (5.95)[a]	27.08 (5.30)[a]	28.16 (5.40)[a]	29.22 (5.50)[a]	-	74.08 (8.66)[a]	76.17 (8.78)[a]	76.87 (8.82)[a]	77.86 (8.88)[a]	-
C.D @ 0.05%		NS	1.68	1.33	1.32		NS	4.05	2.67	4.62	
SE(m) ±		0.75	0.55	0.44	0.44		1.94	1.33	0.88	1.52	
C.V.		3.03	7.17	5.75	5.30		5.57	5.26	7.61	7.98	

[*] Values in the parenthesis are square root transformed
PTC: Pre-treatment count
DAS: Days after spray
ROC: Reduction over control

Efficacy of botanical and microbial formulations against whiteflies, *Bemisia tabaci* (Genn.)

The pre-treatment population count of whiteflies was in the range of 8.64 to 8.92 and 9.49 to 9.88 whiteflies/ plant before first and the second sprays respectively. The *L. lecanii* @ 5 g/l treatment was found superior with 4.39, 4.03, 4.24 and 4.66, 3.36, 3.78 whiteflies/ plant, 3, 7, 10 days after first and second spray respectively. This was followed by neem oil 0.5% with 4.52, 5.30, 5.52 and 4.30, 4.20, 4.37 whiteflies /plant on 3, 7, 10 days after first and second spray respectively. Whereas, other treatments like *B thuringiensis (Bt)* @ 2 ml /l and *M. anisopliae* @ 5 g /l and recorded no significanr pest reduction (Table.3 & Fig.3).

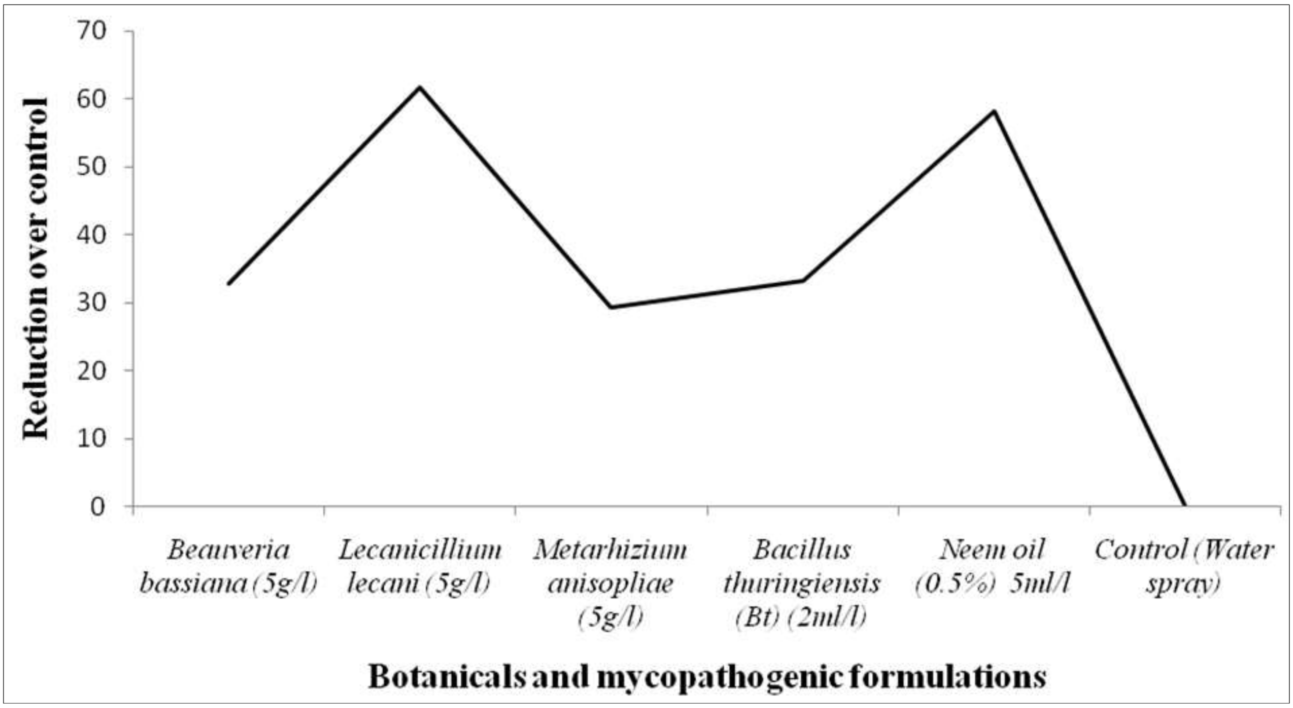

Fig 3: Efficacy of botanicals and mycopathogen formulations against whiteflies on Okra

Table 3: Efficacy of botanicals and mycopathogenic formulation against whiteflies on Okra

Tr. No.	Treatments	1st spray (No. of whiteflies /3 leaves)				% ROC	2nd spray (No. of whiteflies /3 leaves)				% ROC
		PTC	3 DAS	7 DAS	10 DAS		PTC	3 DAS	7 DAS	10 DAS	
T_1	*Beauveria bassiana* (5 g/l)	8.83 (3.14)a	5.86 (2.59)bc	6.49 (2.73)bcd	5.32 (2.51)bc	44.90	9.62 (3.26)a	6.54 (2.74)b	6.49 (2.73)b	7.67 (2.94)b	32.89
T_2	*Lecanicillium lecani* (5 g/l)	8.64 (3.10)a	4.39 (2.30)c	4.03 (2.23)d	4.24 (2.28)c	60.52	9.58 (3.25)a	4.66 (2.37)c	3.36 (2.08)c	3.78 (2.18)c	61.74
T_3	*Metarhizium anisopliae* (5 g/l)	8.92 (3.15)a	8.02 (3.00)ab	8.33 (3.05)ab	7.97 (2.99)b	24.16	9.51 (3.24)a	8.22 (3.03)ab	6.71 (2.77)b	6.86 (2.80)b	29.36
T_4	*Bacillus thuringiensis (Bt)* (2 ml/l)	8.79 (3.13)a	7.60 (2.92)ab	7.83 (2.96)abc	7.93 (2.98)b	27.17	9.49 (3.24)a	8.02 (3.00)b	6.49 (2.73)b	6.11 (2.66)b	33.18
T_5	Neem oil (0.5%) 5 ml/l	8.92 (3.15)a	4.52 (2.33)c	5.30 (2.51)cd	5.52 (2.55)bc	52.16	9.88 (3.29)a	4.30 (2.30)c	4.20 (2.28)c	4.37 (2.31)c	58.28
T_6	Control (Water spray)	8.72 (3.12)a	10.06 (3.32)a	10.55 (3.40)a	11.45 (3.52)a	-	9.85 (3.29)a	10.11 (3.33)a	10.25 (3.35)a	10.48 (3.39)a	-
C.D @ 0.05%		NS	1.76	1.78	1.70		NS	0.77	0.72	0.89	
SE(m) ±		0.23	0.58	0.59	0.56		0.51	0.25	0.24	0.29	
C.V.		5.25	17.17	16.52	15.79		10.49	7.21	7.61	8.98	

* Values in the parenthesis are square root transformed
PTC: Pre-treatment count
DAS: Days after spray
ROC: Reduction over control

Discussion

The current findings are consistent with those of Rosaiah *et al*. (2001) [23], who revealed that increased efficacy of Neem oil @ 0.5 percent against leafhoppers was significantly superior by recording the lowest leafhopper population. The enhanced efficacy of Neem oil 0.5% on leafhoppers could be attributed to feeding deterrent as well as mortality. Further, Anitha *et al*. (2007) [2] found that neem oil 0.5% and *M. anisopliae* reduced 2.56 and 8.33 mean leafhoppers/3 leaves, respectively. Girish Kumar (2000) [9] reported that *V. lecanii* (*L. lecanii*) and *B. bassiana* infected the leafhopper in the field and were confirmed in the laboratory. Baladaniya *et al*. (2010) [4] confirmed that at *V. lecanii* 7 g/l gave significantly high mortality of okra leafhopper under field condition.

Harika and Gogoi (2021) [11] who observed lowest mean population of leafhoppers in neem oil application (2.54 leaf hoppers/3 leaves) followed by karanj oil (3.20 leaf hoppers/3 leaves). Okra plants treated with neem oil significantly controlled the Jassid population (5.33/leaf) as compared to control (30.33/ leaf). So, neem oil spray controlled the sucking insect pests on okra effectively and kept the population below economic threshold levels (Channa 2017) [7]. Both *M. anisopliae* and *Bt* demonstrated reduced effectiveness in decreasing the leafhopper population, in accordance with the findings presented by Sarkar *et al*. (2016) [24].

Anitha (2007) [2] revealed that Neem oil 0.5% and *V. lecanii* (*L. lecanii*) recorded 2.56 and 3.33 mean number of aphids/3 leaves, respectively. According to Kabir and Mia (1987) [13], neem oil 0.5% proved efficient against mustard aphids. Bhavani Sankar Rao *et al*. (1991) [6] found that neem oil at 1% reduced aphid population by 63% when compared to an untreated as control. According to Nirmala *et al*. (2006) [17], the mycopathogen *V. lecanii* (*L. lecanii*) recorded the highest mortality of *A. craccivora* and *A. gossypii*. The neem oil recorded least mean population of aphids (5.87 aphids/3 leaves) followed by karanj oil (6.82 aphids/3 leaves) (Harika and Gogoi 2021) [11].

The present results align with those of Mallappanavar (2000) [14], who showed that the reduction of different stages of whiteflies was distinctly obvious at 15 DAS. *V. lecanii* (*L. lecanii*) @ 1.33 108 spores/ ml and Vertilec 7.5 g /l were shown to be the most effective. According to Andrew *et al.* (2004) [1], the *Lecanicillium muscarium* oil formulation was observed to reduce the *B. tabaci* population on tomato and verbena foliage under high humidity. Anitha (2007) [2] found that *V. lecanii* was much more effective than Neem oil 0.5% at controlling whiteflies. In the study by Scorsetti *et al.* (2008) [25], it was recorded that *L. lecanii* exhibited significant virulence towards *B. tabaci* in both organic and conventional horticultural settings, spanning greenhouses and open fields in Argentina. Raheem and Al-Keridis (2017) [20] conducted research that indicated the potential of *L. lecanii* and *B. bassiana* isolates as effective fungal biocontrol agents for managing whiteflies in field conditions. Their findings also highlighted that, among the three entomopathogenic fungi (EPF) evaluated, *L. lecanii* demonstrated superior virulence against *B. tabaci* within the tomato ecosystems. Lambdacyhalothrin and neem oil were equally effective against whitefly and jassid feeding on okra plants (Rehman 2015) [22].

Conclusion

Employing entomopathogenic fungi such as *L. lecanii*, *B. bassiana*, and *M. anisopliae*, in conjunction with botanicals like neem oil at their recommended levels, offers a prospective and environmentally sustainable strategy for proficiently controlling the sap-sucking pests affecting okra plants.

References

1. Andrew GS, Keith C, Walters FA, Northing F. The susceptibility of immature stages of *Bemisia tabaci* (G.) to the entomopathogenic fungus *Lecanicillum muscarium* (*V. lecanii* (Zimm.) on tomato and verbena foliage. Mycopathologia. 2004;159:23-29.
2. Anitha KR, Nandihalli BS. Utilization of botanicals and mycopathogens in the management of sucking pests of okra. Karnataka Journal of Agricultural Sciences. 2007;21(2):231-233.
3. Bairwa DK, Sharma JK, Kumawat KC. Efficacy of insecticides, biopesticide and plant products against whitefly, *Bemisia tabaci* on mothbean, *Vigna*

aconitifolia. Indian Journal of Plant Protection. 2006;34(2):210-212.
4. Baladaniya RB, Kapadia MN, Jethva DM. Concentration response of mycoinsecticides against *Amrasca biguttula biguttula* (Ishida) on okra. Indian Journal of Entomology. 2010;72(2):181-182.
5. Benson GAS. Efficacy of Selected Insecticides and Botanicals in the Control of Field Insect Pest of Okra (*Abelmoschus Esculentus*) in Akure. International Journal for Horticulture. 2017;3(4):1-5.
6. Bhavani Sankara Rao T, Reddy GPV, Murthy MMK, Deva Prasad V. Efficacy of neem products in the control of Okra pest complex. International Journal of Plant Protection. 1991;19:49-52.
7. Channa AA. Effect of neem oil on vegetative growth and production of okra. [Unpublished M.Sc. thesis]. Sindh Agriculture University, Tandojam, Pakistan; c2017.
8. Chaturvedani J, Ganguli J, Bhagat M. Succession of sucking pests infesting okra and their associated defenders at Raipur, Chhattisgarh. The Pharma Innovation Journal. 2023;12(6):1642-1647.
9. Kumar GHM. Studies on population dynamic and management of mango leafhoppers. [M. Sc. (Agri.) Thesis]. University of Agricultural Sciences, Dharwad, India; c2000.
10. Halder J, Srivastava C, Dhingra S, Dureja P. Effect of essential oils on feeding, survival, growth and development of third instar larvae of *Helicoverpa armigera* Hubner. National Academy Science Letters. 2012;35(4):271-276.
11. Harika D, Gogoi I. Efficacy of certain bio-pesticides against sucking pests of okra, *Abelmoschus esculentus* (L.) Moench. Pest Management in Horticultural Ecosystems. 2021;27(1):37-44.
12. Jaleel W, Wang D, Lei Y, Qi G, Chen T, Rizvi SAH, *et al*. Evaluating the repellent effect of four botanicals against two *Bactrocera* species on mangoes. PeerJ. 2020;8:e8537.
13. Kabir KH, Mia MD. Effectiveness of some indigenous materials as repellent against mustard aphid. Bangladesh Journal of Zoology. 1987;15:87-88.
14. Mallappanavar MC. Bio ecology and management of spiraling whitefly, *Aleurodicus disperses* Russell by *Verticillium lecanii* (Zimm.) on guava. [M. Sc. (Agri.) Thesis]. University of Agricultural Sciences, Dharwad, India; 2000.
15. Malsam O, Kilian M, Dehne HW. *Metarhizium anisopliae* - biological control of the greenhouse white fly (*Trialeurodes vaporariorum*). Bulletin-OILB/SROP. 1998;21(4):125-128.
16. Nier T, River F, Bermudez JC. First report of Mexico on the isolation of *Verticillium lecanii* from whitefly and *in vitro* pathogenicity tests on this insect. Revista Iberoamericana de Micología. 1993;7:149-156.
17. Nirmala R, Ramanujam B, Rabindra RJ, Rao NS. Effect entomofungal pathogen on mortality of three aphid species. Journal of Biological Control. 2006;20(1):89-94.
18. Pal S, Maji TB, Mondal P. Incidence of insect pest on okra *Abelmoschus esculentus* (L.) Moench in red lateritic zone of West Bengal. Journal of Plant Protection Sciences. 2013;5(1):59-64.
19. Quinden ED. The use of *V. lecanii* entomopathogenic fungi to control glasshouse whitefly. In: Proceedings of a conference at Brighton, England. 1994;25:9-12.
20. Raheem MAA, Al-Keridis LA. Virulence of three entomopathogenic fungi against whitefly, *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) in tomato crop. Journal of Entomology. 2017;14(4):155-159.
21. Rai AB, Loganathan M, Halder J, Venkataravanappa V, Naik PS. Eco-friendly approaches for sustainable management of vegetable pests. Technical Bulletin, ICAR-IIVR, Varanasi; c2014. p. 104.
22. Rehman H, Nadeem M, Ayyaz M, Begum HA. Comparative efficacy of neem oil and lambdacyhalothrin against whitefly (*Bemesia tabaci*) and jassid (*Amrasca devastans* Dist.) in okra field. Russian Agricultural Sciences. 2015;41:138-145.
23. Rosaiah R. Performance of different botanicals against the pest complex of Okra. Pestology. 2001;25:17-19.
24. Sarkar S, Patra P, Samanta A. Efficacy of different bio-pesticides against sucking pests of okra (*Abelmoschus esculentus* L. Moench). Journal of Applied and Natural Science. 2016;8(1):333-339.
25. Scorsetti AC, Humber R, Gregorio CD, Lastra CCL. New records of entomopathogenic fungi infecting *Bemisia tabaci* and *Trialeurodes vaporariorum*, pests of horticultural crops, in Argentina. Biocontrol. 2008;53:787-796. https://doi.org/10.1007/s10526-007-9118-9.