Plant Archives Vol. 26, Supplement 2, 2026 pp. 2137-2147 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2026.v26.supplement-2.268

MICROBIAL VOLATILES –AN ECO FRIENDLY ALTERNATE APPROACH FOR SUCKING PESTS MANAGEMENT IN COTTON

M. Sivarama Krishna[1*], K. Ashok Kumar[1], K. Mohan Vishnu Vardhan[1], M. Johnson[1] and Rishi Kumar [2]
[1]Regional Agricultural Research Station, Nandyal, Kurnool Dt. A.P 518502, India
[2]AICRP-Cotton -Regional Center, Sirsa, Haryana, India
*Corresponding author E-mail: m.sivaramakrihna@angrau.ac.in
(Date of Receiving : 12-04-2026; Date of Revision : 28-05-2026; Date of Acceptance : 18-06-2026)

ABSTRACT

Two years of field study was conducted at RARS, Nandyal during 2023 and 2024 to evaluate the sucking pest specific microbial bacterial volatiles along with yellow sticky traps (attract &kill) for managing sucking pests in cotton. Pooled data indicated that all the pest specific microbial volatiles are effective in attracting the sucking pests when compared to control which recorded lowest attraction. Volatile attractant formulations are expected to reduce environmental pollution through the reduction of insecticidal sprays and safe to natural enemies.
Keywords **:** Sucking pests, synthetic insecticides, microbial volatiles, environmental pollution, natural enemies.

Introduction

Sucking pests cause significant yield and quality loss in cotton. Farmers largely depend on conventional insecticides to manage them. Continuous use of pesticides resulted in pest resistance to insecticides, resurgence of minor pests, decline of natural enemies and increase in environmental pollution apart from escalating cost of production. Although yellow sticky traps (YST) were popularly used as mechanical control options for sucking pest management in cotton, further enhancement in the attraction of sucking pests to Yellow sticky traps will be useful. In the present situation, farmers demand alternative ecofriendly and cost-effective sustainable sucking pest management options in cotton. Microbial volatile organic compounds (MVOCs) represent a new frontier in bioprospecting where they produce complex volatile compounds having multifunctional roles in agriculture including plant growth promotion and pest management. Chemical ecologists consider MVOCs as potential semiochemicals that function as attractants and repellents to insects. MVOCs inhibit the growth of microorganisms competing with associated insects, stimulate oviposition, mimic plant hormones, or even induce plant resistance. Although MVOCs play a versatile role in agriculture, till date, no MVOCs have been explored for the management of sucking pests in cotton. ICAR-CICR has developed bacterial-based microbial volatile (MVOC) formulations, which on three-year large-scale field studies and multi-location evaluations in 15 AICRP (Cotton) centers proved to manage sucking pests of cotton through their attraction toward YST. The MVOC formulations CICR-BVW, CICR-BVJ, CICR-BVA and CICR-BVT used along with YST enhanced the attraction efficiencies by 168%, 197%, 189%, and 175% over control (only YST) for whiteflies, jassids, aphids and thrips, respectively. Furthermore, MVOC usage in cotton also enhanced the field populations of natural enemies (predators and parasitoids) by 268%. The developed MVOC formulations are eco-friendly and cost-effective, do not cause any harmful effects on cotton plants, soil nutrient status, soil biology, and can reduce chemical usage, pest resurgence, and environmental pollution apart from enhancing farmers health, farm income and farm sustainability, thus has wider commercial application prospects in agriculture.

Among the emerging strategies, volatile organic compounds (VOCs) produced by soil and plant microbiota offer promising eco-friendly alternatives to

synthetic pesticides, with potential applications in disease control, growth promotion, and stress resistance.

Over the recent decades, Volatile Organic Compounds produced by living beings have received growing attention in agricultural, environmental and ecological researches due to their various properties, and their potential applications in the biocontrol of plant pests and pathogens, as well as plant growth promotion (Choudhary *et al*., 2008; Pickett and Khan, 2016; Gualtieri *et al*., 2022; Devrnja *et al*., 2022; Russo *et al*., 2022; Patel *et al*., 2023).

Materials and Method

An experiment was conducted to evaluate the performance of bacterial based sucking pest specific microbial volatiles along with Yellow sticky traps in managing the sucking pests in cotton during kharif 2023 and 2024 at Regional Agricultural Research station, Nandyal. The experiment was laid out in Randomized block design with ten treatments replicated thrice. Eight pest specific and natural enemy specific microbial volatiles along with yellow sticky traps and yellow sticky trap and microbial solvent alone (Positive control) and yellow sticky trap alone (negative control) were taken as treatments to study the attractiveness of particular pest to particular microbial and trap on yellow sticky traps which specifies trap and kill mechanism. The cotton crop was sown during last week of July during both the years and all agronomic practices were followed except plant protection measures. Microbial volatiles along with yellow sticky traps were installed at 40, 50, 60 and 70 DAS and observations on no of sucking pests trapped in square centimeter on yellow sticky trap at five days after each installation i.e. 45th, 55th, 65th and 75th day were recorded and the recorded data was transformed into to square root transformation for conducting statistical analysis with LSD.

Table 1: Treatment details:

S.No	Treatment	Insect
1	CICR-MV-W (TPCXTCXBHTXHTC)	Whiteflies
2	CICR-MV-J- (ECXHCXTPC)	Jassids
3	CICR-MV-A(PDXPYXTPCXHTC)	Aphids
4	CICR-MV-T (HCXTPC)	Thrips
5	CICR-MV BI-W (DCTXPY)	Whiteflies
6	CICR-MV BI-J (PYXTPCXTC)	Jassids
7	CICR-MV BI-A (HCXDCTXTD)	Aphids
8	CICR-MV BI-T PDXPYXDBP)	Thrips
9	YST+ SOLVENT (Positive)	
10	YST only (Negative)	

Result and Discussion

During 2023-24:

45 Days after installation:

Jassid : At 45 DAI pest and BI specific volatile treatment T6- CICR-BI-J had attracted maxium number of jassidsi.e 21.33/trap which is statistically at par with the treatment T2-CICR-J which attracted 15.33/trap, lowest number of 4.0/trap were attracted to treatment T9-Positive control

Whiteflies: All the treatments were significantly superior over negative control T10 (negative control) in attracting whiteflies where negative control had attracted lowest whiteflies of 5.67/trap. However among different microbial volatiles treatment T5-CICR-BI-W had attracted highest number of whiteflies i.e. 39/trap which is at par with the treatment T1 CICR-W which attracted 37.33/trap.

Thrips: All the treatments were significantly superior over T10 negative control which attracted a lowest thrips/trap i.e. 8.67/trap. However among the treatments T8-CICR-BI-T had attracted highest of 45.33/trap which is at par with the treatment T4-CICR-T which attracted 38.67/trap

Aphid: All the treatments were significantly superior over T9 positive control which recorded a lowest aphid/trap i.e 0.67/trap. However among the treatments T3-CICR-A and T7-CICR-BI-A had attracted highest of 3.33/trap at 45 DAI

Beneficial insects: Highest number of coccinellids were attracted to treatment T7 CICR-MV BI-A i.e 10.33/trap which is at par with T5 CICR-MV BI-W which attracted 9.0/trap

Highest number of spiders was attracted to treatment T5 CICR-MV BI-W i.e. 4/trap which is at par with treatments T7 and T8 which attracted 3.67 and 2.33/trap respectively.

55 Days after installation:

Jassid : All the treatments were significantly superior over negative control T10 which attracted a lowest jassid of 2.0/trap, however among the treatments T6 CICR-MV BI-Jassids and T2 CICR-J had attracted 18.0 and 15.33/trap respectively.

Whiteflies: All the treatments were significantly superior over negative control T10 in attracting whiteflies where negative control had attracted lowest whiteflies of 10.0/trap. However among different microbial volatiles treatment T1 CICR-W had attracted highest number of whiteflies i.e 36.67/trap which is at par with the treatment T5 CICR-BI-W which attracted 35/trap.

Thrips: Highest number of thrips were attracted to treatment T4 CICR-T which attracted 46/trap which is at par with treatment T8-CICR-BI-T which attracted 42.67/trap, lowest number of 11.33/trap thrips were attracted to treatment T9-Positive control which is at par with remaining all other treatments.

Aphid: Highest number of Aphids were attracted to treatment T7 CICR-BI-A which attracted 4.67/trap which is at par with treatment T3-CICR-A which attracted 4.0/trap, lowest number of 1.0/trap aphids were attracted to treatment T9-Positive control which is at par with remaining all other treatments

Beneficial insects: Highest number of coccinellids were attracted to treatment T7 CICR-MV BI-A i.e. 10.33/trap which is at par with T5 CICR-MV BI-W which attracted 8.0/trap

Highest number of spiders was attracted to treatment T5 CICR-MV BI-W i.e. 12.67/trap which is at par with treatment T7 which attracted 10.33/trap.

65 Days after installation:

Jassid : All the treatments were significantly superior over positive control T9 which attracted a lowest jassid of 0.67/trap, however among the treatments T6 CICR-MV BI-Jassids and T2 CICR-J had attracted 3.67 and 3.33/trap respectively which are statistically at par with each other.

Whiteflies: Highest whiteflies were attracted to treatment T5-CICR-BI-W i.e. 3/trap which is at par with treatments T1 and T6 which attracted 2.33 and 2.0/trap respectively, lowest whiteflies of 0.67/trap were attracted to T9 positive control which is at par with majority of the **treatments.**

Thrips: All the treatments were significantly superior over positive control T9 in attracting thrips population which recorded lowest population of 0.67/trap, among treatments T8-CICR-BI-T had attracted highest number 3.67/trap of thrips which is at par with treatment T4-CICR-T which recorded 3.0/trap.

Aphid: Highest number of Aphids were attracted to treatment T3 CICR-A which attracted 3.0/trap which is at par with treatment T7-CICR-BI- A which attracted 2.67/trap, lowest number of 0.67 /trap aphids were attracted to treatment T9-Positive control.

Beneficial insects: Highest number of coccinellids were attracted to treatment T5 CICR-MV BI-W i.e. 6.33/trap which is at par with T7 CICR-MV BI-A which attracted 5.33/trap

The number of spiders attracted towards microbial treatments was non-significant at 65 DAI

75 Days after installation:

Jassid : Treatment T2 CICR-J had attracted highest number of jassids i.e. 6.33/trap which is at par with the treatment T6-CICR-BI-J which attracted 6.0/trap. Lowest number of jassids were attracted to treatment T10 negative control i.e. 0.67/trap which is at par with treatments T3,T5 and T7 which recorded a population of 1.33,1.0 and 1.33/trap respectively.

Whiteflies: Highest whiteflies were attracted to treatment T5-CICR-BI-W i.e. 4/trap which is at par with treatment T1 which attracted 3.67/trap , lowest whiteflies of 0.67/trap were attracted to T9 positive control which is at par with treatment T3.

Thrips: Highest thrips were attracted to T8 CICR-BI-T i.e. 4.67/trap which is at par with treatment T4-CICR-T which recorded 3.67/trap, lowest thrips were attracted to T9 positive control which recorded 1.0/trap which is at par with majority of the treatments.

Aphid: Highest number of Aphids were attracted to treatment T3 CICR-A which attracted 3.33/trap which is at par with treatment T7-CICR-BI- A which attracted 3.0/trap, lowest number of 0.67 /trap aphids were attracted to treatment T9-Positive control which is at par with majority of the treatments..

Beneficial insects: Highest number of coccinellids were attracted to treatment T7 CICR-MV BI-A i.e. 10.33/trap which is at par with T5 CICR-MV BI-W which attracted 9.0/trap

The number of spiders attracted towards microbial treatments was non-significant at 65 DAI

During 2024-25:

45 Days after installation:

Jassid: At 45 DAI pest specific volatile treatment T2-CICR-MV-J had attracted maximum number of jassids i.e. 17.33/trap which is statistically at par with the treatment T6-CICR-MV-B-J which attracted 13.0/trap, lowest number of 2.33.0/trap were attracted to treatment T10-YST only negative control

Whiteflies: All the treatments were significantly superior over positive control T9 in attracting whiteflies where positive control had attracted lowest whiteflies of 0.33/trap. However among different microbial volatiles treatment T5- CICR-MV-BI-W had attracted highest number of whiteflies i.e. 5.67/trap which is at par with the treatment T1 CICR-MV-W which attracted 4.33/trap.

Thrips: All the treatments were significantly superior over T10 and T9 negative & Positive controls which recorded a lowest population of 2.0/trap. However among the treatments T4-CICR-MV-T had attracted

highest of 13.33/trap which is at par with the treatment T8-CICR-MV-BI-T which attracted 10.67/trap

Aphid: All the treatments were significantly superior over T9&T10 positive and negative control which recorded a lowest aphid/trap i.e. 1.0/trap. However among the treatments T7-CICR-MV-BI-A had attracted highest number of aphids i.e. 5.33/trap which is at par with the treatment T3 CICR-MV-A which attracted 3.33/trap at 45 DAI

Beneficial insects: Highest number of coccinellids were attracted to treatment T7 CICR-MV BI-A i.e. 8.0/trap which is at par with T5 CICR-MV BI-W which attracted 7.67/trap

65 Days after installation:

Jassid: All the treatments were significantly superior over positive control T10 negative control which attracted a lowest jassid of 1.00/trap, however among the treatments T6 CICR-MV- BI-Jassids had attracted highest number of jassids i.e. 19.33/trap which is at par with the treatment T2 CICR-MV-J which attracted a jassid of 15.33/trap

Whiteflies: Highest whiteflies were attracted to treatment T5-CICR-MV-BI-W i.e. 13.33/trap which is at par with treatment T1 which attracted 10.67/trap respectively, lowest whiteflies of 1.67/trap were attracted to T10.

Thrips: All the treatments were significantly superior over positive control T9 in attracting thrips population which recorded lowest population of 3.67/trap, among treatments T4-CICR-MV-T had attracted highest number 20.33/trap of thrips which is at par with treatment T8-CICR-MV-BI-T which recorded 20.0 /trap.

Aphid: Highest number of Aphids were attracted to treatment T7 CICR-MV-BI-A which attracted 10.67/trap which is at par with treatment T3-CICR-MV- A which attracted 7.67/trap, lowest number of 1.00 /trap aphids were attracted to treatment T10-negative control.

Beneficial insects: Highest number of coccinellids were attracted to treatment T7 CICR-MV BI-A i.e. 11.67/trap which is significantly superior over all other treatments, highest spiders of 10.33/trap were attracted to treatment T5 CICR-MV-BI-W which is at par with the treatment T7 CICR-MV-BI-A which attracted a spider population of 9.67/trap (Table:11)

75 Days after installation:

Jassid: All the treatments are significantly superior over negative control which attracted a lowest population of 1.00/trap, however among the treatments T2 CICR-MV-J has attracted higher number of leafhoppers i.e. 10.33/trap which is at par with the treatment T6 CICR-MV-BI-J which attracted a population of 7.67/trap.

Whiteflies: Highest whiteflies were attracted to treatment T1-CICR-MV-W i.e. 10.33/trap which is at par with treatment T5 CICR-MV-BI-W which attracted 8.67/trap, lowest whiteflies of 1.33/trap were attracted to T9 positive control.

Thrips: Highest thrips were attracted to T4 CICR-MV-T i.e. 12.00/trap which is at par with treatment T8-CICR-MV-BI-T which recorded 9.33/trap, lowest thrips were attracted to T9 positive control which recorded 1.0/trap which is at par with majority of the treatments.

Aphid: Highest number of Aphids were attracted to treatment T7 CICR-MV-BI-A which attracted 6.00/trap which is at par with treatment T3-CICR-MV-A which attracted 5.33/trap.

Beneficial insects: Highest number of coccinellids were attracted to treatment T5 CICR-MV BI-W i.e. 6.33/trap

The number of spiders attracted towards microbial treatments was non-significant at 65 DAI

Pooled data of two years 2023 & 24 reveals that at 45 DAS highest number of leafhoppers 17.00/trap were attracted to treatment T6 i.e. CICR-MV-BI-J which is at par with the treatment T2 CICR-MV-J which attracted 12.67/trap, highest number of whiteflies were attracted to treatment T5 CICR-MV-BI-W i.e. 22.33/trap which is at par with the treatment T1 CICR-MV-W which attracted a population of 20.83/trap.

Highest number of thrips were attracted to treatment T8 CICR-MV-BI-T i.e. 28.00/trap which is at par with the treatment T4-CICR-MV-T which attracted a population of 26.00/trap. Highest number of aphids were attracted to treatment T7 CICR-MV-BI-A i.e. 4.33/trap which is at par with the treatment T3 CICR-MV-A which attracted 3.33/trap

Highest number of coccinelids were attracted to CICR-MV-BI-A i.e. 9.17/trap which is at par with the treatment T5 CICR-MV-BI-W which attracted a population of 8.33/trap

The number of spiders attracted towards microbial treatments was non-significant at 45 DAI

At 65 DAI T6 CICR-MV-BI-J has attracted highest number of leafhoppers i.e. 10.33/trap which is at par with the treatment T2 CICR-MV-J which attracted 9.33/trap. Highest whiteflies of 7.83/trap were attracted to treatment T5 CICR-MV-BI-W which is at

par with the treatment T1 which attracted 6.33/trap. Highest thrips of 11.83/trap were attracted to treatment T8 CICR-MV-BI-T which is at par with the treatment T4 CICR-MV-T which attracted 11.67/trap. Highest aphids were attracted to treatment T7 CICR-MV-MI-A i.e. 6.67/trap which is at par with the treatment T3 CICR-MV-A which attracted 5.33/trap

Highest coccinellids were attracted to treatment T7 CICR-MV-BI-A i.e. 8.50/trap which significantly superior over all other treatments

At 75 DAI highest number of leafhoppers were attracted to treatment T2 CICR-MV-J i.e 7.50/trap which is at par with the treatment T6 CICR-MV-BI-J which attracted 6.83/trap. Highest whiteflies of 7.00/trap were attracted to treatment T1 CICR-MV-W which is at par with the treatment T5 CICR-MV-BI-W which attracted 6.33/trap. Highest thrips of 7.83/trap were attracted in treatment T4 CICR-MV-T which is at par with the treatment T8 CICR-MV-BI-T which attracted 7.00/trap.

Highest number of aphids were attracted to T7 CICR-MV-BI-A i.e. 4.50/trap which is at par with the treatment T3 CICR-MV-A which attracted a population of 4.33/trap

Highest coccinellids were attracted in treatment T5 CICR-MV-BI-W which attracted 7.67/trap which is at par with the treatment T7 CICR-MV-BI-A which attracted population of 6.83/trap.

The number of spiders attracted towards microbial treatments was non-significant at 75 DAI

Table 2 : Efficacy of different microbial volatiles along with YST in attracting sucking pests at 45 DAI (Days after installation) During 2023-24

Treatment	Treatment no	45 DAI					
		Leaf hopper	**Whitefly**	**Thrips**	**Aphids**	**Coccinellids**	**spiders**
T1	**CICRMV-W**	4.00	37.33	19.33	2.00	2.67	2.33
		(2.08)*	(6.15)*	(4.45)*	(1.56)*	(1.76)*	(1.68)*
T2	**CICRMV-J**	15.33	18.33	20.00	1.33	2.00	2.00
		(3.97)	(4.34)	(4.52)	(1.34)	(1.47)	(1.47)
T3	**CICRMV-A**	4.00	10.33	18.00	3.33	1.33	1.33
		(2.08)	(3.29)	(4.30)	(1.95)	(1.18)	(1.34)
T4	**CICRMV-T**	2.67	28.33	38.67	1.33	1.33	1.33
		(1.76)	(5.33)	(6.25)	(1.34)	(1.29)	(1.29)
T5	**CICRMVBI-W**	8.00	39.00	21.33	1.00	9.00	4.00
		(2.90)	(6.28)	(4.66)	(1.22)	(3.08)	(2.08)
T6	**CICRMVBI-J**	21.33	15.00	20.00	1.33	2.00	2.00
		(4.66)	(3.93)	(4.52)	(1.34)	(1.47)	(1.47)
T7	**CICRMVBI-A**	10.00	8.67	16.67	3.33	10.33	3.67
		(3.23)	(3.02)	(4.13)	(1.95)	(3.29)	(2.00)
T8	**CICRMVBI-T**	8.00	8.67	45.33	2.67	3.00	2.33
		(2.90)	(3.00)	(6.72)	(1.77)	(1.82)	(1.68)
T9	**YST+Sovlent(s) (positive)**	4.00	8.00	19.00	0.67	9.00	6.00
		(2.08)	(2.86)	(4.41)	(1.05)	(3.08)	(2.53)
T10	**YST only (negative)**	4.67	5.67	8.67	1.00	10.00	6.67
		(2.24)	(2.46)	(3.02)	(1.17)	(3.23)	(2.67)
F Test		**S**	**S**	**S**	**S**	**S**	**S**
SEd		**0.330**	**0.37**	**0.33**	**0.17**	**0.4**	**0.38**
CD (P = 0.05)		**0.7**	**0.78**	**0.71**	**0.36**	**0.85**	**0.81**
CV %		**14.68**	**11.15**	**8.84**	**14.3**	**22.99**	**25.94**

*TV are √(x+0.5) transformed values

Table 3 : Efficacy of different microbial volatiles along with YST in attracting sucking pests at 55 DAI (Days after installation) During 2023-24.

Treatment	Treatment no	55 DAI					
		Leaf hopper	Whitefly	Thrips	Aphids	Coccinellids	spiders
T1	CICRMV-W	8.67	36.67	14.00	2.00	1.33	1.33
		(3.00)*	(6.08)*	(3.77)*	(1.56)*	(1.29)*	(1.29)*
T2	CICRMV-J	15.33	15.00	16.00	2.33	1.33	0.33
		(3.97)	(3.90)	(4.05)	(1.68)	(1.18)	(0.88)
T3	CICRMV-A	4.67	11.00	14.00	4.00	2.33	0.33
		(2.21)	(3.38)	(3.79)	(2.11)	(1.64)	(0.88)
T4	CICRMV-T	6.67	16.00	46.00	1.67	2.00	1.00
		(2.64)	(4.04)	(6.80)	(1.46)	(1.56)	(1.17)
T5	CICRMVBI-W	10.00	35.00	15.33	2.33	8.00	12.67
		(3.23)	(5.95)	(3.97)	(1.68)	(2.90)	(3.61)
T6	CICRMVBI-J	18.00	21.67	13.67	2.00	2.00	1.00
		(4.30)	(4.70)	(3.76)	(1.56)	(1.56)	(1.10)
T7	CICRMVBI-A	10.00	17.00	11.00	4.67	10.00	10.33
		(3.21)	(4.18)	(3.38)	(2.24)	(3.23)	(3.29)
T8	CICRMVBI-T	8.00	14.67	42.67	2.33	3.67	0.67
		(2.90)	(3.89)	(6.56)	(1.68)	(2.00)	(1.00)
T9	YST+Sovlent(s) (positive)	6.00	11.00	11.33	1.00	6.67	0.67
		(2.53)	(3.36)	(3.44)	(1.17)	(2.64)	(1.00)
T10	YST only (negative)	2.00	10.00	12.00	1.33	6.00	0.33
		(1.47)	(3.23)	(3.50)	(1.34)	(2.51)	(0.88)
F Test		**S**	**S**	**S**	**S**	**S**	**S**
SEd		**0.39**	**0.36**	**0.36**	**0.24**	**0.39**	**0.31**
CD (P = 0.05)		**0.84**	**0.76**	**0.77**	**0.51**	**0.82**	**0.67**
CV %		**16.55**	**10.41**	**10.45**	**18.01**	**23.27**	**25.78**

*TV are √(x+0.5) transformed values

Table 3 : Efficacy of different microbial volatiles along with YST in attracting sucking pests at 65 DAI (Days after installation) During 2023-24.

Treatment	Treatment no	65 DAI					
		Leaf hopper	Whitefly	Thrips	Aphids	Coccinellids	spiders
T1	CICRMV-W	1.33	2.33	1.00	1.67	1.00	0.00
		(1.34)*	(1.68)*	(1.17)*	(1.46)*	(1.17)*	(0.71)*
T2	CICRMV-J	3.33	1.33	1.00	1.00	0.33	0.33
		(1.95)	(1.34)	(1.22)	(1.17)	(0.88)	(0.88)
T3	CICRMV-A	2.00	1.67	1.33	3.00	0.67	1.00
		(1.56)	(1.46)	(1.34)	(1.86)	(1.05)	(1.17)
T4	CICRMV-T	1.33	2.00	3.00	1.33	1.00	0.67
		(1.34)	(1.56)	(1.86)	(1.34)	(1.17)	(1.00)
T5	CICRMVBI-W	2.33	3.00	1.33	1.33	6.33	1.67
		(1.68)	(1.87)	(1.34)	(1.29)	(2.59)	(1.46)
T6	CICRMVBI-J	3.67	2.00	1.33	1.00	1.00	1.00
		(2.04)	(1.56)	(1.34)	(1.17)	(1.17)	(1.10)
T7	CICRMVBI-A	2.67	0.67	1.67	2.67	5.33	0.33
		(1.77)	(1.05)	(1.46)	(1.77)	(2.41)	(0.88)
T8	CICRMVBI-T	2.33	1.33	3.67	1.33	1.33	0.00
		(1.68)	(1.34)	(2.04)	(1.27)	(1.27)	(0.71)
T9	YST+Sovlent(s) (positive)	0.67	0.67	0.67	0.67	0.67	1.00
		(1.05)	(1.05)	(1.05)	(1.05)	(1.00)	(1.17)
T10	YST only (negative)	1.33	1.00	0.67	1.33	0.33	0.67
		(1.34)	(1.17)	(1.05)	(1.34)	(0.88)	(1.00)
F Test		**S**	**S**	**S**	**S**	**S**	**NS**
SEd		**0.12**	**0.14**	**0.21**	**0.28**	**0.24**	**0.3**
CD (P =0.05)		**0.26**	**0.31**	**0.45**	**0.60**	**0.52**	**0.64**
CV %		**9.70**	**12.87**	**19.09**	**25.66**	**22.45**	**36.79**

*TV are √(x+0.5) transformed values

Table 4 : Efficacy of different microbial volatiles along with YST in attracting sucking pests at 75 DAI and yield in Kg/ha (Days after installation) During 2023-24.

Treatment	Treatment no	75 DAI						Yield kg/ha
		Leaf hopper	Whitefly	Thrips	Aphids	Coccinellids	spiders	
T1	CICRMV-W	2.67	3.67	1.67	1.33	2.67	0.33	923
		(1.77)*	(2.04)*	(1.46)*	(1.34)*	(1.76)*	(0.88)*	
T2	CICRMV-J	6.33	1.67	2.00	1.33	2.00	0.33	**846**
		(2.61)	(1.46)	(1.56)	(1.34)	(1.47)	(0.88)	
T3	CICRMV-A	1.33	1.00	1.33	3.33	1.33	0.00	750
		(1.34)	(1.22)	(1.34)	(1.95)	(1.29)	(0.71)	
T4	CICRMV-T	1.67	2.00	3.67	1.00	1.33	0.67	700
		(1.46)	(1.56)	(2.04)	(1.22)	(1.29)	(1.05)	
T5	CICRMVBI-W	1.00	4.00	1.67	1.33	9.00	1.00	**883**
		(1.22)	(2.11)	(1.46)	(1.34)	(3.08)	(1.17)	
T6	CICRMVBI-J	6.00	2.67	0.67	1.00	2.00	0.33	**808**
		(2.54)	(1.77)	(1.05)	(1.17)	(1.56)	(0.88)	
T7	CICRMVBI-A	1.33	1.67	1.67	3.00	10.33	1.00	776
		(1.34)	(1.46)	(1.44)	(1.86)	(3.29)	(1.17)	
T8	CICRMVBI-T	1.67	2.00	4.67	1.67	2.67	1.00	700
		(1.44)	(1.56)	(2.27)	(1.46)	(1.76)	(1.17)	
T9	YST+Sovlent(s) (positive)	1.00	0.67	1.00	0.67	9.00	0.67	590
		(1.22)	(1.05)	(1.17)	(1.05)	(3.08)	(1.05)	
T10	YST only (negative)	0.67	1.33	1.33	1.33	10.00	1.00	416
		(1.05)	(1.34)	(1.27)	(1.34)	(3.23)	(1.17)	
F Test		**S**	**S**	**S**	**S**	**S**	**S**	**S**
SEd		**0.158**	**0.145**	**0.224**	**0.204**	**0.32**	**0.24**	**97.59**
CD (P =0.05)		**0.33**	**0.30**	**0.47**	**0.43**	**0.67**	**0.52**	**205.03**
CV %		**12.11**	**11.37**	**18.20**	**17.70**	**18.02**	**29.99**	**16.16**

Table 5 : Efficacy of different microbial volatiles along with YST in attracting sucking pests at 45 DAI (Days after installation) During 2024-25.

T.No	Treatment details	45 DAI sucking pests/Trap					
		Leaf hopper/ trap	Whitefly/ trap	Thrips/ trap	Aphids/ trap	Coccinellids/ trap	Spiders/ trap
T1	CICRMV-W	4.33	4.33	4.00	1.33	3.67	1.67
		(2.18)*	(2.20)*	(2.08)*	(1.34)*	(2.02)*	(1.34)*
T2	CICRMV-J	17.33	2.00	4.00	2.33	3.00	3.67
		(3.50)	(1.58)	(2.06)	(1.66)	(1.86)	(1.99)
T3	CICRMV-A	3.00	0.67	4.00	3.33	2.00	1.33
		(1.86)	(1.05)	(2.11)	(1.95)	(1.52)	(1.31)
T4	CICRMV-T	4.33	0.33	13.33	0.33	3.00	1.67
		(2.19)	(0.88)	(3.71)	(0.88)	(1.84)	(1.43)
T5	CICRMVBI-W	5.00	5.67	2.33	1.67	7.67	3.33
		(2.34)	(2.48)	(1.68)	(1.46)	(2.83)	(1.91)
T6	CICRMVBI-J	13.00	0.00	3.67	1.33	3.67	2.33
		(3.66)	(0.71)	(2.00)	(1.27)	(2.02)	(1.61)
T7	CICRMVBI-A	5.67	1.00	3.33	5.33	8.00	4.33
		(2.47)	(1.22)	(1.94)	(2.41)	(2.91)	(2.16)
T8	CICRMVBI-T	5.33	2.00	10.67	1.33	3.33	1.67
		(2.41)	(1.58)	(3.34)	(1.34)	(1.94)	(1.43)
T9	YST+Sovlent(s) (positive)	3.00	0.33	2.00	1.00	9.33	5.67
		(1.84)	(0.88)	(1.58)	(1.17)	(3.13)	(2.44)
T10	YST only (negative)	2.33	0.67	2.00	1.00	12.00	8.00
		(1.68)	(1.05)	(1.52)	(1.22)	(3.52)	(2.88)
F Test		**S**	**S**	**S**	**S**	**S**	**S**
SEd		**0.290**	**0.16**	**0.29**	**0.24**	**0.31**	**0.31**
CD (P = 0.05)		**0.62**	**0.35**	**0.60**	**0.51**	**0.66**	**0.68**
CV %		**13.46**	**15.14**	**16.00**	**20.31**	**16.38**	**21.00**

*TV are $\sqrt{(x+0.5)}$ transformed values

Table 6 : Efficacy of different microbial volatiles along with YST in attracting sucking pests at 65 DAI (Days after installation During 2024-25.

T.No	Treatment details	65 DAI sucking pests/Trap					
		Leaf hopper	Whitefly	Thrips	Aphids	Coccinellids	spiders
T1	CICRMV-W	5.00	10.67	7.33	4.33	1.00	1.33
		(2.32)*	(3.34)*	(2.79)*	(2.18)*	(1.17)*	(1.24)*
T2	CICRMV-J	15.33	4.67	8.33	3.33	2.00	1.00
		(3.95)	(2.26)	(2.94)	(1.93)	(1.47)	(1.18)
T3	CICRMV-A	5.33	3.67	8.00	7.67	2.67	1.00
		(2.40)	(2.03)	(2.89)	(2.85)	(1.76)	(1.12)
T4	CICRMV-T	5.33	5.33	20.33	4.00	2.67	1.33
		(2.39)	(2.39)	(4.56)	(2.06)	(1.72)	(1.31)
T5	CICRMVBI-W	6.67	13.33	10.00	4.67	6.33	10.33
		(2.65)	(3.71)	(3.23)	(2.27)	(2.60)	(3.27)
T6	CICRMVBI-J	19.33	5.00	8.67	3.00	1.33	1.33
		(4.45)	(2.34)	(3.02)	(1.87)	(1.34)	(1.22)
T7	CICRMVBI-A	6.67	5.00	6.67	10.67	11.67	9.67
		(2.65)	(2.30)	(2.67)	(3.34)	(3.48)	(3.16)
T8	CICRMVBI-T	6.67	4.00	20.00	5.00	4.33	1.00
		(2.64)	(2.11)	(4.53)	(2.34)	(2.16)	(1.12)
T9	YST+Sovlent(s) (positive)	2.33	2.33	3.67	2.00	7.33	1.00
		(1.64)	(1.68)	(2.04)	(1.58)	(2.76)	(1.12)
T10	YST only (negative)	1.00	1.67	5.67	1.00	7.00	2.00
		(1.22)	(1.39)	(2.48)	(1.22)	(2.73)	(1.53)
F Test		**S**	**S**	**S**	**S**	**S**	**S**
SEd		**0.3**	**0.27**	**0.23**	**0.2**	**0.306**	**0.32**
CD (P =0.05)		**0.64**	**0.58**	**0.49**	**0.43**	**0.64**	**0.69**
CV %		**12.73**	**14.33**	**9.08**	**11.64**	**17.67**	**24.59**

*TV are √(x+0.5) transformed values

Table 7 : Efficacy of different microbial volatiles along with YST in attracting sucking pests at 75 DAI (Days after installation During 2024-25.

T.No	Treatment details	75 DAI sucking pests/Trap					
		Leaf hopper	Whitefly	Thrips	Aphids	Coccinellids	spiders
T1	CICRMV-W	3.33	10.33	6.00	2.00	2.33	2.67
		(1.95)*	(3.29)*	(2.53)*	(1.58)*	(1.68)*	(1.71)*
T2	CICRMV-J	10.33	2.00	3.67	0.67	2.00	1.67
		(3.28)	(1.56)	(2.02)	(1.05)	(1.52)	(1.43)
T3	CICRMV-A	2.00	0.33	2.33	5.33	1.67	1.00
		(1.56)	(0.88)	(1.68)	(2.41)	(1.44)	(1.12)
T4	CICRMV-T	2.00	6.00	12.00	2.33	1.67	1.67
		(1.56)	(2.55)	(3.53)	(1.68)	(1.46)	(1.40)
T5	CICRMVBI-W	1.67	8.67	4.00	1.67	6.33	2.33
		(1.39)	(3.03)	(2.12)	(1.44)	(2.59)	(1.61)
T6	CICRMVBI-J	7.67	6.33	3.00	2.00	2.33	1.33
		(2.85)	(2.58)	(1.86)	(1.58)	(1.64)	(1.31)
T7	CICRMVBI-A	2.00	4.33	3.00	6.00	3.33	2.00
		(1.58)	(2.18)	(1.86)	(2.51)	(1.90)	(1.53)
T8	CICRMVBI-T	3.00	8.67	9.33	4.67	1.67	1.00
		(1.86)	(3.00)	(3.11)	(2.26)	(1.44)	(1.12)
T9	YST+Sovlent(s) (positive)	2.67	1.33	1.00	2.33	1.33	1.33
		(1.77)	(1.34)	(1.17)	(1.68)	(1.29)	(1.31)
T10	YST only (negative)	1.00	2.33	1.33	3.00	4.00	2.33
		(1.17)	(1.68)	(1.34)	(1.86)	(2.11)	(1.61)
F Test		**S**	**S**	**S**	**S**	**S**	**NS**
SEd		**0.23**	**0.25**	**0.26**	**0.22**	**0.31**	**0.28**
CD (P =0.05)		**0.46**	**0.53**	**0.55**	**0.48**	**0.66**	**NS**
CV %		**13.71**	**14.08**	**15.16**	**15.38**	**22.7**	**24.23**

*TV are√(x+0.5) transformed values

Table 8 : Efficacy of different microbial volatiles along with YST in attracting sucking pests at 45 DAI (Days after installation).

Pooled data 2023-24&24-25							
Tr.No	**Treatment details**	**45 DAI Sucking pests/Trap**					
		Jassids	**whiteflies**	**Thrips**	**Aphids**	**coccinellids**	**Spiders**
T1	**CICRMV-W**	3.33	20.83	11.67	1.67	3.17	2.00
		(1.95)*	(4.62)*	(3.49)*	(1.47)*	(1.90)*	(1.56)*
T2	**CICRMV-J**	12.67	10.17	12.00	1.83	2.50	4.67
		(3.61)	(3.26)	(3.53)	(1.51)	(1.71)	(2.14)
T3	**CICRMV-A**	3.50	5.50	11.00	3.33	1.67	3.83
		(1.98)	(2.44)	(3.39)	(1.96)	(1.37)	(1.91)
T4	**CICRMV-T**	3.83	14.33	26.00	0.83	2.17	4.17
		(2.05)	(3.82)	(5.14)	(1.15)	(1.63)	(2.03)
T5	**CICRMVBI-W**	6.00	22.33	11.83	1.33	8.33	3.67
		(2.53)	(4.78)	(3.51)	(1.35)	(2.96)	(2.04)
T6	**CICRMVBI-J**	17.00	7.50	11.83	1.33	2.83	2.17
		(4.18)	(2.82)	(3.51)	(1.34)	(1.81)	(1.58)
T7	**CICRMVBI-A**	8.33	4.83	10.00	4.33	9.17	4.00
		(2.96)	(2.31)	(3.23)	(2.20)	(3.11)	(2.11)
T8	**CICRMVBI-T**	7.33	5.33	28.00	2.00	3.17	2.00
		(2.79)	(2.40)	(5.31)	(1.58)	(1.89)	(1.58)
T9	**YST+Sovlent(s) (positive)**	3.17	4.17	10.50	0.83	3.17	5.83
		(1.90)	(2.12)	(3.32)	(1.14)	(1.90)	(2.50)
T10	**YST only (negative)**	5.33	3.17	5.33	1.00	10.33	7.33
		(2.40)	(1.90)	(2.40)	(1.21)	(3.17)	(2.79)
F Test		**S**	**S**	**S**	**S**	**S**	**NS**
SEd		**0.396**	**0.266**	**0.234**	**0.138**	**0.273**	**0.448**
CD (P =0 .05)		**0.83**	**0.56**	**0.49**	**0.29**	**0.57**	**0.94**
CV %		**17.88**	**10.69**	**7.79**	**11.33**	**14.64**	**27.14**

Table 9 : Efficacy of different microbial volatiles along with YST in attracting sucking pests at 65 DAI (Days after installation.

Pooled data 2023-24&24-25							
Tr.No	**Treatment details**	**65 DAI Sucking pests and Natural enemies/trap**					
		Jassids	**whiteflies**	**Thrips**	**Aphids**	**coccinellids**	**Spiders**
T1	**CICRMV-W**	3.17	6.33	4.17	3.00	1.00	0.67
		(1.90)*	(2.61)*	(2.16)*	(1.86)*	(1.17)*	(1.05)*
T2	**CICRMV-J**	9.33	3.00	4.67	2.17	1.17	0.67
		(3.12)	(1.86)	(2.26)	(1.61)	(1.22)	(1.07)
T3	**CICRMV-A**	3.67	2.67	4.67	5.33	1.67	1.00
		(2.03)	(1.77)	(2.26)	(2.41)	(1.46)	(1.21)
T4	**CICRMV-T**	3.33	4.00	11.67	2.67	1.83	1.00
		(1.94)	(2.11)	(3.48)	(1.76)	(1.47)	(1.21)
T5	**CICRMVBI-W**	4.50	7.83	5.67	3.00	6.33	6.00
		(2.22)	(2.88)	(2.48)	(1.87)	(2.61)	(2.54)
T6	**CICRMVBI-J**	10.33	3.33	5.00	2.00	1.17	1.17
		(3.28)	(1.95)	(2.34)	(1.58)	(1.27)	(1.19)
T7	**CICRMVBI-A**	4.67	3.00	4.17	6.67	8.50	5.00
		(2.26)	(1.85)	(2.16)	(2.67)	(3.00)	(2.34)
T8	**CICRMVBI-T**	4.50	2.50	11.83	3.17	2.83	0.50
		(2.22)	(1.72)	(3.51)	(1.91)	(1.80)	(0.98)
T9	**YST+Sovlent(s) (positive)**	1.50	1.50	2.17	1.33	4.00	1.00
		(1.39)	(1.41)	(1.63)	(1.35)	(2.08)	(1.17)
T10	**YST only (negative)**	3.17	1.50	3.17	1.17	3.67	1.33
		(1.91)	(1.38)	(1.91)	(1.29)	(2.04)	(1.35)
F Test		**S**	**S**	**S**	**S**	**S**	**NS**
SEd		**0.199**	**0.169**	**0.157**	**0.147**	**0.232**	**0.242**
CD (P = 0.05)		**0.42**	**0.36**	**0.33**	**0.31**	**0.49**	**0.51**
CV %		**10.33**	**10.62**	**7.93**	**9.85**	**15.71**	**21.00**

Table 10 : Efficacy of different microbial volatiles along with YST in attracting sucking pests at 75 DAI (Days after installation.

Pooled data 2023-24&24-25							
Tr.No	**Treatment details**	**75 DAI Sucking pests and Natural enemies/trap**					
		Jassids	**whiteflies**	**Thrips**	**Aphids**	**Coccinellids**	**Spiders**
T1	**CICRMV-W**	3.00	7.00	3.83	1.67	2.50	0.50
		(1.87)*	(2.74)*	(2.07)*	(1.47)*	(1.73)*	(0.98)*
T2	**CICRMV-J**	7.50	1.83	2.83	1.00	2.00	0.83
		(2.83)	(1.51)	(1.80)	(1.21)	(1.58)	(1.15)
T3	**CICRMV-A**	1.67	0.67	1.83	4.33	1.50	0.83
		(1.47)	(1.07)	(1.52)	(2.19)	(1.41)	(1.15)
T4	**CICRMV-T**	1.83	4.00	7.83	1.67	1.50	1.67
		(1.52)	(2.12)	(2.89)	(1.47)	(1.41)	(1.46)
T5	**CICRMVBI-W**	1.33	6.33	2.83	1.50	7.67	1.33
		(1.33)	(2.61)	(1.82)	(1.41)	(2.86)	(1.34)
T6	**CICRMVBI-J**	6.83	4.50	1.83	1.50	2.17	1.33
		(2.71)	(2.22)	(1.51)	(1.41)	(1.61)	(1.33)
T7	**CICRMVBI-A**	1.67	3.00	2.33	4.50	6.83	1.33
		(1.47)	(1.86)	(1.67)	(2.21)	(2.70)	(1.34)
T8	**CICRMVBI-T**	2.33	5.33	7.00	3.17	2.17	1.83
		(1.67)	(2.41)	(2.72)	(1.91)	(1.61)	(1.51)
T9	**YST+Sovlent(s) (positive)**	1.83	1.00	1.00	1.50	5.17	0.83
		(1.53)	(1.21)	(1.22)	(1.41)	(2.37)	(1.14)
T10	**YST only (negative)**	5.50	1.83	1.33	2.17	7.00	0.83
		(2.44)	(1.52)	(1.32)	(1.63)	(2.73)	(1.12)
F Test		**S**	**S**	**S**	**S**	**S**	**NS**
SEd		**0.151**	**0.160**	**0.186**	**0.154**	**0.184**	**0.187**
CD (P = 0.05)		**0.32**	**0.34**	**0.39**	**0.32**	**0.39**	**0.39**
CV %		**9.82**	**10.15**	**12.31**	**11.54**	**11.28**	**18.30**

Discussions

The honeydew is also a source of carbohydrates for various microorganisms, and the volatile organic compounds (mVOCs) produced by microbes digesting honeydew can be used as foraging cues by the natural enemies of the honeydew-producing species (Goelen *et al*., 2021, Leroy *et al*., 2011, Rering *et al*., 2018)

In recent years, many studies have demonstrated that volatile compounds produced by microorganisms can regulate natural enemies, thereby facilitating biological control (Davis *et al*., 2013, Liu *et al*., 2024)

six compounds including 2,4 Dimethylstyrene, Eucalyptol, Linalool and so on exhibited significant repellency against *Apolygus lucorum* . Eucalyptol, a component of essential oil isolated from *Eucalyptus globulus*, *Cinnamomum longepaniculatum*, *Rosmarinus officinalis*, and *Salvia japonica*, has been shown to have repellent activities against *Aedes albopictus* (Huang *et al*., 2010; Cai *et al*., 2021).

Conclusion

The Microbial volatile formulations CICR-BVW, CICR-BVJ, CICR-BVA and CICR-BVT used along with Yellow sticky traps successfully managed the sucking pests and increased natural enemy population in cotton ecosystem . Furthermore, MVOCS usage in cotton also enhanced the field populations of natural enemies (predators and parasitoids) . The developed MVOC formulations are eco-friendly and cost-effective, do not cause any harmful effects on cotton plants, soil nutrient status, soil biology, and can reduce chemical usage, pest resurgence, and environmental pollution apart from enhancing farmers health, farm income and farm sustainability, thus has wider commercial application prospects in agriculture.

Author's contribution: Author Mr. M. Sivarama Krishna, working as a scientist in AICRP-Cotton entomology had conducted this trial for two seasons of 2023 and 2024 at RARS, Nandyal and generated field data for further analysis. Second author helped in statistical analysis of data, third author helped in draft verification fourth author helped in collection of literature for the research article.

Declaration: I do hereby declare that above research article is based of field trial conducted for two seasons at RARS-Nandyala.

Acknowledgements: The authors are thankful to the Associate Director of Research, RARS, Nandyala for providing the experimental land and Dr. Rishi Kumar Principal Investigator, (Entomology) AICRP-Cotton for guiding in conducting the experiment

References

Cai, Z., Peng, J., Chen, Y., Tao, L., Zhang, Y., Fu, L. *et al*. (2021). 1,8-Cineole: a review of source, biological activities, and application. *J. Asian. Nat. Prod. Res.* **23**, 938–954. doi: 10.1080/10286020.2020.1839432

Goelen, T., Vuts, J., Sobhy, I. S., Wäckers, F., Caulfield, J. C., Birkett, M. A., Rediers, H., Jacquemyn, H., & Lieven, B. (2021). Identification and application of bacterial volatiles to attract a generalist aphid parasitoid: From laboratory to greenhouse assays. *Pest Management Science*, ***77***, 930–938. https://doi.org/10.1002/ps.6102

Leroy, P. D., Sabri, A., Heuskin, S., Thonart, P., Lognay, G., Verheggen, F. J., Francis, F., Brostaux, Y., Felton, G. W., & Haubruge, E. (2011). Microorganisms from aphid honeydew attract and enhance the efficacy of natural enemies. *Nature Communications*, ***2***, 348. https://doi.org/10.1038/ncomms1347

Rering, C. C., Beck, J. J., Hall, G. W., McCartney, M. M., & Vannette, R. L. (2018). Nectar-inhabiting microorganisms influence nectar volatile composition and attractiveness to a generalist pollinator. *New Phytologist*, ***220***, 750–759. https://doi.org/10.1111/nph.14809

Huang, C., Xia, L., Yang, X., He, Y., Xia, H., & Huang, H. (2010). Gas chromatography and *Aedes albopictus* repellent activity of eucalyptus oil patch. *Chinese Journal of Hygienic Insecticides and Equipment*, ***27***, 210–212. https://doi.org/10.19821/j.1671-2781.2021.03.005