International Journal of Environmental & Agriculture Research (IJOEAR)
ISSN: [2454-1850]
[Vol-12, Issue-7, July- 2026]
Website: www.ijoear.com
Journal DOI: 10.25125/agriculture-journal

Management of Major Insect Pests of Ash Gourd, *Benincasa hispida* Thunb. with Traps, Biopesticides and Newer Insecticides

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Received:- 01 July 2026/ Revised:- 14 July 2026/ Accepted:- 19 July 2026/ Published: 31-07-2026

***Abstract*—** *Ash gourd, Benincasa hispida Thunb., is an important vegetable crop, cultivated globally for its medicinal values, and its production is hampered by many insect pests. Therefore, field experiments were conducted to study the efficacy of sticky traps, botanicals and organic pesticides, biopesticides, and newer insecticides against major pests of ash gourd in the farmer's holdings at Kaliyavur village of Thoothukudi district, Tamil Nadu, India during Rabi 2018. The results revealed that cylindrical white sticky traps attracted more number of alate forms of Myzus persicae Sulzer, and cylindrical yellow sticky traps attracted more number of adults of Liriomyza trifolii Burgess. Azadirachtin 3000 ppm at 2 mL/L was effective in reducing the insect pests. Beauveria bassiana formulation at 2 g/L was effective against Myzus persicae Sulzer and* Aulacophora foveicollis *Lucas. Diaphania indica Saunders was controlled by the application of Bacillus thuringiensis at 2 g/L. Newer insecticide molecules were very prominent in managing the major insect pests of ash gourd. The findings of the study will be helpful for the effective management of insect pests of ash gourd.*

***Keywords*— Ash gourd, Insect pests, Sticky traps, Biopesticides, Newer molecules, Benincasa hispida, IPM, Botanicals, Myzus persicae, Aulacophora foveicollis, Diaphania indica.**

I. INTRODUCTION

Ash gourd, *Benincasa hispida* Thunb., is one of the most important vegetable crops, being cultivated throughout the humid tropical and subtropical regions. Ash gourd is mainly grown in India, China, Malaysia, Bangladesh, Indonesia, Philippines, Taiwan, and the Caribbean Islands for vegetable and medicinal purposes (Tindall, 1986). Ash gourd fruit constitutes volatile oils, flavonoids, glycosides, proteins, carotenes, vitamins, minerals, and uronic acid. It is a good source of Vitamin B1 (thiamine), Vitamin B3 (niacin), and Vitamin C (ascorbic acid), and is also rich in calcium and potassium.

In India, the production of ash gourd is hampered by many insect pests viz., aphids, *Aphis gossypii* Glover and *Myzus persicae* Sulzer (Aphididae: Hemiptera); whitefly, *Bemisia tabaci* Gennadius (Aleyrodidae: Hemiptera); leafhopper, *Amrasca devastans* Distant (Cicadellidae: Hemiptera); thrips, *Scirtothrips dorsalis* Hood (Thripidae: Thysanoptera); serpentine leaf miner, *Liriomyza trifolii* Burgess (Agromyzidae: Diptera); pumpkin caterpillar, *Diaphania indica* Saunders (Crambidae: Lepidoptera); red pumpkin beetle, *Aulacophora foveicollis* Lucas (Chrysomelidae: Coleoptera); and melon fruit fly, *Bactrocera cucurbitae* Coquillett (Tephritidae: Diptera) (Atwal, 1993; Dhillon et al., 2005; Tamilnayagan et al., 2017a; Tamilnayagan et al., 2017b).

In Tamil Nadu, ash gourd was cultivated in an area of 441 hectares with a production of 8901.28 tonnes and productivity of 20.18 tonnes per hectare during 2016-17 (DES, 2019). Ash gourd growers mainly rely on synthetic chemical pesticides for managing the pests, and indiscriminate usage of chemical insecticides disturbs the ecosystem and leaves harmful pesticide residues which cause health concerns in consumers (Azmi et al., 2006). Hence the present study was undertaken to study the efficacy of sticky traps, botanicals and organic pesticides, biopesticides, and newer insecticides against major pests of ash gourd.

II. MATERIALS AND METHODS

The field experiments were carried out during the Rabi season (November 2018 - February 2019) in the farmer's holdings at Kaliyavur village of Thoothukudi district, Tamil Nadu, India to evaluate the efficacy of sticky traps, botanicals and organic pesticides, biopesticides, and newer insecticides against major pests of ash gourd.

2.1 Evaluation of Sticky Traps

Cylindrical shaped sticky traps of different colours were evaluated against the sucking pests viz., *B. tabaci* and *S. dorsalis*. Cylindrical shaped containers of 45.47 cm^2 dimension were taken and painted with yellow, blue, and white colours each. They were coated with castor oil as a sticking agent and kept in the field (1 foot above the canopy) at a distance of 5 m to avoid trap interactions. Weekly observations were made for trap catches and expressed as number of insects per trap.

2.2 Efficacy of Botanicals and Organic Pesticides, Biopesticides, and Newer Insecticides

The field experiments were laid out in a completely randomized block design (CRBD) with four replications separately for each set of treatments. Ash gourd F1 hybrid MAH 1 was sown on ridges and furrows (2 m × 60 cm) at a spacing of 45 cm between plants. The treatments were imposed when the pests reached the economic threshold level as a foliar spray. Pre-treatment and post-treatment counts on target pests were done on five randomly selected plants per replication. Post-treatment counts were recorded on 3, 7, 10, and 14 days after treatment (DAT). The incidence of insect pests is expressed as number of insects per five plants, and leaf damage by *L. trifolii* is expressed as per cent leaf damage per five plants.

2.3 Statistical Analysis

The data obtained from the field experiments were analyzed using SPSS (Statistical Package for Social Sciences) software Version 21. The data in numbers were subjected to square root transformation, and the data in percentage were subjected to arcsine transformation (Gomez and Gomez, 1984). Least significant difference (LSD) at $p < 0.05$ was used to evaluate the difference between treatments.

III. RESULTS

3.1 Evaluation of sticky traps

The trap catches of alate forms of *M. persicae* were recorded from 2 WAS (weeks after sowing) to 8 WAS. The trap catches were highest in white sticky traps as compared to blue and yellow sticky traps. The trap catches of *L. trifolii* adults were recorded from 2 WAS to 6 WAS, and yellow sticky traps recorded the highest catches as compared to blue and white sticky traps (Table 1).

TABLE 1
EFFICACY OF CYLINDRICAL STICKY TRAPS AGAINST MAJOR PESTS OF ASH GOURD

Treatments/ Weeks of observation	Number of insects/trap*					
	T1 - Yellow sticky trap		T2 - Blue sticky trap		T3 - White sticky trap	
	L. trifolii	*M. persicae*	*L. trifolii*	*M. persicae*	*L. trifolii*	*M. persicae*
2 WAS	2.5	0	2.3	1	1.9	1.2
3 WAS	3.1	1.9	2.9	2.2	2.5	3.5
4 WAS	2.4	5.1	1.8	6.5	1.6	6.7
5 WAS	2.2	5.9	1	7	0.8	7.2
6 WAS	1.2	3.7	0.6	4.5	0.2	4.7
7 WAS	0	2.1	0	3.4	0	4
8 WAS	0	1.2	0	1.9	0	2

***WAS = Weeks After Sowing;* Mean of seven replications**

3.2 Efficacy of Botanicals and Organic Pesticides

3.2.1 Aphid, *M. persicae*

The results of the field experiment conducted at farmer's holdings at Kaliyavur village of Thoothukudi district during Rabi 2018 revealed that among the five botanical and organic pesticides evaluated, Azadirachtin 3000 ppm at 2 mL/L was significantly effective against *M. persicae*, which reduced the population from 30.25 aphids per five plants before treatment to

0.25 per five plants at 14 days after treatment (DAT), followed by Neem Seed Kernel Extract at 5%. Fish ensilage oil at 10 mL/L recorded 1.50 aphids per five plants at 14 DAT (Table 2).

3.2.2 Serpentine Leaf Miner, *L. trifolii*

The per cent leaf damage caused by *L. trifolii* was lowest in the plots applied with Azadirachtin 3000 ppm at 2 mL/L. All other botanicals and organic insecticides also recorded reduction in leaf damage due to *L. trifolii* when compared to the untreated check (Table 2).

3.2.3 Red Pumpkin Beetle, *A. foveicollis*

Among the five botanical and organic pesticides, Azadirachtin 3000 ppm at 2 mL/L was effective against *A. foveicollis*, which reduced the population of beetles from 3.00 beetles per five plants before treatment to 1.75, 1.00, 0.25, and 0.00 beetles per five plants at 3, 7, 10, and 14 DAT, and was on par with Neem Seed Kernel Extract at 5% (Table 3).

3.2.4 Pumpkin Caterpillar, *D. indica*

The results showed that Azadirachtin 3000 ppm at 2 mL/L was effective against *D. indica* by reducing the population from 3.25 larvae per five plants before treatment to 2.00, 1.25, 0.25, and 0.00 larvae per five plants at 3, 7, 10, and 14 DAT, respectively, followed by Neem Seed Kernel Extract at 5% (Table 3).

3.2.5 Yield

The highest fruit yield was recorded in the plots treated with Azadirachtin 3000 ppm at 2 mL/L (37.48 t/ha), followed by Neem Seed Kernel Extract at 5% (37.17 t/ha) and Agni asthiram at 30 mL/L (36.92 t/ha) (Table 3).

TABLE 2
EFFICACY OF BOTANICALS AND ORGANIC PESTICIDES AGAINST *M. PERSICAE* AND *L. TRIFOLII* ON ASH GOURD DURING RABI 2018

S. No.	Treatments	Number of aphids/5 plants*					Per cent leaf damage by *L. trifolii*/5 plants#				
		PTC	3 DAT	7 DAT	10 DAT	14 DAT	PTC	3 DAT	7 DAT	10 DAT	14 DAT
T1	Agni asthiram @ 30 mL/L	30.00 (5.52)	10.50 (3.31)[a]	5.50 (2.44)[ab]	1.75 (1.44)[a]	0.75 (1.10)[ab]	12.78 (20.93)	3.99 (11.49)[ab]	3.89 (11.31)[b]	2.62 (9.22)[b]	1.38 (6.73)[b]
T2	Fish ensilage oil @ 10 mL/L	31.00 (5.61)	11.75 (3.50) [a]	6.75 (2.68)[b]	2.50 (1.72) [a]	1.50 (1.40)[b]	12.41 (20.60)	4.95 (12.84)[c]	4.51 (12.22)[b]	3.08 (9.98)[b]	1.87 (7.79)[b]
T3	Neem oil @ 20 mL/L	34.25 (5.89)	10.75 (3.34) [a]	5.75 (2.49) [ab]	2.00 (1.56) [a]	1.00 (1.18)[ab]	12.95 (21.07)	4.16 (11.74)[b]	3.95 (11.38)[b]	2.89 (9.75)[b]	1.45 (6.87)[b]
T4	Neem Seed Kernel Extract @ 5%	31.50 (5.65)	10.00 (3.23) [a]	5.25 (2.40) [ab]	1.75 (1.49) [a]	0.50 (0.97)[ab]	12.08 (20.31)	3.86 (11.33)[ab]	3.77 (11.14)[b]	2.40 (8.87)[ab]	1.28 (6.47)[b]
T5	Azadirachtin 3000 ppm @ 2 mL/L	30.25 (5.53)	9.50 (3.16) [a]	5.00 (2.34)[a]	1.50 (1.40) [a]	0.25 (0.84)[a]	12.50 (20.69)	3.32 (10.49)[a]	2.12 (8.33)[a]	1.49 (6.99)[a]	0.13 (1.01)[a]
T6	Untreated check	31.50 (5.65)	32.50 (5.74)[b]	33.50 (5.83)[c]	34.25 (5.89)b	35.00 (5.96)[c]	12.81 (20.96)	13.13 (21.23)[d]	13.23 (21.31)[c]	13.45 (21.52)[c]	13.82 (21.81)[c]
	CD (p=0.05)	NS	0.35	0.32	0.43	0.45	NS	1	1.46	1.89	1.75

PTC = Pre-treatment count; DAT = Days after treatment
Figures in parentheses are √(x+0.5) transformed values; #Figures in parentheses are arc-sine transformed values
In a column, means followed by common letters are not significantly different by LSD (P=0.05)

TABLE 3
EFFICACY OF BOTANICALS AND ORGANIC PESTICIDES AGAINST A. FOVEICOLLIS AND D. INDICA ON ASH GOURD DURING RABI 2018

S. No.	Treatments	Number of beetles/5 plants*					Number of larvae/5 plants*					Yield (t/ha)
		PTC	3 DAT	7 DAT	10 DAT	14 DAT	PTC	3 DAT	7 DAT	10 DAT	14 DAT	
T1	Agni asthiram @ 30 mL/L	3.25 (1.93)	2.25 (1.65)[ab]	1.25 (1.31)[b]	0.75 (1.10)[b]	0.25 (0.84)[b]	3.25 (1.93)	2.25 (1.65)[ab]	1.75 (1.49)[b]	1.00 (1.18)[b]	0.25 (0.84)[b]	36.92[ab]
T2	Fish ensilage oil @ 10 mL/L	3.00 (1.87)	2.50 (1.73)[b]	2.00 (1.58)[c]	1.25 (1.27)[b]	0.75 (1.10)[b]	3.25 (1.93)	2.75 (1.80)[ab]	2.00 (1.58)[b]	1.50 (1.40)[b]	0.75 (1.10)[a]	35.11[b]
T3	Neem oil @ 20 mL/L	3.25 (1.92)	2.25 (1.65)[b]	1.75 (1.49)[b]	1.00 (1.22)[b]	0.50 (0.97)[b]	3.75 (2.06)	2.50 (1.73)[b]	1.75 (1.49)[b]	1.25 (1.31)[b]	0.25 (0.84)[b]	36.56[ab]
T4	Neem Seed Kernel Extract @ 5%	3.75 (2.06)	2.00 (1.58)[ab]	1.25 (1.31)[ab]	0.50 (0.97)[ab]	0.00 (0.71)[a]	3.50 (2.00)	2.25 (1.65)[a]	1.50 (1.40)[ab]	0.75 (1.10)[ab]	0.00 (0.71)[a]	37.17[a]
T5	Azadirachtin 3000 ppm @ 2 mL/L	3.00 (1.86)	1.75 (1.49)[a]	1.00 (1.22)[a]	0.25 (0.84)[a]	0.00 (0.71)[a]	3.25 (1.93)	2.00 (1.58)[a]	1.25 (1.31)[a]	0.25 (0.84)[a]	0.00 (0.71)[a]	37.48[a]
T6	Untreated check	3.00 (1.86)	3.25 (1.93)[c]	3.50 (2.00)[d]	3.50 (2.00)[c]	3.75 (2.06)[c]	3.50 (2.00)	3.50 (2.00)[b]	3.75 (2.06)[c]	4.00 (2.11)[c]	3.75 (2.06)[b]	23.25[c]
	CD (p=0.05)	NS	0.19	0.21	0.33	0.31	NS	0.22	0.26	0.38	0.39	2.01

PTC = Pre-treatment count; DAT = Days after treatment
Figures in parentheses are √(x+0.5) transformed values
In a column, means followed by common letters are not significantly different by LSD (P=0.05)

3.3 Efficacy of Biopesticides

3.3.1 Aphid, *M. persicae*

The results of the field experiment conducted at farmer's holdings at Kaliyavur village of Thoothukudi district during Rabi 2018 are presented in Table 4. Among the four biopesticides evaluated, *Beauveria bassiana* at 2 g/L was effective against *M. persicae*, which reduced the population before treatment (31.50 aphids per five plants) to 23.50, 12.00, 8.25, and 4.50 aphids per five plants at 3, 7, 10, and 14 DAT, respectively. *Lecanicillium lecanii* at 2 g/L reduced the aphid population from 31.50 aphids per five plants (before treatment) to 24.25, 12.75, 9.25, and 5.25 aphids per five plants at 3, 7, 10, and 14 DAT, respectively.

3.3.2 Serpentine leaf miner, *L. trifolii*

The per cent leaf damage due to infestation of *L. trifolii* was lowest in the plots treated with *Metarhizium anisopliae* at 2 g/L (11.96 per cent leaf damage per five plants before treatment and 1.87 per cent leaf damage per five plants at 14 DAT), followed by *B. bassiana* at 2 g/L (12.85 per cent leaf damage per five plants before treatment and 2.36 per cent leaf damage per five plants at 14 DAT) (Table 4).

3.3.3 Red Pumpkin beetle, *A. foveicollis*

The results of the experiment revealed that all the biopesticides significantly reduced the population of *A. foveicollis* in comparison with the untreated check. *B. bassiana* at 2 g/L was most effective against *A. foveicollis*, which reduced the population from 3.25 beetles per five plants (before treatment) to 1.00 beetles per five plants at 14 DAT and was on par with other biopesticides (Table 5).

3.3.4 Pumpkin caterpillar, *D. indica*

Among the biopesticides evaluated, *Bacillus thuringiensis* at 2 g/L applied plots recorded the lowest population of *D. indica*. The larval population was 0.50 per five plants at 3 days after treatment, and no larvae were recorded at 10 days after *B. thuringiensis* application (Table 5).

3.3.5 Yield

The highest yield was recorded in the plots applied with *B. bassiana* at 2 g/L (33.65 t/ha), followed by *M. anisopliae* at 2 g/L (32.55 t/ha). *L. lecanii* at 2 g/L (31.16 t/ha) and *B. thuringiensis* at 2 g/L (31.11 t/ha) also recorded the highest yield compared to untreated check (23.05 t/ha) and were on par with each other (Table 5).

TABLE 4
EFFICACY OF BIOPESTICIDES AGAINST *M. PERSICAE* AND *L. TRIFOLII* ON ASH GOURD DURING RABI 2018

S. No.	Treatments	Number of aphids/5 plants*					Per cent leaf damage by *L. trifolii*/5 plants#				
		PTC	3 DAT	7 DAT	10 DAT	14 DAT	PTC	3 DAT	7 DAT	10 DAT	14 DAT
T1	*Beauveria bassiana* @ 1×10⁸ CFU/g @ 2 g/L	31.50 (5.65)	23.50 (4.90)a	12.00 (3.53)a	8.25 (2.96)a	4.50 (2.22)a	12.85 (20.97)	5.30 (13.30)a	3.38 (10.58)a	2.84 (9.64)ab	2.36 (8.76)ab
T2	*Metarhizium anisopliae* @ 1×10⁸ CFU/g @ 2 g/L	32.00 (5.70)	25.00 (5.05)a	13.50 (3.74)ab	10.25 (3.27)bc	5.75 (2.49)ab	11.96 (20.19)	5.03 (12.96)a	3.06 (10.07)a	2.21 (8.54)a	1.87 (7.82)a
T3	*Lecanicillium lecanii* @ 1×10⁸ CFU/g @ 2 g/L	31.50 (5.65)	24.25 (4.97)a	12.75 (3.64)a	9.25 (3.12)ab	5.25 (2.39)ab	12.19 (20.41)	5.55 (13.63)ab	3.45 (10.69)a	3.22 (10.31)bc	2.52 (9.08)ab
T4	*Bacillus thuringiensis* @ 0.5% WP @ 2 g/L	34.75 (5.94)	25.75 (5.12)a	14.75 (3.90)b	11.75 (3.50)c	6.50 (2.64)b	12.89 (21.03)	6.01 (14.19)b	4.04 (11.60)b	3.87 (11.33)c	3.15 (10.19)b
T5	Untreated check	31.75 (5.66)	32.50 (5.74)b	33.25 (5.81)c	34.00 (5.87)d	35.50 (6.00)c	12.18 (20.41)	12.57 (20.75)c	12.92 (21.04)c	13.02 (21.14)d	13.03 (21.16)c
	CD (p=0.05)	NS	0.29	0.37	0.41	0.4	NS	1.29	1.9	2.32	2.06

PTC = Pre-treatment count; DAT = Days after treatment; WP = Wettable powder
Figures in parentheses are √(x+0.5) transformed values; #Figures in parentheses are arc-sine transformed values
In a column, means followed by common letters are not significantly different by LSD (P=0.05)

TABLE 5
EFFICACY OF BIOPESTICIDES AGAINST A. FOVEICOLLIS AND D. INDICA ON ASH GOURD DURING RABI 2018

S. No.	Treatments	Number of beetles/5 plants*					Number of larvae/5 plants*					Yield (t/ha)
		PTC	3 DAT	7 DAT	10 DAT	14 DAT	PTC	3 DAT	7 DAT	10 DAT	14 DAT	
T1	*Beauveria bassiana* @ 1×10⁸ CFU/g @ 2 g/L	3.25 (1.93)	2.00 (1.56)a	1.75 (1.49)a	1.25 (1.31)a	1.00 (1.22)a	3.25 (1.92)	2.75 (1.80)b	1.25 (1.31)b	0.50 (0.97)b	0.25 (0.84)ab	33.65a
T2	*Metarhizium anisopliae* @ 1×10⁸ CFU/g @ 2 g/L	3.50 (2.00)	2.25 (1.65)a	2.00 (1.58)a	1.50 (1.40)a	1.25 (1.31)a	3.50 (2.00)	3.00 (1.86)b	1.75 (1.49)bc	1.25 (1.31)b	0.75 (1.10)b	32.55a
T3	*Lecanicillium lecanii* @ 1×10⁸ CFU/g @ 2 g/L	3.25 (1.92)	2.25 (1.65)a	2.00 (1.58)a	1.75 (1.49)a	1.50 (1.40)a	3.50 (1.99)	2.75 (1.80)b	2.50 (1.73)cd	1.50 (1.40)b	0.75 (1.10)b	31.16a
T4	*Bacillus thuringiensis* @ 0.5% WP @ 2 g/L	3.50 (1.99)	2.50 (1.71)a	2.25 (1.65)a	1.75 (1.49)a	1.50 (1.40)a	3.75 (2.06)	0.50 (0.97)a	0.25 (0.84)a	0.00 (0.71)a	0.00 (0.71)a	31.11a
T5	Untreated check	3.50 (2.00)	3.75 (2.06)b	3.75 (2.06)b	3.50 (2.00)b	3.50 (2.00)b	3.25 (1.93)	3.50 (2.00)b	3.50 (2.00)d	3.75 (2.06)c	3.75 (2.06)c	23.05b
	CD (p=0.05)	NS	0.29	0.28	0.31	0.31	NS	0.28	0.23	0.34	0.32	3.93

PTC = Pre-treatment count; DAT = Days after treatment; WP = Wettable powder
Figures in parentheses are √(x+0.5) transformed values
In a column, means followed by common letters are not significantly different by LSD (P=0.05)

3.4 Efficacy of newer insecticides against major sucking pests

The results of the field experiment conducted during Rabi 2018 revealed that all the newer insecticides significantly reduced the population of *M. persicae*. The plots treated with Imidacloprid 17.8 SL (soluble liquid) at 0.2 mL/L recorded nil population of *M. persicae* from 3 DAT onwards till harvest, followed by Thiamethoxam 25 WG (water-dispersible granules) at 0.2 g/L, which recorded 0.25 aphids per five plants at 3 DAS and the population was nil after 7 DAT (Table 6). The plots treated with Imidacloprid 17.8 SL at 0.2 mL/L recorded the highest yield (37.25 t/ha), followed by Thiamethoxam 25 WG at 0.2 g/L (37.12 t/ha) and Acetamiprid 20 SP (soluble powder) at 0.2 g/L (36.82 t/ha) (Table 6).

TABLE 6
EFFICACY OF NEWER INSECTICIDES AGAINST APHID, *M. PERSICAE* ON ASH GOURD DURING RABI 2018

S. No.	Treatments	Number of aphids/5 plants*					Yield (t/ha)
		PTC	3 DAT	7 DAT	10 DAT	14 DAT	
T1	Imidacloprid 17.8 SL @ 0.2 mL/L	30.75 (5.59)	0.00 (0.71)[a]	0.00 (0.71)[a]	0.00 (0.71)[a]	0.00 (0.71)[a]	37.25[a]
T2	Thiamethoxam 25 WG @ 0.2 g/L	31.50 (5.65)	0.25 (0.84)[ab]	0.00 (0.71)[a]	0.00 (0.71)[a]	0.00 (0.71)[a]	37.12[a]
T3	Acetamiprid 20 SP @ 0.2 g/L	31.25 (5.63)	0.75 (1.10)[bc]	0.00 (0.71)[a]	0.00 (0.71)[a]	0.00 (0.71)[a]	36.82[a]
T4	Thiacloprid 240 SC @ 0.6 mL/L	33.50 (5.83)	1.00 (1.22)[cd]	0.00 (0.71)[a]	0.00 (0.71)[a]	0.00 (0.71)[a]	36.78[a]
T5	Dimethoate 30 EC @ 1.5 mL/L	32.25 (5.70)	1.50 (1.40)[d]	1.25 (1.31)[b]	1.00 (1.22)[b]	0.25 (0.84)[a]	36.11[a]
T6	Untreated check	33.50 (5.82)	34.00 (5.87)[e]	36.50 (6.08)[c]	37.75 (6.18)[c]	39.00 (6.28)[b]	21.98[b]
	CD (p=0.05)	NS	0.32	0.34	0.3	0.29	1.95

PTC = Pre-treatment count; DAT = Days after treatment; SL = Soluble liquid; WG = Water-dispersible granules; SP = Soluble powder; SC = Suspension concentrate; EC = Emulsifiable concentrate
Mean of four replications; Figures in parentheses are √(x+0.5) transformed values
In a column, means followed by common letters are not significantly different by LSD (P=0.05)

3.5 Efficacy of newer insecticides against major defoliators and borers

3.5.1 Red Pumpkin beetle, *A. foveicollis*

The results of the field experiment conducted at farmer's holdings at Kaliyavur village of Thoothukudi district during Rabi 2018 revealed that all the insecticides applied had significantly reduced the population of *A. foveicollis* in comparison with the untreated check. Spinosad 45 SC (suspension concentrate) at 0.5 mL/L, Flubendiamide 480 SC at 0.1 mL/L, and Chlorantraniliprole 18.5 SC at 0.3 mL/L were most effective against *A. foveicollis* and recorded nil population from 3 DAT till harvest, and they were on par with Emamectin benzoate 5 SG at 0.4 g/L and Chlorpyriphos 20 EC at 2 mL/L (Table 7).

3.5.2 Pumpkin caterpillar, *D. indica*

The plots treated with Flubendiamide 480 SC at 0.1 mL/L and Chlorantraniliprole 18.5 SC at 0.3 mL/L recorded cent per cent control of *D. indica* from 3 DAT till harvest. Emamectin benzoate 5 SG at 0.4 g/L and Spinosad 45 SC at 0.5 mL/L were also effective and recorded nil population from 7 DAT till harvest (Table 7).

3.5.3 Yield

All the newer insecticides significantly recorded the highest fruit yield compared to untreated check. Chlorantraniliprole 18.5 SC at 0.3 mL/L treated plots recorded the highest yield of 37.65 t/ha, followed by Flubendiamide 480 SC at 0.1 mL/L (37.55 t/ha) and Spinosad 45 SC at 0.5 mL/L (37.51 t/ha) (Table 7).

TABLE 7
EFFICACY OF NEWER INSECTICIDES AGAINST *A. FOVEICOLLIS* AND *D. INDICA* ON ASH GOURD DURING RABI 2018

S. No.	Treatments	Number of beetles/5 plants*					Number of larvae/5 plants*					Yield (t/ha)
		PTC	3 DAT	7 DAT	10 DAT	14 DAT	PTC	3 DAT	7 DAT	10 DAT	14 DAT	
T1	Spinosad 45 SC @ 0.5 mL/L	3.00 (1.87)	0.00 (0.71)[a]	0.00 (0.71)[a]	0.00 (0.71)[a]	0.00 (0.71)[a]	3.00 (1.86)	0.25 (0.84)[a]	0.00 (0.71)[a]	0.00 (0.71)[a]	0.00 (0.71)[a]	37.51[a]
T2	Flubendiamide 480 SC @ 0.1 mL/L	3.25 (1.93)	0.00 (0.71)[a]	0.00 (0.71)[a]	0.00 (0.71)[a]	0.00 (0.71)[a]	3.25 (1.93)	0.00 (0.71)[a]	0.00 (0.71)[a]	0.00 (0.71)[a]	0.00 (0.71)[a]	37.55[a]
T3	Chlorantraniliprole 18.5 SC @ 0.3 mL/L	3.25 (1.92)	0.00 (0.71)[a]	0.00 (0.71)[a]	0.00 (0.71)[a]	0.00 (0.71)[a]	3.00 (1.86)	0.00 (0.71)[a]	0.00 (0.71)[a]	0.00 (0.71)[a]	0.00 (0.71)[a]	37.65[a]
T4	Emamectin benzoate 5 SG @ 0.4 g/L	3.25 (1.92)	0.25 (0.84)[a]	0.00 (0.71)[a]	0.00 (0.71)[a]	0.00 (0.71)[a]	3.50 (2.00)	0.25 (0.84)[a]	0.00 (0.71)[a]	0.00 (0.71)[a]	0.00 (0.71)[a]	37.35[a]
T5	Chlorpyriphos 20 EC @ 2 mL/L	2.75 (1.80)	0.25 (0.84)[a]	0.00 (0.71)[a]	0.00 (0.71)[a]	0.00 (0.71)[a]	3.25 (1.92)	0.50 (0.97)[a]	0.25 (0.84)[a]	0.00 (0.71)[a]	0.00 (0.71)[a]	37.11[a]
T6	Untreated check	3.00 (1.87)	3.25 (1.93)[b]	3.50 (2.00)[b]	3.75 (2.06)[b]	3.75 (2.06)[b]	3.00 (1.86)	3.25 (1.93)[b]	3.50 (2.00)[b]	3.50 (2.00)[b]	3.75 (2.06)[b]	22.75[b]
	CD (p=0.05)	NS	0.24	0.29	0.3	0.27	NS	0.3	0.39	0.35	0.26	2.06

PTC = Pre-treatment count; DAT = Days after treatment; SC = Suspension concentrate; SG = Soluble granule; EC = Emulsifiable concentrate

Mean of four replications; Figures in parentheses are √(x+0.5) transformed values

In a column, means followed by common letters are not significantly different by LSD (P=0.05)

IV. DISCUSSION

4.1 Evaluation of Sticky Traps

In the present investigation, cylindrical yellow sticky traps recorded the highest catches of *L. trifolii* adults, whereas white cylindrical sticky traps attracted the highest number of alate forms of *M. persicae*. The present findings are in confirmatory with Arida et al. (2013), who reported that yellow sticky traps are more attractive to *L. trifolii* adults than blue, purple, or white traps in onion. Sticky traps are efficient in attracting winged forms of aphids, which is in confirmation with earlier findings of Elango et al. (2017), Jasrotia et al. (2022), and Grupe et al. (2023).

4.2 Efficacy of Botanicals and Organic Pesticides

Among the botanical and organic pesticides tested against major pests of ash gourd, Azadirachtin 3000 ppm at 2 mL/L was most effective against pests viz., *M. persicae*, *L. trifolii*, *A. foveicollis*, and *D. indica* in Rabi 2018. This is in line with the findings of Tandon and Sirohi (2009) and Patel et al. (2021), who reported that Azadirachtin was effective in repelling *A. foveicollis*. Christopher et al. (2009) found that the survival of *M. persicae* nymphs was affected by azadirachtin.

4.3 Efficacy of Biopesticides

Biopesticides are good alternatives to synthetic chemical pesticides, and in the present study, *Beauveria bassiana* at 1×10^8 CFU/g at 2 g/L was effective against *M. persicae* and *A. foveicollis*. Khan et al. (2012) stated that *L. lecanii* and *B. bassiana* strains were effective against *M. persicae*. Earlier, Joseph and Sudharma (2016) and Gahlot et al. (2024) reported that *B. bassiana* was highly effective in bringing mortality of *A. foveicollis*. *Metarhizium anisopliae* at 1×10^8 CFU/g at 2 g/L was effective against *L. trifolii* on ash gourd. El-Salam et al. (2013) also reported that *M. anisopliae* was effective against *L. trifolii* on fababean. *Bacillus thuringiensis* at 0.5% WP at 2 g/L recorded the lowest population of pumpkin caterpillar, *D. indica*, which is confirmatory with Jacob et al. (2019). Soumya et al. (2017) also reported that *B. thuringiensis* was very effective against *D. indica*.

4.4 Efficacy of Newer Insecticides

Newer insecticide molecules with novel modes of action at lower rates than the conventional insecticides are being used against different insect pests in various crops. These chemicals are relatively safer to the non-target organisms and leave no harmful residues in the environment. Keeping this in mind, newer insecticide molecules were evaluated against the major sucking pests and defoliators of ash gourd. In the present course of study, Imidacloprid 17.8 SL at 0.2 mL/L, followed by Thiamethoxam 25 WG at 0.2 g/L and Acetamiprid 20 SP at 0.2 g/L, significantly reduced the population of *M. persicae* on ash gourd and recorded higher yield over the untreated check. Similar kinds of results were obtained by various scientific workers on different crops (Christopher et al., 2009; Halder et al., 2011; El-Sayed, 2013; Gavkare et al., 2013; Sretenovic et al., 2019), which shows the effectiveness of newer insecticides.

Similarly, Spinosad 45 SC at 0.5 mL/L, Flubendiamide 480 SC at 0.1 mL/L, and Chlorantraniliprole 18.5 SC at 0.3 mL/L were most effective against *A. foveicollis* and *D. indica*. The reduction of *D. indica* population might be due to the translaminar action of the newer molecules, and these results are in accordance with the findings of Nagaraju et al. (2018), who reported that chlorantraniliprole 18.5 SC at 0.2 mL/L followed by flubendiamide 48 SC at 0.15 mL/L were effective against *D. indica*.

V. CONCLUSION

The study tested the efficacy of sticky traps, botanicals and organic pesticides, biopesticides, and newer insecticides against major pests of ash gourd in field conditions. The findings of the study will be helpful in developing Biointensive Pest Management (BIPM) modules for the effective management of insect pests of ash gourd.

Key Recommendations:

1) **Sticky Traps:** White sticky traps for monitoring *M. persicae* (alate forms) and yellow sticky traps for monitoring *L. trifolii* can be effectively used in IPM programmes.
2) **Botanicals:** Azadirachtin 3000 ppm at 2 mL/L was the most effective botanical, followed by Neem Seed Kernel Extract at 5%, for managing multiple pests and recording the highest yield (37.48 t/ha).
3) **Biopesticides:** *Beauveria bassiana* at 2 g/L was effective against *M. persicae* and *A. foveicollis*; *Metarhizium anisopliae* at 2 g/L against *L. trifolii*; and *Bacillus thuringiensis* at 2 g/L against *D. indica*. These can be integrated into organic pest management programmes.
4) **Newer Insecticides:** Imidacloprid 17.8 SL at 0.2 mL/L for sucking pests, and Spinosad 45 SC at 0.5 mL/L, Flubendiamide 480 SC at 0.1 mL/L, and Chlorantraniliprole 18.5 SC at 0.3 mL/L for defoliators and borers, were highly effective and should be recommended to farmers for effective pest management with minimal environmental impact.
5) **Future Research:** Long-term studies on the impact of these treatments on natural enemies, and their integration into a comprehensive IPM package, are recommended.

ACKNOWLEDGEMENT

The authors thank the farmers of Kaliyavur village, Thoothukudi district, Tamil Nadu, for providing their fields for conducting the experiments. The authors also acknowledge the support of Tamil Nadu Agricultural University for providing the necessary facilities.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this manuscript. The authors alone are responsible for the content and writing of this article.

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