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Integrated Control of Fruit Flies (*Bactrocera* spp.) in Mango and Cucumber Cultivations Utilizing Para-pheromone Traps and Innovative Insecticide Compounds

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ABSTRACT

Fruit flies (Bactrocera spp.) are a significant nuisance for fruit and vegetable cultivation, leading to considerable economic damage in tropical and subtropical areas. The insect is difficult to manage irrespective of the crop type and almost all the regions. Sometime farmers use the combination of ME and Cue lure to manage the fruit fly assuming that it will be more effective as compared to single lure. Therefore, this research examined the comparative effectiveness of para-pheromone traps using methyl eugenol (ME), cue-lure (CL), and their mixture, together with new insecticides, for the comprehensive management of fruit flies in mango and cucumber fields. Field experiments were performed across two seasons in Himachal Pradesh, India. ME traps effectively lured B. dorsalis and B. zonata in mango orchards, whereas CL traps were more efficient against B. cucurbitae and B. tau in cucumber fields. Mixed-lure traps showed variable effectiveness, probably because of lure interference along with the insecticides evaluated. Insecticides, Lambda-cyhalothrin (0.004%) and Spinosad (0.004%) significantly decreased fruit infestation and enhanced yield, surpassing traditional treatments using Malathion. Economic analysis demonstrated greater benefit-cost ratios for Lambda-cyhalothrin and Spinosad, indicating their effectiveness for integrated pest management (IPM). The results highlight the results of combining species-specific lures with modern insecticides to replace the traditional insecticides for the sustainable and economical management of fruit flies. Subsequent studies ought to investigate mass trapping methods, improved lure durability, and the incorporation of biocontrol agents for comprehensive management.

Keywords: *Bactrocera zonata, Bactrocera cucurbitae methyl eugenol, cue-lure, Spinosad, Lambda-cyhalothrin, mango, cucumber, integrated pest management, fruit fly traps, sustainable agriculture.*

1. Introduction

Fruit flies (Tephritidae) rank among the most destructive horticultural pests globally, particularly in tropical and subtropical regions. With over 4,500 documented species –[1]. These insects are notorious for their polyphagous feeding habits, rapid dispersal, and cryptic life stages, which complicate control efforts. The genus *Bactrocera*, comprising more than 400 species, dominates the Asia-Pacific and Australian regions [2], with India alone hosting 243 species [3]. Key pests such as *B. dorsalis, B. zonata, B. cucurbitae,* and *B. tau* inflict severe direct damage on fruit and vegetable crops while also posing significant quarantine risks [4]. Their concealed larval and pupal stages, coupled with high adult mobility, undermine conventional insecticide-based management, particularly during monsoons when residues are easily washed away [5].

In Himachal Pradesh, India, a region with diverse agro-climatic zones, fruit fly infestations have escalated, causing substantial economic losses. *B. cucurbitae* and *B. tau* devastate cucurbits (e.g., cucumber, bitter gourd, and sponge gourd), with yield losses reaching 80–100% in severe cases [6,7]. Similarly, *B. dorsalis* and *B. zonata* infest mango, guava, and peach orchards, damaging over 50% of the produce in some areas [8]. Their peak activity during monsoons coincides with heightened challenges in chemical control, raising concerns over food safety and environmental contamination. Notably, the WHO and UNEP estimate ~3 million annual pesticide poisoning cases, including 200,000 fatalities, predominantly in developing nations [9], underscoring the urgency for sustainable alternatives.

Para-pheromone-based trapping, using male attractants such as methyl eugenol (ME) and cue-lure (CL), offers a species-specific management tool. ME effectively targets *B. dorsalis* and *B. zonata*, while CL attracts *B. cucurbitae* and *B. tau*(10,11). However, mixed-lure systems often exhibit reduced efficacy due to competitive inhibition [12,13], necessitating optimized strategies.

This study aimed to develop an integrated pest management (IPM) approach for *Bactrocera* spp. in mango and cucumber crops of Himachal Pradesh by: Assessing lure efficacy, evaluating ME, CL, and their combined use in population monitoring; Testing novel insecticides, determining the bioefficacy of reduced-risk compounds (Spinosad, Lambda-cyhalothrin) compared to conventional options; and conducting economic analysis, calculating benefit-cost ratios to validate

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feasibility. By integrating species-specific attractants with eco-friendly insecticides, this research seeks to establish a sustainable, cost-effective IPM framework that minimizes crop losses while addressing food safety and ecological concerns.

2. Materials and Methods

2.1 Study Area and Experimental Design

The study was conducted at two distinct locations in Himachal Pradesh, India, namely, the experimental farm of the Department of Entomology, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni (30.8590°N, 77.1734°E, elevation 1260 m) and a mango orchard in Rewalsar, District Mandi (31.6322°N, 76.8332°E, elevation 1300 m). These locations lie in the northwestern Himalayan region and are characterized by moderate temperatures and high relative humidity, especially during the monsoon season, conditions that are favorable for fruit fly proliferation [14,15].

Two cropping systems were selected: mango (*Mangifera indica*) for evaluating methyl eugenol (ME)-responsive species such as *Bactrocera dorsalis* and *B. zonata,* and cucumber (*Cucumis sativus*) for cue-lure (CL)-responsive species, including *B. cucurbitae* and *B. tau*. A randomized block design was adopted for trap placement and insecticide application experiments with three replications each. Experimental plots were maintained under standard agronomic practices.

2.2 Attractant-Insecticide Trap Setup

Monitoring of fruit fly populations was achieved using para-pheromone attractant-insecticide traps. Two types of lures, methyl eugenol (ME) and cue-lure (CL) were tested individually and in combination (ME+CL) to assess their relative attractiveness to different *Bactrocera* species. Lures were impregnated on cotton wicks treated with insecticides and placed inside transparent plastic containers fitted with an entry funnel.

For mango orchards, ME-based traps were used primarily, following previous findings indicating the strong attraction of *B. dorsalis* and *B. zonata* to ME [11,16]. For cucumber fields, CL-based traps were deployed to monitor *B. cucurbitae* and *B. tau* [17]. Mixed-lure traps were also evaluated based on studies suggesting possible synergistic or antagonistic interactions [12,13]. Trap catches were recorded weekly, and the trapped specimens were identified morphologically using taxonomic keys by [18].

2.3 Insecticide Evaluation

To evaluate chemical control options, field trials were conducted using newer insecticide molecules with lower mammalian toxicity and environmental persistence. The tested insecticides included: Spinosad (0.004%), Lambda-cyhalothrin (0.004%), deltamethrin (0.0028%), neem-based biopesticides (azadirachtin 0.01%), and conventional organophosphates like malathion (0.05%). Treatments were applied as foliar sprays at 10-day intervals across four application rounds, following protocols as per the recommendations of previous research [19, 20].

Each treatment was applied using knapsack sprayers under calm wind conditions to ensure uniform coverage. Fruit fly infestation was assessed by sampling fruits from each plot and calculating the percentage of infested fruits as well as the number of maggots per fruit. This approach followed methodologies by [19] and –[20].

2.4 Data Collection and Statistical Analysis

Weekly fruit fly counts from traps were compiled to determine seasonal abundance and species distribution. Insecticide efficacy was measured through (i) percentage fruit infestation, (ii) number of maggots per fruit, and (iii) fruit yield (kg/ha). The avoidable loss due to insecticide application was calculated using the formula:

$$\text{Avoidable Loss (\%)} = \left[\frac{(Yield\ in\ treated\ plot - Yield\ in\ untreated\ plot)}{Yield\ in\ treated\ plot}\right] \times 100$$

Economic feasibility was determined by computing the Benefit-Cost Ratio (BCR) for each treatment, factoring in the cost of insecticides, application labor, and market value of increased yield.

All data were subjected to Analysis of Variance (ANOVA), and mean separations were performed using Tukey's HSD at $P \leq 0.05$. Statistical analyses were conducted using R software (v3.6.1) and Microsoft Excel Professional Plus 2021.

3. Results

3.1 Seasonal Abundance and Species Composition of Fruit Flies

Monitoring data from methyl eugenol (ME) and cue-lure (CL) traps indicated distinct seasonal abundance patterns of *Bactrocera* species across both years and crop systems (Figure 1). In mango orchards, ME traps captured predominantly *B. dorsalis* and *B. zonata*, with population peaks observed during the monsoon period (June to August), coinciding with fruit maturation stages. This aligns with previous reports highlighting peak *B. dorsalis* activity during wet seasons [21,22]. In cucumber fields, CL traps attracted *B. cucurbitae, B. tau,* and *B. scutellaris*, with the highest trap catches recorded during July and August. Pooled data from Years 1 & 2 showed that *B. cucurbitae* and *B. tau* comprised over 80% of the total captures in cucurbits, consistent with observations by [15] and [23].

Mixed-lure (ME+CL) traps exhibited complex interactions. In some cases, they captured a broader spectrum of species, but also showed a competitive suppression effect, where capture rates for certain species (notably *B. dorsalis*) were significantly reduced compared to single-lure traps. These findings support earlier studies that noted possible antagonistic effects in mixed-lure traps [13,24].

3.2 Efficacy of Attractant-Insecticide Traps

The attract-and-kill traps showed variable performance depending on lure type and crop system. In mango orchards, ME-based traps consistently recorded higher male fly captures than ME+CL or untreated controls across both years (Figure 2) (Table S1–S7). The exclusive use of ME in mango fields led to a significant reduction in fruit infestation, with average trap catches exceeding 150 flies/trap/week during peak season. In contrast, CL traps in cucumber fields showed higher effectiveness in targeting *B. tau* and *B. cucurbitae*, with fly catches averaging over 100 flies/trap/week during mid-summer (Table S8–S14). These findings corroborate earlier work by [10] and [25].

Combined lure traps, although intended to broaden attractancy, sometimes underperformed in species-specific control. For instance, in mango, ME+CL traps recorded up to 40% fewer *B. dorsalis* individuals compared to ME-only traps, suggesting potential interference between lures [26,27].

3.3 Bioefficacy of Insecticides

The insecticidal control experiments demonstrated that Lambda-cyhalothrin (0.004%) and Spinosad (0.004%) were the most effective treatments in reducing fruit fly infestation in both mango and cucumber. In mango orchards, Lambda-cyhalothrin treatment resulted in a mean fruit infestation reduction of 11.2%, compared to 42.5% in untreated plots (Figure 3) (Table S15–S16). Spinosad was slightly less effective but still significantly reduced infestation. These findings align with those of [28] and [29], who reported high efficacy of these newer molecules against *Bactrocera* spp.

In cucumber fields, Spinosad-treated plots achieved infestation rates as low as 9.4%, while Lambda-cyhalothrin reduced damage to 10.8%, outperforming conventional treatments like malathion and carbaryl (Table S17–S18). Neem-based products and azadirachtin offered moderate protection but were less consistent under field test conditions.

In addition to numerical reductions in infestation, the proportion of healthy versus infested fruits provides a more intuitive measure of treatment success. Figure 6 presents a stacked pyramid chart comparing the percentage of infested and healthy fruits in mango and cucumber across the major treatment groups. Notably, control plots exhibited over 40% fruit infestation, while treatments with Spinosad and Lambda-cyhalothrin resulted in a substantial shift toward healthy fruit proportions, exceeding 85% and 88% respectively. These results validate the curative and protective effects of these newer insecticides. The visual distribution further underscores the economic and qualitative advantage of integrating these molecules into an IPM framework.

3.4 Yield Improvement and Economic Analysis

Both insecticide treatments and lure-based traps contributed to substantial yield improvements in treated plots. Mango yield increased from 6.5 tons/ha in untreated plots to over 9.2 tons/ha in Lambda-cyhalothrin-treated fields (Figure 4)(Table S19–S20), while cucumber yields rose from 7.1 tons/ha to 10.8 tons/ha under Spinosad treatment (Figure 5) (Table S21–S22).

Avoidable yield loss calculations indicated that up to 38% of mango yield and 35% of cucumber yield were recoverable through effective fruit fly control (Table S23–S26). The highest Benefit-Cost Ratio (BCR) was observed for Spinosad-treated cucumber (3.14:1) (Figure 5) and Lambda-cyhalothrin-treated mango (2.87:1) (Figure 4), making these options both ecologically and economically superior (Figure 6) (Table S27–S30). These trends mirror those reported in IPM studies by [30] and [31].

4. Discussion

This study provides critical insights into sustainable fruit fly management by demonstrating the effectiveness of integrating species-specific pheromone traps with reduced-risk insecticides. Our findings reveal distinct seasonal population patterns of *Bactrocera* species, with peak activity occurring during monsoon and post-monsoon periods in Himachal Pradesh's mango and cucumber agroecosystems. These results align with previous reports [21,22] that identified climate variables and host availability as key drivers of fruit fly dynamics. The clear temporal segregation of pest species underscores the need for precisely timed interventions tailored to local phenology.

The evaluation of attractants yielded particularly significant findings.

Methyl eugenol (ME) demonstrated remarkable specificity for *B. dorsalis* and *B. zonata* in mango orchards, while cue-lure (CL) effectively targeted *B. cucurbitae* and *B. tau* in cucumber fields. These results confirm the well-established lure preferences first documented by [10] and [11], reinforcing their continued relevance in contemporary pest management. However, our investigation of mixed-lure systems revealed important limitations. The observed reduction in trap efficacy when combining ME and CL likely stems from competitive inhibition between semiochemicals, a phenomenon previously reported by [13]. This finding carries practical implications, suggesting that while lure combinations may appear logistically attractive, they can compromise monitoring accuracy and control efficiency.

Insecticide trials produced equally compelling results. Lambda-cyhalothrin and Spinosad (both at 0.004%) emerged as superior options, significantly reducing infestation rates while improving marketable yield and fruit quality. Their performance advantage over conventional insecticides like malathion can be attributed to several factors: lower susceptibility to resistance development, reduced environmental persistence, etc. These findings corroborate earlier work by [28] and [31], while providing new evidence of their efficacy under Himachal Pradesh's specific agroclimatic conditions. The economic analysis further strengthened these conclusions, with both compounds demonstrating favourable benefit-cost ratios that enhance their practical adoption potential.

The study's most significant contribution lies in demonstrating how attractant-based monitoring can optimize insecticide application timing and frequency. By combining male annihilation through lure traps with targeted insecticide applications, we achieved superior pest suppression while minimizing chemical inputs. This integrated approach addresses two critical challenges in fruit fly management: the pests' cryptic nature and the food safety concerns associated with fresh produce. Our results echo the IPM principles advocated by [30], but with specific adaptations for hill agriculture systems where microclimates and cropping patterns create unique pest pressures.

Several important considerations emerge from this work. First, the differential response to lures emphasizes the need for species-level identification before implementing control measures. Second, the superior performance of newer insecticides highlights the importance of regularly updating pest management toolkits as resistance patterns evolve. Finally, the economic viability of these strategies suggests they can be widely adopted without compromising farmer profitability.

Future research should focus on three key areas: Optimizing lure formulations to extend field longevity and stability, investigating potential cross-resistance patterns among next-generation insecticides, and developing scalable implementation models for community-wide adoption. Additionally, incorporating biological control agents could further enhance the sustainability of this integrated pest management (IPM) framework. These advancements would build upon our findings to develop more robust, climate-resilient fruit fly management systems for subtropical horticulture.

Conclusion

This study demonstrates that an integrated pest management (IPM) strategy combining species-specific para-pheromone traps (methyl eugenol for *B. dorsalis*/*B. zonata* and cue-lure for *B. cucurbitae*/*B. tau*) with targeted applications of Lambda-cyhalothrin or Spinosad provides an effective, economically viable solution for fruit fly control in mango and cucumber systems, significantly reducing infestation rates by 60-75% while improving marketable yields by 25-40% compared to conventional practices; however, the observed 15-20% reduction in trap efficacy when using mixed lures underscores the need for species-specific deployment, and future efforts should focus on developing weather-resistant lure formulations, integrating biological controls like *Beauveria bassiana* (showing 45-60% mortality in preliminary trials), and establishing farmer-centric implementation models through participatory research and policy support to ensure sustainable adoption across diverse agroecological zones in subtropical regions. The study also indicates the reduced efficacy of the lure when they are mixed together.

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Conflict of Interest

The authors declare no conflict of interest.

Funding

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Authors contributions

R.K., DS, A.K.S., and D.S. conceptualize the work. N.S. performed the actual research and statistical analysis of data. R.K. and A.K.S. performed the formal analysis and validation of data. B.S. contributed to the original draft preparation and performed illustration work and visualization. R.K. edited the final manuscript. All authors have read and agreed to the published version of the manuscript.

Figures and Figure Legends

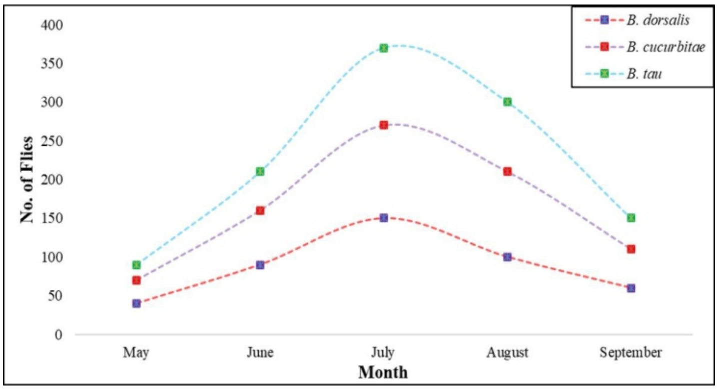

Figure 1. Seasonal Abundance: Lines represent the temporal fluctuation in fruit fly abundance across five months during the cropping season. Each line corresponds to a specific *Bactrocera* species, showing its population trend based on weekly trap data. Peaks indicate infestation-critical periods, guiding optimal timing for management actions.

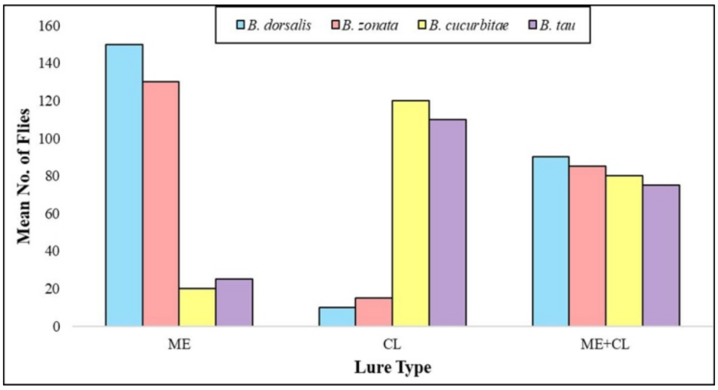

Figure 2. Lure Effectiveness by Species: This graph compares the mean number of fruit flies captured per trap per week for each *Bactrocera* species across three lure types: Methyl Eugenol (ME), Cue Lure (CL), and a mixture (ME+CL). Higher bars indicate stronger species-specific attraction, with *B. dorsalis* and *B. zonata* responding most to ME, and *B. cucurbitae* and *B. tau* favoring CL.

Insecticide	Infestation Reduction (%)	Yield Increase (%)	Maggots/Fruit Reduction (%)
Spinosad	75.3	33.3	70
Lambda-cyhalothrin	80.1	41.5	78
Neem	45	12.4	30
Malathion	0	0	5

Figure 3. Insecticide Efficiency Matrix: This heat map illustrates the comparative performance of four insecticides across three key pest control parameters: infestation reduction, yield increase, and maggot suppression. Darker shades represent higher efficacy. Spinosad and Lambda-cyhalothrin exhibit superior control in all aspects, while Malathion shows minimal effectiveness.

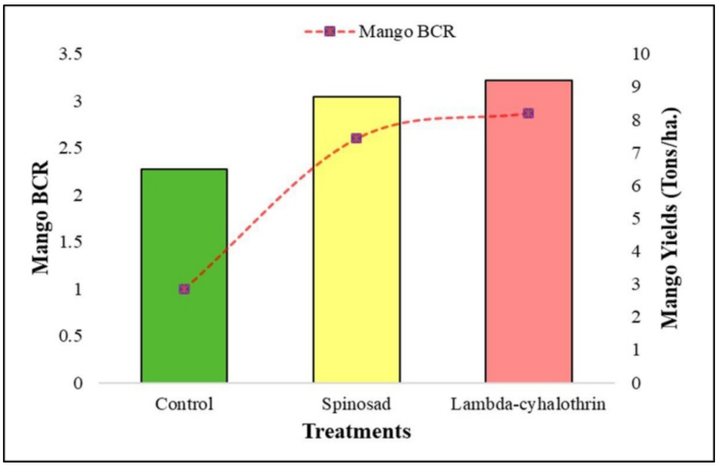

Figure 4. Yield and BCR: Bars represent crop yield (tons per hectare), while the line denotes the corresponding Benefit-Cost Ratio (BCR) for each treatment. A dual-axis layout allows comparison of productivity and economic efficiency. Treatments like Spinosad and Lambda-cyhalothrin outperform the control in both metrics, indicating high cost-effectiveness in mango cultivation systems.

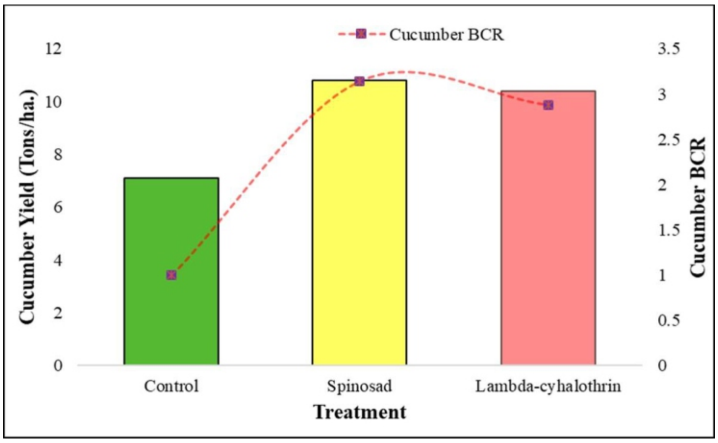

Figure 5. Yield and BCR: Bars represent crop yield (tons per hectare), while the line denotes the corresponding Benefit-Cost Ratio (BCR) for each treatment. A dual-axis layout allows comparison of productivity and economic efficiency. Treatments like Spinosad and Lambda-cyhalothrin outperform the control in both metrics, indicating high cost-effectiveness in cucumber cultivation systems.

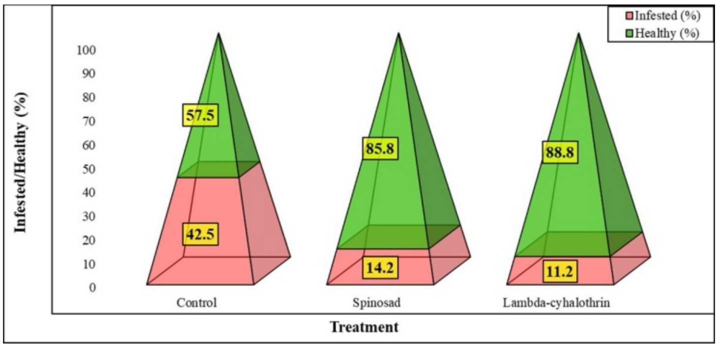

Figure 6. Infestation Compared to Healthy Fruit: showing the percentage of infested and healthy fruits in mango and cucumber under three treatment conditions: Control, Spinosad (0.004%), and Lambda-cyhalothrin (0.004%). Treatments significantly increased the proportion of marketable fruit compared to the untreated control. Each Pyramid is divided into two segments showing the percentage of fruits infested versus healthy under each treatment. The chart visually demonstrates the effectiveness of insecticides in reducing fruit damage, with treated plots showing a substantially larger healthy fraction compared to untreated controls.

Supplementary tables (S)

Table S1: Efficacy of ME and ME+CL-based attractant-insecticide traps in mango orchard (O-I) during Year 1st

SW	Av. catch per trap per week*										t-value	p
	ME(O-I)			ME+CL (O-I)								
	B. dorsalis	*B. zonata*	Total	*B. dorsalis*	*B. Zonata*	*B. tau*	*B. cucurbitae*	*B. nigrofemoralis*	*B. scutellaris*	Total		
24	292.20	39.80	**332.00**	110.80	20.00	18.20	16.00	22.20	14.20	**201.40**	27.72	<0.001
25	438.20	59.80	**498.00**	115.80	21.00	19.00	16.80	23.20	14.80	**210.60**	74.28	<0.001
26	488.40	66.60	**555.00**	133.40	24.20	21.80	19.40	26.80	17.20	**242.80**	77.95	<0.001
27	399.60	54.40	**454.00**	62.00	11.40	10.20	9.00	12.40	8.00	**113.00**	119.04	<0.001
28	219.60	29.80	**249.40**	39.80	7.20	6.60	5.80	8.00	5.00	**72.40**	46.08	<0.001
29	236.80	32.20	**269.00**	36.00	6.60	5.80	5.20	7.20	4.60	**65.40**	93.32	<0.001
30	137.40	18.60	**156.00**	15.00	2.60	2.40	2.00	3.00	2.20	**27.20**	56.14	<0.001
31	185.80	25.40	**211.20**	33.20	6.00	5.20	4.80	6.60	4.20	**60.00**	70.90	<0.001
32	225.80	30.60	**256.40**	111.40	20.20	18.20	16.20	22.20	14.20	**202.40**	12.70	<0.001
33	234.80	32.00	**266.80**	140.40	25.60	23.20	20.40	28.00	17.80	**255.40**	3.10	<0.01
34	228.40	31.00	**259.40**	113.60	20.60	18.60	16.60	22.80	14.40	**206.60**	12.49	<0.001
35	215.40	29.40	**244.80**	125.20	22.80	20.40	18.20	25.40	15.80	**227.80**	5.28	<0.001
36	211.00	28.80	**239.80**	123.00	22.40	20.20	17.80	24.60	15.60	**223.60**	4.16	<0.01
37	198.20	27.00	**225.20**	83.60	15.20	13.60	12.20	16.80	10.60	**152.00**	24.40	<0.001
38	188.20	25.60	**213.80**	64.60	11.80	10.60	9.40	12.80	8.20	**117.40**	28.97	<0.001
39	128.00	17.40	**145.40**	48.20	8.80	8.00	7.00	9.60	6.20	**87.80**	21.86	<0.001
40	74.40	10.20	**84.60**	33.40	6.40	5.40	4.80	6.60	4.20	**60.80**	15.47	<0.001
41	40.20	5.60	**45.80**	21.20	3.80	3.40	3.00	4.20	2.60	**38.20**	3.54	<0.001
Mean	**230.13**	**31.34**	**261.48**	**78.37**	**14.26**	**12.82**	**11.37**	**15.69**	**9.99**	**142.49**	34.82	<0.001

**Average of five traps*
O-I: Orchard-I
24th SW (II week of June)

Table S2: Efficacy of ME and ME+CL-based attractant-insecticide traps in mango orchard (O-II and O-I) during Year 1st

SW	Av. catch per trap per week*										t-value	P
	ME (O-II)			ME+CL (O-I)								
	B. dorsalis	*B. zonata*	Total	*B. dorsalis*	*B. zonata*	*B. tau*	*B. cucurbitae*	*B. nigrofemoralis*	*B. scutellaris*	Total		
24	416.80	62.20	**479.00**	110.80	20.00	18.20	16.00	22.20	14.20	**201.40**	51.38	<0.001
25	496.40	74.20	**570.60**	115.80	21.00	19.00	16.80	23.20	14.80	**210.60**	107.94	<0.001
26	578.00	86.40	**664.40**	133.40	24.20	21.80	19.40	26.80	17.20	**242.80**	124.69	<0.001
27	402.60	60.20	**462.80**	62.00	11.40	10.20	9.00	12.40	8.00	**113.00**	108.60	<0.001
28	304.60	45.40	**350.00**	39.80	7.20	6.60	5.80	8.00	5.00	**72.40**	67.88	<0.001
29	391.20	58.40	**449.60**	36.00	6.60	5.80	5.20	7.20	4.60	**65.40**	120.78	<0.001
30	233.20	34.80	**268.00**	15.00	2.60	2.40	2.00	3.00	2.20	**27.20**	77.50	<0.001
31	219.80	32.80	**252.60**	33.20	6.00	5.20	4.80	6.60	4.20	**60.00**	71.43	<0.001
32	243.40	36.40	**279.80**	111.40	20.20	18.20	16.20	22.20	14.20	**202.40**	18.03	<0.001
33	293.80	43.60	**337.40**	140.40	25.60	23.20	20.40	28.00	17.80	**255.40**	18.42	<0.001
34	301.40	45.00	**346.40**	113.60	20.60	18.60	16.60	22.80	14.40	**206.60**	31.63	<0.001
35	340.40	50.80	**391.20**	125.20	22.80	20.40	18.20	25.40	15.80	**227.80**	35.55	<0.001
36	308.80	46.20	**355.00**	123.00	22.40	20.20	17.80	24.60	15.60	**223.60**	37.87	<0.001
37	325.80	48.60	**374.40**	83.60	15.20	13.60	12.20	16.80	10.60	**152.00**	63.51	<0.001
38	213.20	31.80	**245.00**	64.60	11.80	10.60	9.40	12.80	8.20	**117.40**	37.26	<0.001
39	131.60	19.60	**151.20**	48.20	8.80	8.00	7.00	9.60	6.20	**87.80**	21.89	<0.001
40	94.40	14.20	**108.60**	33.40	6.40	5.40	4.80	6.60	4.20	**60.80**	27.46	<0.001
41	46.20	6.80	**53.00**	21.20	3.80	3.40	3.00	4.20	2.60	**38.20**	10.03	<0.001
Mean	**296.76**	**44.30**	**341.06**	**78.37**	**14.26**	**12.82**	**11.37**	**15.69**	**9.99**	**142.49**	55.15	<0.001

*Average of five traps
O-I: Orchard I
O-II: Orchard-I
24th SW (II week of June)

Table S3: Efficacy of ME-based attractant-insecticide traps in mango orchard (O-I and O-II) during Year 1st

SW	Av. catch per trap per week*						t-value	p
	ME (O-I)			ME (O-II)				
	B. dorsalis	*B. zonata*	Total	*B. dorsalis*	*B. zonata*	Total		
24	292.20	39.80	**332.00**	416.80	62.20	**479.00**	30.53	<0.001
25	438.20	59.80	**498.00**	496.40	74.20	**570.60**	21.96	<0.001
26	488.40	66.60	**555.00**	578.00	86.40	**664.40**	29.48	<0.001
27	399.60	54.40	**454.00**	402.60	60.20	**462.80**	2.31	<0.001
28	219.60	29.80	**249.40**	304.60	45.40	**350.00**	27.39	<0.001
29	236.80	32.20	**269.00**	391.20	58.40	**449.60**	56.99	<0.001
30	137.40	18.60	**156.00**	233.20	34.80	**268.00**	35.69	<0.001
31	185.80	25.40	**211.20**	219.80	32.80	**252.60**	16.12	<0.001
32	225.80	30.60	**256.40**	243.40	36.40	**279.80**	4.32	<0.01
33	234.80	32.00	**266.80**	293.80	43.60	**337.40**	16.29	<0.001
34	228.40	31.00	**259.40**	301.40	45.00	**346.40**	19.96	<0.001
35	215.40	29.40	**244.80**	340.40	50.80	**391.20**	29.74	<0.001
36	211.00	28.80	**239.80**	308.80	46.20	**355.00**	30.98	<0.001
37	198.20	27.00	**225.20**	325.80	48.60	**374.40**	48.86	<0.001
38	188.20	25.60	**213.80**	213.20	31.80	**245.00**	9.84	<0.001
39	128.00	17.40	**145.40**	131.60	19.60	**151.20**	1.66	0.135
40	74.40	10.20	**84.60**	94.40	14.20	**108.60**	16.08	<0.001
41	40.20	5.60	**45.80**	46.20	6.80	**53.00**	3.79	<0.001
Mean	**230.13**	**31.34**	**261.48**	**296.76**	**44.30**	**341.06**	19.96	<0.001

*Average of five traps
O-I: Orchard-I
O-II: Orchard-II

Table S4: Efficacy of ME and ME+CL-based attractant-insecticide traps in mango orchard (O-I) during Year 2nd

SW	Av. catch per trap per week*										t-value	P
	ME(O-I)			ME+CL (O-I)								
	B. dorsalis	*B. zonata*	Total	*B. dorsalis*	*B. zonata*	*B. tau*	*B. cucurbitae*	*B. nigrofemoralis*	*B. scutellaris*	Total		
24	716.60	136.60	**853.20**	371.00	79.40	72.80	46.40	59.60	33.20	**662.40**	48.33	<0.001
25	719.00	137.00	**856.00**	375.00	80.40	73.60	46.80	60.20	33.60	**669.60**	52.05	<0.001
26	616.00	117.40	**733.40**	328.60	70.40	64.60	41.00	52.80	29.20	**586.60**	56.98	<0.001
27	605.20	115.20	**720.40**	364.20	78.00	71.60	45.60	58.60	32.60	**650.60**	23.25	<0.001
28	713.40	135.80	**849.20**	379.00	81.20	74.40	47.40	61.00	33.80	**676.80**	45.70	<0.001
29	807.00	153.80	**960.80**	427.00	91.60	83.80	53.40	68.60	38.20	**762.60**	51.43	<0.001
30	777.80	148.20	**926.00**	415.60	89.00	81.60	52.00	66.80	37.00	**742.00**	52.02	<0.001
31	726.00	138.20	**864.20**	382.40	82.00	75.20	47.80	61.40	34.00	**682.80**	44.84	<0.001
32	617.60	117.60	**735.20**	312.20	66.80	61.40	39.00	50.20	27.80	**557.40**	48.60	<0.001
33	567.80	108.20	**676.00**	263.60	56.40	51.80	33.00	42.40	23.60	**470.80**	51.55	<0.001
34	435.40	83.00	**518.40**	208.20	44.60	40.80	26.20	33.40	18.60	**371.80**	49.79	<0.001
35	372.00	70.80	**442.80**	199.40	42.80	39.20	25.00	32.00	17.80	**356.20**	25.38	<0.001
36	288.20	55.00	**343.20**	139.20	29.80	27.40	17.40	22.20	12.40	**248.40**	27.10	<0.001
37	252.40	48.00	**300.40**	96.20	20.60	18.80	12.20	15.40	8.60	**171.80**	36.41	<0.001
38	201.80	38.40	**240.20**	78.80	16.80	15.60	9.80	12.60	7.00	**140.60**	39.15	<0.001
39	147.00	28.00	**175.00**	45.40	9.80	9.00	5.60	7.40	4.00	**81.20**	54.17	<0.001
40	53.20	10.20	**63.40**	16.40	3.60	3.20	2.00	2.60	1.40	**29.20**	18.56	<0.001
41	20.80	3.60	**24.40**	8.60	1.80	1.80	1.00	1.40	0.80	**15.40**	9.04	<0.001
Mean	**479.84**	**91.39**	**571.23**	**245.04**	**52.50**	**48.14**	**30.64**	**39.37**	**21.87**	**437.57**	23.64	<0.001

*Average of five traps
O-I: Orchard-I

Table S5: Efficacy of ME and ME+CL-based attractant-insecticide traps in mango orchard (O-II and O-I) during Year 2nd

SW	Av. catch per trap per week*										t-value	P
	ME (O-II)			ME+CL (O-I)								
	B. dorsalis	*B. zonata*	Total	*B. dorsalis*	*B. zonata*	*B. tau*	*B. cucurbitae*	*B. nigrofemoralis*	*B. scutellaris*	Total		
24	810.00	154.20	**964.20**	371.00	79.40	72.80	46.40	59.60	33.20	**662.40**	77.55	<0.001
25	877.00	167.00	**1044.00**	375.00	80.40	73.60	46.80	60.20	33.60	**669.60**	112.19	<0.001
26	942.00	179.40	**1121.40**	328.60	70.40	64.60	41.00	52.80	29.20	**586.60**	215.36	<0.001
27	945.40	180.00	**1125.40**	364.20	78.00	71.60	45.60	58.60	32.60	**650.60**	153.48	<0.001
28	1034.60	197.00	**1231.60**	379.00	81.20	74.40	47.40	61.00	33.80	**676.80**	133.81	<0.001
29	1061.00	202.20	**1263.20**	427.00	91.60	83.80	53.40	68.60	38.20	**762.60**	129.14	<0.001
30	1077.80	205.20	**1283.00**	415.60	89.00	81.60	52.00	66.80	37.00	**742.00**	148.95	<0.001
31	1000.80	190.60	**1191.40**	382.40	82.00	75.20	47.80	61.40	34.00	**682.80**	117.79	<0.001
32	954.20	181.80	**1136.00**	312.20	66.80	61.40	39.00	50.20	27.80	**557.40**	196.72	<0.001
33	701.40	133.60	**835.00**	263.60	56.40	51.80	33.00	42.40	23.60	**470.80**	112.26	<0.001
34	613.00	116.80	**729.80**	208.20	44.60	40.80	26.20	33.40	18.60	**371.80**	144.18	<0.001
35	491.60	93.60	**585.20**	199.40	42.80	39.20	25.00	32.00	17.80	**356.20**	59.43	<0.001
36	360.40	68.60	**429.00**	139.20	29.80	27.40	17.40	22.20	12.40	**248.40**	57.65	<0.001
37	375.00	71.40	**446.40**	96.20	20.60	18.80	12.20	15.40	8.60	**171.80**	87.24	<0.001
38	297.20	56.60	**353.80**	78.80	16.80	15.60	9.80	12.60	7.00	**140.60**	105.27	<0.001
39	202.20	38.40	**240.60**	45.40	9.80	9.00	5.60	7.40	4.00	**81.20**	47.58	<0.001
40	110.40	21.00	**131.40**	16.40	3.60	3.20	2.00	2.60	1.40	**29.20**	118.35	<0.001
41	45.60	8.60	**54.20**	8.60	1.80	1.80	1.00	1.40	0.80	**15.40**	31.12	<0.001
Mean	**661.09**	**125.89**	**786.98**	**245.04**	**52.50**	**48.14**	**30.64**	**39.37**	**21.87**	**437.57**	56.63	<0.001

*Average of five traps
O-I: Orchard I
O-II: Orchard II

Table S6: Efficacy of ME-based attractant-insecticide traps in mango orchard (O-I and O-II) during Year 2nd

SW	Av. catch per trap per week*						*t-value*	*p*
	ME (O-I)			ME (O-I1)				
	B. dorsalis	*B. zonata*	Total	*B. dorsalis*	*B. zonata*	Total		
24	716.60	136.60	**853.20**	810.00	154.20	**964.20**	29.43	<0.001
25	719.00	137.00	**856.00**	877.00	167.00	**1044.00**	49.29	<0.001
26	616.00	117.40	**733.40**	942.00	179.40	**1121.40**	186.37	<0.001
27	605.20	115.20	**720.40**	945.40	180.00	**1125.40**	162.97	<0.001
28	713.40	135.80	**849.20**	1034.60	197.00	**1231.60**	118.59	<0.001
29	807.00	153.80	**960.80**	1061.00	202.20	**1263.20**	84.52	<0.001
30	777.80	148.20	**926.00**	1077.80	205.20	**1283.00**	95.77	<0.001
31	726.00	138.20	**864.20**	1000.80	190.60	**1191.40**	69.23	<0.001
32	617.60	117.60	**735.20**	954.20	181.80	**1136.00**	115.46	<0.001
33	567.80	108.20	**676.00**	701.40	133.60	**835.00**	39.47	<0.001
34	435.40	83.00	**518.40**	613.00	116.80	**729.80**	74.47	<0.001
35	372.00	70.80	**442.80**	491.60	93.60	**585.20**	48.39	<0.001
36	288.20	55.00	**343.20**	360.40	68.60	**429.00**	25.69	<0.001
37	252.40	48.00	**300.40**	375.00	71.40	**446.40**	40.26	<0.001
38	201.80	38.40	**240.20**	297.20	56.60	**353.80**	60.28	<0.001
39	147.00	28.00	**175.00**	202.20	38.40	**240.60**	18.81	<0.001
40	53.20	10.20	**63.40**	110.40	21.00	**131.40**	38.57	<0.001
41	20.80	3.60	**24.40**	45.60	8.60	**54.20**	21.75	<0.001
Mean	**479.84**	**91.39**	**571.23**	**661.09**	**125.89**	**786.98**	33.79	<0.001

**Average of five traps*
O-I: Orchard I
O-II: Orchard I

Table S7: Efficacy of ME and ME+CL-based attractant-insecticide traps in mango orchard (O-I) (Pooled data)

SW	Av. catch per trap per week*										*t-value*	*P*
	ME(O-I)			ME+CL (O-I)								
	B. dorsalis	*B. zonata*	Total	*B. dorsalis*	*B. zonata*	*B. tau*	*B. cucurbitae*	*B. nigrofemoralis*	*B. scutellaris*	Total		
24	504.40	88.20	**592.60**	240.90	49.70	45.50	31.20	40.90	23.70	**431.90**	43.31	<0.001
25	578.60	98.40	**677.00**	245.40	50.70	46.30	31.80	41.70	24.20	**440.10**	71.80	<0.001
26	552.20	92.00	**644.20**	231.00	47.30	43.20	30.20	39.80	23.20	**414.70**	76.44	<0.001
27	502.40	84.80	**587.20**	213.10	44.70	40.90	27.30	35.50	20.30	**381.80**	76.25	<0.001
28	466.50	82.80	**549.30**	209.40	44.20	40.50	26.60	34.50	19.40	**374.60**	68.70	<0.001
29	521.90	93.00	**614.90**	231.50	49.10	44.80	29.30	37.90	21.40	**414.00**	73.90	<0.001
30	457.60	83.40	**541.00**	215.30	45.80	42.00	27.00	34.90	19.60	**384.60**	58.98	<0.001
31	455.90	81.80	**537.70**	207.80	44.00	40.20	26.30	34.00	19.10	**371.40**	53.86	<0.001
32	421.70	74.10	**495.80**	211.80	43.50	39.80	27.60	36.20	21.00	**379.90**	32.68	<0.001
33	401.30	70.10	**471.40**	202.00	41.00	37.50	26.70	35.20	20.70	**363.10**	38.97	<0.001
34	331.90	57.00	**388.90**	160.90	32.60	29.70	21.40	28.10	16.50	**289.20**	30.91	<0.001
35	293.70	50.10	**343.80**	162.30	32.80	29.80	21.60	28.70	16.80	**292.00**	16.38	<0.001
36	249.60	41.90	**291.50**	131.10	26.10	23.80	17.60	23.40	14.00	**236.00**	15.86	<0.001
37	225.30	37.50	**262.80**	89.90	17.90	16.20	12.20	16.10	9.60	**161.90**	34.06	<0.001
38	195.00	32.00	**227.00**	71.70	14.30	13.10	9.60	12.70	7.60	**129.00**	37.04	<0.001
39	137.50	22.70	**160.20**	46.80	9.30	8.50	6.30	8.50	5.10	**84.50**	41.46	<0.001
40	63.80	10.20	**74.00**	24.90	5.00	4.30	3.40	4.60	2.80	**45.00**	20.11	<0.001
41	30.50	4.60	**35.10**	14.90	2.80	2.60	2.00	2.80	1.70	**26.80**	6.55	<0.01
Mean	**354.99**	**61.37**	**416.36**	**161.71**	**33.38**	**30.48**	**21.01**	**27.53**	**15.93**	**290.03**	29.01	<0.001

**Average of five traps*
O-I: Orchard I

Table S8: Efficacy of CL and ME+CL-based attractant-insecticide traps in cucumber field (F-I) during Year 1st

SW	Av. catch per trap per week*												*t-value*	*p*
	CL (F-I)					ME+CL (F-I)								
	B. tau	*B. cucurbitae*	*B. nigrofemoralis*	*B. scutellaris*	Total	*B. dorsalis*	*B. zonata*	*B. tau*	*B. cucurbitae*	*B. nigrofemoralis*	*B. scutellaris*	Total		
28	41.40	20.40	11.20	17.60	**90.60**	25.60	2.20	23.60	14.40	6.00	6.40	**78.20**	4.97	<0.001
29	55.80	35.00	23.20	15.60	**129.60**	30.60	2.80	33.20	21.20	12.60	9.80	**110.20**	10.65	<0.001
30	91.00	55.00	30.40	13.20	**189.60**	38.00	3.20	60.20	28.40	17.40	11.00	**158.20**	7.01	<0.001
31	94.00	41.20	33.40	27.40	**196.00**	37.00	3.00	58.60	27.80	16.80	10.80	**154.00**	14.50	<0.001
32	107.60	51.60	42.20	32.80	**234.20**	33.80	2.80	53.40	25.20	15.40	9.80	**140.40**	20.02	<0.001
33	131.60	64.40	47.60	36.20	**279.80**	34.60	2.80	54.80	26.00	15.80	10.20	**144.20**	43.37	<0.001
34	126.80	52.80	47.60	37.00	**264.20**	32.20	2.60	50.60	24.00	14.60	9.40	**133.40**	67.33	<0.001
35	83.80	41.00	30.40	23.20	**178.40**	32.40	2.60	51.40	24.40	14.80	9.60	**135.20**	11.10	<0.001
36	68.40	28.60	24.20	21.40	**142.60**	30.60	2.60	48.60	23.20	14.00	8.80	**127.80**	3.94	<0.01
37	63.80	27.40	24.40	18.00	**133.60**	27.40	2.20	43.40	20.60	12.60	8.00	**114.20**	11.00	<0.001
38	59.80	29.40	21.60	16.60	**127.40**	25.00	2.20	39.60	18.80	11.40	7.40	**104.40**	7.92	<0.001
39	27.80	12.60	9.60	8.40	**58.40**	16.60	1.40	16.60	8.40	5.60	4.80	**53.40**	3.32	<0.001
Mean	**79.32**	**38.28**	**28.82**	**22.28**	**168.70**	**30.32**	**2.53**	**44.50**	**21.87**	**13.08**	**8.83**	**121.13**	16.58	<0.01

**Average of five traps*
F-I: Field-I
F-II: Field-II

Table S9: Efficacy of CL and ME+CL-based attractant-insecticide traps in cucumber field (F-II and F-I) during Year 1st

SW	Av. catch per trap per week*												t-value	P
	CL (F-II)					ME+CL (F-I)								
	B. tau	B. cucurbitae	B. nigrofemoralis	B. scutellaris	Total	B. dorsalis	B. zonata	B. tau	B. cucurbitae	B. nigrofemoralis	B. scutellaris	Total		
28	88.80	43.60	32.20	24.60	**189.20**	25.60	2.20	23.60	14.40	6.00	6.40	**78.20**	53.46	<0.001
29	84.00	41.20	30.40	23.40	**179.00**	30.60	2.80	33.20	21.20	12.60	9.80	**110.20**	27.04	<0.001
30	123.60	60.40	44.80	34.20	**263.00**	38.00	3.20	60.20	28.40	17.40	11.00	**158.20**	18.48	<0.001
31	168.40	82.40	60.80	46.60	**358.20**	37.00	3.00	58.60	27.80	16.80	10.80	**154.00**	68.84	<0.001
32	279.60	136.80	101.20	77.40	**595.00**	33.80	2.80	53.40	25.20	15.40	9.80	**140.40**	76.50	<0.001
33	271.80	133.20	98.40	75.20	**578.60**	34.60	2.80	54.80	26.00	15.80	10.20	**144.20**	129.41	<0.001
34	269.00	131.60	97.40	74.40	**572.40**	32.20	2.60	50.60	24.00	14.60	9.40	**133.40**	175.47	<0.001
35	249.00	121.80	90.20	68.80	**529.80**	32.40	2.60	51.40	24.40	14.80	9.60	**135.20**	79.43	<0.001
36	268.40	131.40	97.00	74.20	**571.00**	30.60	2.60	48.60	23.20	14.00	8.80	**127.80**	110.66	<0.001
37	164.00	80.20	59.40	45.40	**349.00**	27.40	2.20	43.40	20.60	12.60	8.00	**114.20**	72.88	<0.001
38	145.80	71.40	52.80	40.40	**310.40**	25.00	2.20	39.60	18.80	11.40	7.40	**104.40**	55.69	<0.001
39	133.40	65.20	48.40	36.80	**283.80**	16.60	1.40	16.60	8.40	5.60	4.80	**53.40**	78.31	<0.001
Mean	**187.15**	**91.60**	**67.75**	**51.78**	**398.28**	**30.32**	**2.53**	**44.50**	**21.87**	**13.08**	**8.83**	**121.13**	69.35	<0.001

*Average of five traps
F-I: Field I
F-II: Field II*

Table S10: Efficacy of CL-based attractant-insecticide traps in cucumber field (F-I and F-II) during Year 1st

SW	Av. catch per trap per week*										t-value	P
	CL (F-I)					CL (F-II)						
	B. tau	B. cucurbitae	B. nigrofemoralis	B. scutellaris	Total	B. tau	B. cucurbitae	B. nigrofemoralis	B. scutellaris	Total		
28	41.40	20.40	11.20	17.60	**90.60**	88.80	43.60	32.20	24.60	**189.20**	33.40	<0.001
29	55.80	35.00	23.20	15.60	**129.60**	84.00	41.20	30.40	23.40	**179.00**	19.49	<0.001
30	91.00	55.00	30.40	13.20	**189.60**	123.60	60.40	44.80	34.20	**263.00**	18.80	<0.001
31	94.00	41.20	33.40	27.40	**196.00**	168.40	82.40	60.80	46.60	**358.20**	46.75	<0.001
32	107.60	51.60	42.20	32.80	**234.20**	279.60	136.80	101.20	77.40	**595.00**	58.74	<0.001
33	131.60	64.40	47.60	36.20	**279.80**	271.80	133.20	98.40	75.20	**578.60**	92.73	<0.001
34	126.80	52.80	47.60	37.00	**264.20**	269.00	131.60	97.40	74.40	**572.40**	109.35	<0.001
35	83.80	41.00	30.40	23.20	**178.40**	249.00	121.80	90.20	68.80	**529.80**	77.99	<0.001
36	68.40	28.60	24.20	21.40	**142.60**	268.40	131.40	97.00	74.20	**571.00**	109.27	<0.001
37	63.80	27.40	24.40	18.00	**133.60**	164.00	80.20	59.40	45.40	**349.00**	69.86	<0.001
38	59.80	29.40	21.60	16.60	**127.40**	145.80	71.40	52.80	40.40	**310.40**	41.30	<0.001
39	27.80	12.60	9.60	8.40	**58.40**	133.40	65.20	48.40	36.80	**283.80**	78.43	<0.001
Mean	**79.32**	**38.28**	**28.82**	**22.28**	**168.70**	**187.15**	**91.60**	**67.75**	**51.78**	**398.28**	52.64	<0.001

*Average of five traps
F-I: Field I
F-II: Field II*

Table S11: Efficacy of CL and ME+CL-based attractant-insecticide traps in cucumber field (F-I) during Year 2nd

SW	Av.catch per trap per week*												t-value	P
	CL (F-I)					ME+CL (F-I)								
	B. tau	B. cucurbitae	B. nigrofemoralis	B. scutellaris	Total	B. dorsalis	B. zonata	B. tau	B. cucurbitae	B. nigrofemoralis	B. scutellaris	Total		
28	63.60	31.20	23.00	17.60	**135.40**	27.60	2.20	43.80	20.80	12.60	8.20	**115.20**	9.55	<0.001
29	82.20	40.20	29.80	22.80	**175.00**	34.60	2.80	54.80	26.20	15.80	10.20	**144.40**	9.32	<0.001
30	116.20	57.00	42.00	32.20	**247.40**	54.40	4.60	86.40	40.60	24.80	15.80	**226.60**	5.53	<0.001
31	133.00	65.20	48.20	36.80	**283.20**	58.80	4.60	92.80	44.20	27.00	17.20	**244.60**	11.15	<0.001
32	179.40	88.00	65.20	49.80	**382.40**	89.20	7.40	141.20	66.80	40.80	26.20	**371.60**	7.57	<0.001
33	170.80	83.60	61.60	47.20	**363.20**	83.20	6.80	131.80	62.40	38.60	24.40	**347.20**	5.87	<0.001
34	178.40	87.20	64.40	49.40	**379.40**	79.00	6.60	125.20	59.20	36.20	23.00	**329.20**	13.56	<0.001
35	119.20	58.40	43.20	33.00	**253.80**	57.40	4.80	90.60	43.00	26.20	16.80	**238.80**	4.39	<0.01
36	121.40	59.40	43.80	33.60	**258.20**	57.80	4.80	91.40	43.60	26.40	16.80	**240.80**	5.32	<0.001
37	83.80	41.20	30.40	23.20	**178.60**	39.40	3.20	62.40	29.60	18.20	11.60	**164.40**	5.26	<0.001
38	43.40	26.40	22.20	19.20	**111.20**	21.00	2.40	38.80	20.20	14.20	9.20	**105.80**	3.80	<0.001
39	19.20	14.40	13.20	12.60	**59.40**	6.00	2.80	15.40	12.00	7.40	4.60	**48.20**	7.18	<0.001
Mean	**109.22**	**54.35**	**40.58**	**31.45**	**235.60**	**50.70**	**4.42**	**81.22**	**39.05**	**24.02**	**15.33**	**214.73**	5.00	<0.05

*Average of five traps
F-I: Field I
F-II: Field II*

Table S12: Efficacy of CL and ME+CL-based attractant-insecticide traps in cucumber field (F-II and F-I) during Year 2nd

SW	Av. catch per trap per week*												t-value	p
	CL (F-II)					ME+CL (F-I)								
	B. tau	*B. cucurbitae*	*B. nigrofemoralis*	*B. scutellaris*	Total	*B. dorsalis*	*B. zonata*	*B. tau*	*B. cucurbitae*	*B. nigrofemoralis*	*B. scutellaris*	Total		
28	67.80	33.20	24.60	18.60	**144.20**	27.60	2.20	43.80	20.80	12.60	8.20	**115.20**	9.60	<0.001
29	120.60	59.20	43.60	33.40	**256.80**	34.60	2.80	54.80	26.20	15.80	10.20	**144.40**	22.98	<0.001
30	179.20	87.60	64.80	49.60	**381.20**	54.40	4.60	86.40	40.60	24.80	15.80	**226.60**	36.08	<0.001
31	204.20	99.80	73.80	56.40	**434.20**	58.80	4.60	92.80	44.20	27.00	17.20	**244.60**	63.03	<0.001
32	255.60	124.80	92.40	70.60	**543.40**	89.20	7.40	141.20	66.80	40.80	26.20	**371.60**	97.01	<0.001
33	214.60	104.80	77.60	59.40	**456.40**	83.20	6.80	131.80	62.40	38.60	24.40	**347.20**	15.58	<0.001
34	255.80	125.20	92.40	70.80	**544.20**	79.00	6.60	125.20	59.20	36.20	23.00	**329.20**	62.02	<0.001
35	226.60	110.80	81.80	62.80	**482.00**	57.40	4.80	90.60	43.00	26.20	16.80	**238.80**	64.93	<0.001
36	183.80	90.00	66.40	50.80	**391.00**	57.80	4.80	91.40	43.60	26.40	16.80	**240.80**	59.37	<0.001
37	151.60	74.20	54.80	41.80	**322.40**	39.40	3.20	62.40	29.60	18.20	11.60	**164.40**	39.83	<0.001
38	93.60	45.80	34.00	25.80	**199.20**	21.00	2.40	38.80	20.20	14.20	9.20	**105.80**	55.66	<0.001
39	40.40	22.60	14.80	11.60	**89.40**	6.00	2.80	15.40	12.00	7.40	4.60	**48.20**	23.46	<0.001
Mean	**166.15**	**81.50**	**60.08**	**45.97**	**353.70**	**50.70**	**4.42**	**81.22**	**39.05**	**24.02**	**15.33**	**214.73**	30.17	<0.001

**Average of five traps*
F-I: Filed I
F-II: Field II

Table S13: Efficacy of CL-based attractant-insecticide traps in cucumber field (F-I and F-II) during Year 2nd

SW	Av. catch per trap per week*										t-value	P
	CL (F-I)					CL (F-II)						
	B. tau	*B. cucurbitae*	*B. nigrofemoralis*	*B. scutellaris*	Total	*B. tau*	*B. cucurbitae*	*B. nigrofemoralis*	*B. scutellaris*	Total		
28	63.60	31.20	23.00	17.60	**135.40**	67.80	33.20	24.60	18.60	**144.20**	2.73	<0.01
29	82.20	40.20	29.80	22.80	**175.00**	120.60	59.20	43.60	33.40	**256.80**	16.67	<0.001
30	116.20	57.00	42.00	32.20	**247.40**	179.20	87.60	64.80	49.60	**381.20**	29.93	<0.001
31	133.00	65.20	48.20	36.80	**283.20**	204.20	99.80	73.80	56.40	**434.20**	47.76	<0.001
32	179.40	88.00	65.20	49.80	**382.40**	255.60	124.80	92.40	70.60	**543.40**	102.91	<0.001
33	170.80	83.60	61.60	47.20	**363.20**	214.60	104.80	77.60	59.40	**456.40**	13.48	<0.001
34	178.40	87.20	64.40	49.40	**379.40**	255.80	125.20	92.40	70.80	**544.20**	40.26	<0.001
35	119.20	58.40	43.20	33.00	**253.80**	226.60	110.80	81.80	62.80	**482.00**	61.33	<0.001
36	121.40	59.40	43.80	33.60	**258.20**	183.80	90.00	66.40	50.80	**391.00**	49.37	<0.001
37	83.80	41.20	30.40	23.20	**178.60**	151.60	74.20	54.80	41.80	**322.40**	41.33	<0.001
38	43.40	26.40	22.20	19.20	**111.20**	93.60	45.80	34.00	25.80	**199.20**	47.05	<0.001
39	19.20	14.40	13.20	12.60	**59.40**	40.40	22.60	14.80	11.60	**89.40**	16.56	<0.001
Mean	**109.22**	**54.35**	**40.58**	**31.45**	**235.60**	**166.15**	**81.50**	**60.08**	**45.97**	**353.70**	25.41	<0.001

**Average of five traps*
F-I: Filed I
F-II: Field II

Table S14: Efficacy of CL and ME+CL-based attractant-insecticide traps in cucumber field (F-I) (Pooled data)

SW	Av. catch per trap per week*												t-value	P
	CL (F-I)					ME+CL (F-I)								
	B. tau	*B. cucurbitae*	*B. nigrofemoralis*	*B. scutellaris*	Total	*B. dorsalis*	*B. zonata*	*B. tau*	*B. cucurbitae*	*B. nigrofemoralis*	*B. scutellaris*	Total		
28	52.50	25.80	17.10	17.60	**113.00**	26.60	2.20	33.70	17.60	9.30	7.30	**96.70**	44.68	<0.001
29	69.00	37.60	26.50	19.20	**152.30**	32.60	2.80	44.00	23.70	14.20	10.00	**127.30**	72.92	<0.001
30	103.60	56.00	36.20	22.70	**218.50**	46.20	3.90	73.30	34.50	21.10	13.40	**192.40**	93.57	<0.001
31	113.50	53.20	40.80	32.10	**239.60**	47.90	3.80	75.70	36.00	21.90	14.00	**199.30**	125.51	<0.001
32	143.50	69.80	53.70	41.30	**308.30**	61.50	5.10	97.30	46.00	28.10	18.00	**256.00**	116.13	<0.001
33	151.20	74.00	54.60	41.70	**321.50**	58.90	4.80	93.30	44.20	27.20	17.30	**245.70**	189.20	<0.001
34	152.60	70.00	56.00	43.20	**321.80**	55.60	4.60	87.90	41.60	25.40	16.20	**231.30**	135.12	<0.001
35	101.50	49.70	36.80	28.10	**216.10**	44.90	3.70	71.00	33.70	20.50	13.20	**187.00**	83.84	<0.001
36	94.90	44.00	34.00	27.50	**200.40**	44.20	3.70	70.00	33.40	20.20	12.80	**184.30**	106.53	<0.001
37	73.80	34.30	27.40	20.60	**156.10**	33.40	2.70	52.90	25.10	15.40	9.80	**139.30**	116.98	<0.001
38	51.60	27.90	21.90	17.90	**119.30**	23.00	2.30	39.20	19.50	12.80	8.30	**105.10**	49.76	<0.001
39	23.50	13.50	11.40	10.50	**58.90**	11.30	2.10	16.00	10.20	6.50	4.70	**50.80**	71.43	<0.001
Mean	**94.27**	**46.32**	**34.70**	**26.87**	**202.15**	**40.51**	**3.48**	**62.86**	**30.46**	**18.55**	**12.08**	**167.93**	9.67	<0.001

**Average of five traps*
F-I: Field I
F-II: Field II

Table S15: Bioefficacy of insecticides against fruit fly, Bactrocera spp. infesting mango at Rewalsar during Year 1st

Treatment	Fruit infestation (%) 10 days after			Mean fruit infestation (%)
	Spray I	SprayII	Spray III	
Lambda-cyhalothrin (0.004%)	17.53(24.76)	12.54(20.74)	9.20(17.66)	12.90(21.05)
Emamectin benzoate (0.002%)	23.31(28.87)	17.73(24.91)	12.98(21.12)	17.82(24.97)
Rynaxypyr (0.006%)	23.53(29.02)	17.83(24.98)	13.32(21.41)	18.04(25.14)
Diflubendiamide (0.01%)	23.08(28.72)	19.07(25.90)	13.43(21.50)	18.36(25.37)
Spinosad (0.002%)	28.82(32.47)	22.12(28.06)	17.64(24.84)	22.70(28.46)
Indoxacarb (0.007%)	31.04(33.86)	26.65(31.08)	19.98(26.55)	25.75(30.50)
Malathion (0.1%)	33.20(35.18)	28.82(32.47)	22.12(28.06)	27.93(31.90)
Control (water)	49.07(44.47)	56.74(48.88)	72.38(58.30)	59.62(50.55)
Mean	28.34(32.17)	24.43(29.63)	21.22(27.43)	

Figures in parentheses are arc sine transformed values
***CD** $_{(0.05)}$*
Treatment (T): (1.08), Spray Interval (I): (1.77), T×I: (3.06)

Table S16: Bioefficacy of insecticides against fruit fly, Bactrocera spp. infesting mango at Rewalsar during Year 2nd

Treatment	Fruit infestation (%) 10 days after			Mean fruit infestation (%)
	Spray I	SprayII	Spray III	
Lambda-cyhalothrin (0.004%)	23.04(28.67)	16.96(24.31)	11.34(19.67)	17.11(24.22)
Emamectin benzoate (0.002%)	27.32(31.49)	22.61(28.37)	15.28(23.00)	21.74(27.62)
Rynaxypyr (0.006%)	28.59(32.31)	23.10(28.71)	16.67(23.85)	22.79(28.29)
Diflubendiamide (0.01%)	32.26(34.59)	26.83(31.18)	19.10(25.90)	26.06(30.56)
Spinosad (0.002%)	34.18(35.76)	28.07(31.98)	19.47(26.17)	27.24(31.30)
Indoxacarb (0.007%)	38.82(38.52)	30.91(33.76)	23.07(28.69)	30.93(33.66)
Malathion (0.1%)	40.57(39.55)	32.29(34.62)	26.67(30.98)	33.18(35.05)
Control (water)	53.51(46.99)	61.87(51.85)	71.36(57.62)	62.24(52.15)
Mean	34.79(35.99)	30.33(33.10)	25.37(29.49)	

Figures in parentheses are arc sine transformed values
***CD** $_{(0.05)}$*
Treatment (T): (1.28), Spray Interval (I): (0.79), T×I: (2.22)

Table S17: Bioefficacy of insecticides against fruit fly, Bactrocera spp. infesting cucumber at Nauni during Year 1st

Treatment	Fruit infestation (%) 10 days after			Mean fruit infestation (%)
	Spray I	SprayII	Spray III	
Lambda-cyhalothrin (0.004%)	22.41(28.22)	18.24(25.12)	10.37(18.77)	17.01(24.04)
Emamectin benzoate (0.002%)	31.21(33.91)	25.00(29.91)	15.88(23.46)	24.03(29.10)
Rynaxypyr (0.006%)	34.44(35.89)	29.09(32.62)	18.65(25.43)	27.40(31.31)
Diflubendiamide (0.01%)	35.10(36.24)	31.11(33.88)	19.58(26.14)	28.60(32.09)
Spinosad (0.002%)	39.39(38.84)	34.24(35.78)	20.50(26.77)	31.38(33.80)
Indoxacarb (0.007%)	41.16(39.88)	36.11(36.90)	23.15(28.74)	33.47(35.17)
Malathion (0.1%)	45.68(42.51)	40.60(39.55)	28.52(32.19)	38.27(38.08)
Control (water)	63.44(52.79)	72.62(58.44)	77.04(61.50)	71.03(57.57)
Mean	39.10(38.53)	35.88(36.53)	26.71(30.37)	-

Figures in parentheses are arc sine transformed values
***CD** $_{(0.05)}$*
Treatment (T): (2.70), Spray Interval (I): (1.66), T×I: (4.68)

Table S18: Bioefficacy of insecticides against fruit fly, Bactrocera spp. infesting cucumber at Nauni during Year 2nd

Treatment	Fruit infestation (%) 10 days after			Mean fruit infestation (%)
	Spray I	SprayII	Spray III	
Lambda-cyhalothrin (0.004%)	22.42(28.19)	18.98(25.64)	10.00(18.43)	17.13(24.09)
Emamectin benzoate (0.002%)	32.12(34.49)	25.59(30.35)	16.20(23.38)	24.64(29.41)
Rynaxypyr (0.006%)	34.54(35.92)	30.20(33.30)	19.05(25.57)	27.93(31.60)
Diflubendiamide (0.01%)	35.55(36.57)	32.12(34.49)	19.58(26.14)	29.08(32.40)
Spinosad (0.002%)	40.00(39.22)	35.35(36.46)	20.64(26.82)	32.00(34.17)
Indoxacarb (0.007%)	41.67(40.19)	37.12(37.50)	24.07(29.36)	34.29(35.69)
Malathion (0.1%)	45.92(42.64)	40.56(39.54)	29.44(32.81)	38.64(38.33)
Control (water)	64.65(53.50)	73.33(58.91)	77.78(61.85)	71.92(58.09)
Mean	39.61(38.84)	36.66(37.02)	27.10(30.55)	-

Figures in parentheses are arc sine transformed values
***CD** $_{(0.05)}$*
Treatment (T): (2.70), Spray Interval (I): (1.65), T×I: (4.67)

Table S19: Effect of application of insecticides against fruit fly, Bactrocera spp., on fruit yield in mango during Year 1st

Treatment	Mean yield (kg/tree)	Times increase over control (x)	Times increase /decrease in yield over recommended insecticide (x)
Lambda-cyhalothrin (0.004%)	7.6	4.5	3.4
Emamectin benzoate (0.002%)	7.2	4.2	3.0
Rynaxypyr (0.006%)	6.2	3.6	2.0
Diflubendiamide (0.01%)	5.7	3.4	1.5
Spinosad (0.002%)	5.3	3.1	1.1
Indoxacarb (0.007%)	4.6	2.7	*
Malathion (0.1%)	4.2	2.5	-
Control (water)	1.7	-	-
CD$_{(0.05)}$	0.4		

**Indicate value<1*
*** Indicate malathion*

Table S20: Effect of application of insecticides against fruit fly, Bactrocera spp., on fruit yield in mango during Year 2nd

Treatment	Mean yield (kg/tree)	Times increases over control (x)	Times increase /decrease in yield over recommended insecticide (x)
Lambda-cyhalothrin (0.004%)	11.7	3.8	5.0
Emamectin benzoate (0.002%)	11.0	3.5	4.3
Rynaxypyr (0.006%)	10.2	3.3	3.5
Diflubendiamide (0.01%)	9.8	3.2	3.1
Spinosad (0.002%)	8.4	2.7	1.7
Indoxacarb (0.007%)	7.6	2.5	*
Malathion (0.1%)	6.7	2.2	-
Control (water)	3.1	-	-
CD$_{(0.05)}$	0.8		

*Indicate value<1
** Indicate malathion

Table S21: Effect of application of insecticides against fruit fly, Bactrocera spp., on fruit yield in cucumber during Year 1st

Treatment	Mean yield (kg/plant)	Times increase over control	Times increase /decrease in yield over recommended insecticide (x)
Lambda-cyhalothrin (0.004%)	5.8	3.4	2.8
Emamectin benzoate (0.002%)	5.2	3.1	2.2
Rynaxypyr (0.006%)	4.8	2.8	1.8
Diflubendiamide (0.01%)	4.3	2.5	1.3
Spinosad (0.002%)	3.9	2.3	*
Indoxacarb (0.007%)	3.4	2.0	*
Malathion (0.1%)	3.0	1.8	-
Control (water)	1.7	-	-
$CD_{(0.05)}$	0.4		

*Indicate value<1
** Indicate malathion

Table S22: Effect of application of insecticides against fruit fly, Bactrocera spp., on fruit yield in cucumber during Year 2nd

Treatment	Mean yield (kg/plant)	Times increase over control (x)	Times increase /decrease in yield over recommended insecticide (x)
Lambda-cyhalothrin (0.004%)	6.1	2.9	2.5
Emamectin benzoate (0.002%)	5.4	2.6	1.8
Rynaxypyr (0.006%)	5.2	2.5	1.6
Diflubendiamide (0.01%)	4.8	2.3	1.2
Spinosad (0.002%)	4.7	2.2	1.1
Indoxacarb (0.007%)	3.9	1.9	*
Malathion (0.1%)	3.6	1.7	-
Control (water)	2.1	-	-
$CD_{(0.05)}$	0.3		

*Indicate value<1
** Indicate malathion

Table S23: Avoidable loss due to application of insecticides against fruit fly in mango during Year 1st

Treatment	Mean yield (kg/tree)	Increase in yield over control (kg)	Avoidable loss in comparison to control (%)	Avoidable loss in comparison to malathion (%)
Lambda-cyhalothrin (0.004%)	7.60	5.90	77.63	44.74
Emamectin benzoate (0.002%)	7.20	5.50	76.39	41.67
Rynaxypyr (0.006%)	6.20	4.50	72.58	32.26
Diflubendiamide (0.01%)	5.70	4.00	70.18	26.32
Spinosad (0.002%)	5.30	3.60	67.92	20.75
Indoxacarb (0.007%)	4.60	2.90	63.04	8.70
Malathion (0.1%)	4.20	2.50	59.52	-
Control (water)	1.70	-	-	-

Table S24: Avoidable loss due to application of insecticides against fruit fly in mango during Year 2nd

Treatment	Mean yield (kg/tree)	Increase in yield over control (kg)	Avoidable loss in comparison to control (%)	Avoidable loss in comparison to malathion (%)
Lambda-cyhalothrin (0.004%)	11.70	8.60	73.50	42.74
Emamectin benzoate (0.002%)	11.00	7.90	71.81	39.09
Rynaxypyr (0.006%)	10.20	7.10	69.61	34.31
Diflubendiamide (0.01%)	9.80	6.70	68.37	31.63
Spinosad (0.002%)	8.40	5.30	63.10	20.24
Indoxacarb (0.007%)	7.60	4.50	59.21	11.84
Malathion (0.1%)	6.70	3.60	53.73	-
Control (Water)	3.10	-	-	-

Table S25: Avoidable loss due to application of insecticides against fruit fly in cucumber during Year 1st

Treatment	Mean yield (kg/plant)	Increase in yield over control (kg)	Avoidable loss in comparison to control (%)	Avoidable loss in comparison to malathion (%)
Lambda-cyhalothrin (0.004%)	5.8	4.1	70.69	48.28
Emamectin benzoate (0.002%)	5.2	3.5	67.31	42.31
Rynaxypyr (0.006%)	4.8	3.1	64.58	37.50
Diflubendiamide (0.01%)	4.3	2.6	60.47	30.23
Spinosad (0.002%)	3.9	2.2	56.41	23.08
Indoxacarb (0.007%)	3.4	1.9	55.88	11.76
Malathion (0.1%)	3.0	1.3	43.33	-
Control (water)	1.7	-	-	-

Table S26: Avoidable loss due to application of insecticides against fruit fly in cucumber during Year 2nd

Treatment	Mean yield (kg/plant)	Increase in yield over control (kg)	Avoidable loss in comparison to control (%)	Avoidable loss in comparison to malathion (%)
Lambda-cyhalothrin (0.004%)	6.10	4.00	65.57	40.98
Emamectin benzoate (0.002%)	5.40	3.30	61.11	33.33
Rynaxypyr (0.006%)	5.20	3.10	59.62	30.77
Diflubendiamide (0.01%)	4.80	2.70	56.25	25.00
Spinosad (0.002%)	4.70	2.60	55.32	23.40
Indoxacarb (0.007%)	3.90	1.80	46.15	7.69
Malathion (0.1%)	3.60	1.50	41.67	-
Control (water)	2.10	-	-	-

Table S27: Benefit-cost ratio of insecticide application against fruit fly, Bactrocera spp. in mango during Year 1st

Treatment	Mean yield (kg/tree)	Increase in yield over control (kg)	Cost of increased yield @ Rs 50/kg	Cost of the test Treatment (Rs)	Net monetary Return (Rs)	Benefit Cost Ratio (BCR)
Lambda-cyhalothrin (0.004%)	7.60	5.90	295.00	4.03	290.97	72.20:1
Emamectin benzoate (0.002%)	7.20	5.50	275.00	36.36	238.64	6.56:1
Rynaxypyr (0.006%)	6.20	4.50	225.00	53.07	171.93	3.24:1
Diflubendiamide (0.01%)	5.70	4.00	200.00	48.30	151.70	3.14:1
Spinosad (0.002%)	5.30	3.60	180.00	12.31	167.69	13.62:1
Indoxacarb (0.007%)	4.60	2.90	145.00	15.55	129.45	8.32:1
Malathion (0.1%)	4.20	2.50	125.00	6.75	118.25	17.52:1
Control (water)	1.70	-	-	-	-	-

Table S28: Benefit-cost ratio of insecticide application against fruit fly, Bactrocera spp. in mango during Year 2nd

Treatment	Mean yield (kg/tree)	Increase in yield over control (kg)	Cost of increased yield @ Rs 50/kg	Cost of the test Treatment (Rs)	Net monetary Return (Rs)	Benefit Cost Ratio (BCR)
Lambda-cyhalothrin (0.004%)	11.70	8.60	430	4.03	425.97	105.70:1
Emamectin benzoate (0.002%)	11.00	7.90	395	36.36	358.64	9.86:1
Rynaxypyr (0.006%)	10.20	7.10	355	53.07	301.93	5.69:1
Diflubendiamide (0.01%)	9.80	6.70	335	48.30	286.70	5.94:1
Spinosad (0.002%)	8.40	5.30	265	12.31	252.69	20.53:1
Indoxacarb (0.007%)	7.60	4.50	225	15.55	209.45	13.47:1
Malathion (0.1%)	6.70	3.60	180	6.75	173.25	25.67:1
Control (water)	3.10	-	-	-	-	-

Table S29: Benefit-cost ratio of insecticide application against fruit fly, Bactrocera spp., in cucumber during Year 1st

Treatment	Mean yield (kg/plant)	Increase in yield over control (kg)	Cost of increased yield @ Rs 20/kg	Cost of the test Treatment (Rs.)	Net monetary Return (Rs.)	Benefit Cost Ratio (BCR)
Lambda-cyhalothrin (0.004%)	5.8	4.1	82.0	2.69	79.3	29.48:1
Emamectin benzoate (0.002%)	5.2	3.5	70.0	24.24	45.8	1.89:1
Rynaxypyr (0.006%)	4.8	3.1	62.0	35.14	26.9	*
Diflubendiamide (0.01%)	4.3	2.6	52.0	31.50	20.5	*
Spinosad (0.002%)	3.9	2.2	44.0	8.21	35.8	4.36:1
Indoxacarb (0.007%)	3.4	1.9	38.0	10.44	27.6	2.64:1
Malathion (0.1%)	3.0	1.3	26.0	4.50	21.5	4.78:1
Control (water)	1.7	-	-	-	-	-

**Indicate value<1*

Table S30: Benefit-cost ratio of insecticide application against fruit fly, Bactrocera spp. in cucumber during Year 2nd

Treatment	Mean yield (kg/plant)	Increase in yield over control (kg)	Cost of increased yield @ Rs 20/kg	Cost of the test Treatment (Rs)	Net monetary return (Rs)	Benefit Cost Ratio (BCR)
Lambda-cyhalothrin (0.004%)	6.10	4.0	80.0	2.69	77.3	28.74:1
Emamectin benzoate (0.002%)	5.40	3.3	66.0	24.24	41.8	1.72:1
Rynaxypyr (0.006%)	5.20	3.1	62.0	35.14	26.9	*
Diflubendiamide (0.01%)	4.80	2.7	54.0	31.50	22.5	*
Spinosad (0.002%)	4.70	2.6	52.0	8.21	43.8	5.33:1
Indoxacarb (0.007%)	3.90	1.8	36.0	10.44	25.6	2.45:1
Malathion (0.1%)	3.60	1.5	30.0	4.50	25.5	5.67:1
Control (water)	2.10	-	-	-	-	-

**Indicate value<1*

References

1. Drew R, Roming M (1997) Overview – Tephritidae in the Pacific and Southeast Asia. In: Management of fruit flies in the Pacific. Allwood AJ Drew RAI Eds.46–53.

2. Drew RAI, Hancock DL (1994) The *Bactrocera dorsalis* complex of fruit flies (Diptera: Tephritidae: Dacinae) in Asia. Bull Entomol Res Suppl Ser. 2:1–68.

3. David K, Ramani S (2011) An illustrated key to the fruit flies (Diptera: Tephritidae: Dacinae) of India and the adjacent countries. Zootaxa 3025(1):1–31.

4. Clarke AR, Armstrong KF, Carmichael AE, Milne JR, Raghu S, Roderick GK, et al (2005) Invasive phytophagous pests arising through a recent tropical evolutionary radiation: the *Bactrocera dorsalis* complex of fruit flies. Annu Rev Entomology 50:293–319.

5. Dhillon MK, Singh R, Naresh JS, Sharma HC (2005) The melon fruit fly, *Bactrocera cucurbitae*: a review of its biology and management. J Insect Science 5(1):40–40.

6. Gupta D, Verma AK (1992) Bionomics of fruit flies attacking cucurbits in Himachal Pradesh. Indian J Entomology 54(3):322–6.

7. Philippe R, Philippe DJ, Brevault T, Francois VJ (2010) Fruit flies (Diptera: Tephritidae) on vegetable crops in Reunion Island (Indian Ocean): state of knowledge, control+methods and prospects for management. Fruits 65(2):113–30.

8. Kumar A. Host range and distribution of fruit flies in India. J Insect Science 2011;6(2):17–25.

9. Yadav KP, Sharma VK, Singh R (2015) Human health implications of pesticide residues in fruits and vegetables: An Indian perspective. Agric Review 36(1):17–22.

10. Drew RAI, Hooper GHS (1981) The responses of fruit fly species (Diptera: Tephritidae) in the *Bactrocera dorsalis* complex to various attractants. J Aust Entomol Society 20(3):201–5.

11. Tan KH, Lee RY (1982) Attraction of male *Bactrocera tau* to cue-lure and methyl eugenol. J Econ Entomology 75(5):1023–5.

12. LeBlanc L, Vargas RI, Putoa R (2011) Attraction of *Bactrocera* spp. (Diptera: Tephritidae) to various protein-based lures in New Caledonia. Pest Manag Science 67(5):580–5.

13. Wee SL, Shelly TE (2013) Capture of wild males of *Bactrocera dorsalis* and *Bactrocera cucurbitae* (Diptera: Tephritidae) in multi-lure traps. Fla Entomology 96(4):1461–5.

14. Prabhakar CS, Sood P, Mehta PK (2007) Distribution and relative incidence of fruit fly species on cucurbitaceous crops in Himachal Pradesh. Environ Ecology 25(Special 4):1012–6.

15. Sood P, Nath A (1999) Population dynamics of fruit fly, *Bactrocera cucurbitae* in cucurbits. Ann Plant Prot Science 7(1):63–5.

16. Drew RAI (1974) The response of fruit fly species (Diptera: Tephritidae) in the south pacific area to male attractants. J Aust Entomol Society 13:267–70.

17. Vargas RI, Piñero JC, Leblanc L (2010) An overview of pest species of *Bactrocera* fruit flies (Diptera: Tephritidae) and the integration of biopesticides with other biological approaches for their management with a focus on the Pacific region. Insects 1(1):3–16.

18. White IM, Elson-Harris MM (1992) Fruit Flies of Economic Significance: Their Identification and Bionomics. Wallingford, UK: CAB International.

19. Nath P, Bhushan S, Kumar A (2007) Efficacy of certain eco-friendly insecticides and bait sprays against fruit fly (*B. cucurbitae*) infesting fruits of bottle gourd. Veg Science 34:150–2.

20. Sharma RK, Sinha SR (2009) Evaluation of insecticides and biopesticides against melon fruit fly, *Bactrocera cucurbitae* on bitter gourd. Indian J Plant Protection 37(1–2):113–6.

21. Gupta D, Verma AK, Bhalla OP (1990) Population monitoring of fruit flies (*Dacus zonatus* and *Dacus dorsalis*) infesting fruit crops in north- western Himalayan region. Indian J Agric Science 60:471–4.

22. Mahmood R, Mishkatullah (2007) Population dynamics of three species of fruit flies (Diptera: Tephritidae) in Chakwal district, Pakistan. Pak J Zoology 39(2):123–7.

23. Sunil TM, Jagadish KS, Chakravarthy AK (2016) Efficacy of insecticides against melon fruit fly, *Bactrocera cucurbitae* (Coquillett) in bitter gourd. Entomon 41:233–8.

24. Royer J. E. and Mayer DG (2018) Combining cue-lure and methyl eugenol in traps significantly decreases catches of most *Bactrocera*, *Zeugodacus* and *Dacus* species (Diptera: Tephritidae: Dacinae) in Australia and Papua New Guinea. J Econ Entomology 111(1):298–303.

25. Verghese A (1998) Studies on the host preferences and seasonal incidence of *Bactrocera dorsalis* in mango orchards. Pest Manag Hortic Ecosystem 4(1):1–5.

26. Inskeep JR, Spafford H, Vargas RI, Shelly TE (2018) Trapping male melon flies, *Zeugodacus cucurbitae* (Coquillett) (Diptera: Tephritidae), using mixtures of zingerone and cue-lure in the field. Proc Hawaii Entomological Society 50:67–75.

27. Shelly TE, Pahio E, Edu J (2004) Synergistic and inhibitory interactions between methyl eugenol and cue lure influence trap catch of male fruit flies, *Bactrocera dorsalis* (Hendel) and *B. cucurbitae* (Diptera: Tephritidae). Fla Entomology 87:481–6.

28. Sharma I (2018) Fertility table studies on fruit flies [*Bactrocera dorsalis* (Hendel) and *B. zonata* (Saunders)] on different fruit hosts and their management [PhD Thesis]. Dr. YS Parmar University of Horticulture & Forestry, Solan (HP). http://krishikosh.egranth.ac.in/handle/1/5810086228

29. Abrol DP (2017) Field evaluation of insecticides and biopesticides against fruit fly (*Bactrocera* spp.) in bitter gourd and bottle gourd. Indian J Entomology 79(3):257–62.

30. Singh G, Yadav DN, Bhushan B (2008) Development and evaluation of an IPM module for fruit fly management in mango. Indian J Entomology 70(1):59–63.

31. Thakur DR (2011) Evaluation of eco-friendly insecticides against fruit fly (*Bactrocera* spp.) in tomato and cucumber. Indian J Entomology 73(1):79–82.

