



Population suppression of fruit flies (*Bactrocera* spp) in mango (*Mangifera indica*) orchards

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ABSTRACT

By continuous trapping of fruit flies (*Bactrocera* spp. males) in 20-25 year old mango orchard (cv. Dashehari) during 2006-08 by using parapheromone-insecticide lure (0.1% methyl eugenol + 0.05% malathion) traps @ 10 traps/ha, also known as male annihilation technique (MAT), fruit fly catches declined significantly (>80%) in 2007 as compared with 2006. The fruit fly catches remained at a lower rate without any significant differences in average weekly catches during 2007 and 2008. Among the trapped species, *Bactrocera dorsalis* Hendel was the predominant with highest seasonal catch in July. The other species, *B. zonata* (Saunders) attained its peak activity in May and its population was almost half that of *B. dorsalis*. In 2008, population of fruit flies in orchard where long term mass trapping of males was carried out was 83.4% lower than in the orchard where traps were not installed. In other field trial, four modules in combination with MAT were tested and all tested modules significantly lowered fruit fly infestation as compared with the control-orchard. Maximum protection (94.5%) was recorded with a module involving MAT+ sanitation+ soil drenching with 0.1% choryriphos+ bait cover spray (0.05% malathion + 0.2% Protinex). It was followed by the one with MAT +sanitation+ soil drenching (87.3% protection), MAT+ sanitation+ cover spray (81.8% protection), and MAT+ sanitation (65.5% protection).

Key words: *Bactrocera dorsalis*, *B. zonata*, Mango, Male annihilation technique, Methyl eugenol

The fruit flies, *Bactrocera* spp (Tephritidae: Diptera), are the most destructive pests of many fruits and vegetables all over the world. They cause heavy losses in mango especially in late maturing varieties. Frequent and excessive use of insecticides to control these pests leads to many environmental hazards including toxic residues on the harvested fruits and also results in inadequate control. Therefore, there is an urgent need of an approach integrating bio-rational methods as one of the components to suppress the pest. Male annihilation technique (MAT) using parapheromone, methyl eugenol along with insecticide has been applied to suppress male population of fruit flies (Vargas *et al.* 2000, 2003, Vergese *et al.* 2006a, Stonehouse *et al.* 2007). Integrated management of fruit flies using this technique along with other methods of management has been found effective by various workers (Patel *et al.* 2005, Thomas *et al.* 2005, Singh *et al.* 2008, Vergese *et al.* 2006b).

In Himachal Pradesh, mango is an emerging fruit crop

of low hills and valley areas. The oriental fruit fly, *Bactrocera dorsalis* Hendel and peach fruit fly, *B. zonata* (Saunders) are serious pests of mango in the state (Gupta and Bhatia 2000, Singh *et al.* 2007) which result in heavy losses in fruit yield. These studies were therefore, conducted to know the long term impact of male annihilation technique on suppression of fruit flies population in a mango orchard and its effect on fruit infestation in combination with other approaches of pest management.

MATERIALS AND METHODS

The studies were conducted from April 2006 to September 2008 in farmer's orchards in village Jalari, district Hamirpur, Himachal Pradesh on 20-25 year old mango trees (cv Dashehari) planted at 10 m × 10 m distance.

To study the effect of long term mass trapping of fruit flies, locally made bottle traps were used in the selected mango orchard. The trap consisted of a wide mouth polyurethane bottle to which a yellow metallic canopy was attached with the help of wire. A similar wire was used for hanging the trap from the branch of the tree. The bottle was filled with 100ml attractant- insecticide (0.1 % methyl eugenol and 0.05 % malathion) solution. Traps were installed on mango trees at about 1.5 m above the ground level @ 10

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Table 1 Fruit fly catches upon continuous mass trapping in methyl eugenol traps

Month	2006			2007			2008			Mean of species**		Overall mean
	<i>B.d.</i>	<i>B.z.</i>	Mean	<i>B.d.</i>	<i>B.z.</i>	Mean	<i>B.d.</i>	<i>B.z.</i>	Mean	<i>B.d.</i>	<i>B.z.</i>	
April	50.7* (7.02)	71.1 (7.8)	60.9 (7.41)	25.4 (4.98)	4.6 (2.12)	15 (3.55)	10.8 (3.27)	5.6 (2.35)	8.2 (2.81)	29 (5.09)	26.1 (4.09)	28 (4.59)
May	46.5 (6.62)	155.2 (12.4)	100.8 (9.51)	12.2 (3.46)	30.2 (5.42)	21.2 (4.44)	18.9 (4.12)	113.3 (10.17)	66.1 (7.14)	25.9 (4.74)	99.5 (9.33)	62.7 (7.03)
June	172.2 (12.62)	106.3 (10.02)	139.2 (11.32)	34.4 (5.85)	13.7 (3.68)	24 (4.76)	28.5 (5.27)	23.2 (4.74)	25.9 (5.01)	78.3 (7.91)	47.7 (6.15)	63 (7.03)
July	405 (20.11)	95.1 (9.1)	250 (14.61)	32.6 (5.69)	10.6 (3.25)	21.6 (4.47)	31.1 (5.52)	6.7 (2.55)	18.9 (4.03)	156.2 (10.44)	37.5 (4.97)	96.8 (7.7)
August	103.6 (10.05)	9.8 (3.11)	56.7 (6.58)	25.2 (5.01)	3.8 (1.95)	14.5 (3.48)	14.3 (3.76)	1.7 (1.28)	8 (2.52)	47.71 (6.28)	5.1 (2.11)	26.4 (4.19)
September	79.6 (8.88)	10.5 (3.21)	45 (6.05)	32.1 (5.63)	7 (2.63)	19.5 (4.13)	26.3 (5.11)	2 (1.4)	14.1 (3.25)	46 (6.54)	6.5 (2.41)	26.3 (4.48)
Mean	142.9 (10.89)	74.6 (7.61)	108.8 (9.25)	27 (5.1)	11.6 (3.17)	19.3 (4.14)	21.6 (4.51)	25.4 (3.75)	23.5 (4.13)	63.8 (6.83)	37.2 (4.84)	

CD (P=0.05): Months: (0.91); Species: (0.52); Years: (0.64); Month × Species: (1.29); Month × Year: (1.59); Species × Year: (0.91); month×Species×Year:(2.25)

* Average of five traps/week and average of four weeks was taken per month; ** *B.d* and *B.z* refer to *Bactrocera dorsalis* and *B. zonata*, respectively; the figures in parentheses are square root transformed values

traps/ha. The fruit fly catches were recorded at weekly interval from April 2006 to September 2008 and solution in traps was replenished after each counting. The data on fruit fly catches were subjected to square root transformation and analyzed by RBD (factorial) for comparing the populations between years, months and species.

To further validate the impact of long term mass trapping of fruit flies, another experiment was conducted during the cropping period, 2008. The population of fruit flies in the orchard where long term mass trapping was carried out from April 2006 was compared with another orchard in the village in which no such trapping was done, using bottle traps containing solution of methyl eugenol (0.1%) and malathion (0.05%). The traps were installed at the rate of 10 traps per hectare in both the orchards in third week of June (25th standard week), 2008. The fruit fly catches were recorded at weekly interval up to first week of September (36th standard week), 2008. The attractant-insecticide solution in traps was replenished after each counting.

To evaluate the male annihilation technique (MAT) along with other management methods for the control of fruit flies in mango (cv. Dashehari), four modules were tested. The trial was conducted in farmer's orchard in a randomized block design. In first module (T₁) MAT and regular destruction of fallen fruits (field sanitation) was followed. For MAT, oblong ply board blocks (80 mm × 25 mm × 20 mm) impregnated with a mixture of ethanol, methyl eugenol and malathion (6:4:1 v/v) were used. The blocks were soaked in it for 24 hours and each block absorbed about 11 ml solution.

These blocks were put in bottle traps (one block per trap) to avoid wetting by rains. The bottle traps carrying treated wooden blocks were installed on mango trees @ 12 traps per hectare at 1.5m above the ground level during 22nd standard week (last week of May). In T₂, MAT+ sanitation and two soil-drenchings with chlorpyrifos (0.1 %) at 15-day interval (first drenching in mid June) were followed. In T₃, MAT+ sanitation + two cover bait sprays with malathion (0.05%) and Protinex (0.2%) at 15-day interval (first spray in mid June) were used. In T₄, all the four control measures, viz. MAT, sanitation, drenching and cover sprays were exercised. Untreated mango orchard at about 1.5 km from the experimental orchard in the village served as control (T₅). There were five replications with a tree as replicate. At harvest, physiologically mature mango fruit (20 and 25 fruit per tree during 2007 and 2008, respectively) were collected randomly from each tree and kept in separate cages for ripening and recording data on infestation by fruit flies. The data were converted into per cent fruit infestation and subjected to $\sqrt{(n+0.5)}$ transformation before the analysis of the same.

RESULTS AND DISCUSSION

The continuous and long term mass trapping of fruit flies using methyl eugenol as parapheromone resulted in significant reductions in mean-population of fruit flies trapped in each trap from 108.8 in 2006 to 19.3 and 23.5 in 2007 and 2008, respectively (Table 1). The weekly catches of *Bactrocera dorsalis* (142.9 and 27 flies/trap) and *B. zonata*

(74.6 and 11.6 flies/trap) differed significantly between years 2006 and 2007. Thus more than 80 per cent reductions in weekly catches were observed during 2007 when compared with that of 2006. After that the population of fruit flies was maintained at lower level and no differences occurred in weekly catches between 2007 and 2008 (27 and 21.6 for *B. dorsalis*; 11.6 and 25.4 flies/trap for *B. zonata*). The highest average fruit fly catch (96.8 flies/trap) was found in the month of July which was also on par with average weekly catches in May and June. However, when compared alone, the highest weekly catches of *B. dorsalis* (156.2 flies/trap) and *B. zonata* (99.5 flies/trap) were found in the months of July and May, respectively. *B. dorsalis* remained the predominant fruit fly species and resulted in significantly higher average weekly catches than *B. zonata* except in the month of May in all the years when the population of *B. zonata* was significantly higher than *B. dorsalis*. This higher population of *B. zonata* in the month of May during the study period seems to be migratory population from adjoining orchards as its trapping in mango orchard coincided with the ripening of the peach fruits.

Further, to find out the impact of long term mass trapping on the population of fruit flies, fruit fly catches in orchard (A) where long term mass trapping was carried out since April 2006 were compared during 2008 with another orchard (B) with no earlier mass trapping history. In orchard (A), there was 83.4 per cent lower number of average fruit fly catches per week as compared to orchard (B). The average number of fruit fly males/trap/week was 30.3 in orchard (A) as against 182.7 in orchard (B) (Table 2). The orchard (B) supported significantly higher fruit fly catches in all the weeks except during 36th standard week (first week of September) when no significant differences occur in fruit fly catches in Orchard (A) and (B). This may be because of the reduction in fruit flies in the traps in both the orchards. Again the fruit fly catches remained higher in the month of July. Average fruit fly catch was highest during 27th standard week (first week of July) which was also at par with fruit fly catch in 29th standard week (third week of July).

Suppression of population of a pest is useful for long term control of that pest. In present studies, by using male annihilation technique we found considerable reductions (more than 80%) in fruit fly catches during 2008 when compared with that in 2006. Suppression of populations of fruit flies using male annihilation technique has also been reported by various workers (Vargas *et al.* 2000,2003, Stonehouse *et al.* 2007). In an eradication programme in Queensland, Australia Hancock *et al.* (2000) found decline in trap catches in fruit fly, *B. papayae* five months after using male annihilation technique along with protein baiting with 99.9% decline after one year as compared to original levels. Area- wide suppression of Mediterranean fruit fly, *Ceratitidis capitata* and oriental fruit fly, *B. dorsalis* in 40 km² in Kamuela, Hawaii in 6 years period has been reported by

Table 2 Comparative weekly catches of fruit flies during 2008 in orchard (A) with long term mass trapping from April 2006 and orchard (B) without long term mass trapping

Standard week (2008)	Average number of fruit flies/ trap/week*		Mean
	Orchard (A)	Orchard (B)	
25	43.8 (6.52)	236.0 (15.29)	139.9 (10.90)
26	43.0 (6.48)	170.8 (12.89)	106.9 (9.69)
27	40.8 (6.37)	482.2 (21.10)	261.5 (13.73)
28	27.6 (5.22)	177.4 (12.10)	102.5 (8.67)
29	51.0 (7.13)	289.2 (15.83)	170.1 (11.48)
30	31.6 (5.45)	329.2 (16.50)	180.4 (10.97)
31	40.6 (6.33)	127.8 (10.51)	84.2 (8.42)
32	18.0 (4.07)	93.8 (9.04)	55.9 (6.55)
33	13.8 (3.64)	78.8 (8.69)	46.3 (6.17)
34	14.2 (3.75)	82.2 (8.70)	48.2 (6.23)
35	17.6 (4.17)	70.0 (8.01)	43.8 (6.09)
36	21.8 (4.61)	55.6 (7.25)	38.7 (5.93)
Mean	30.3 (5.3)	182.7 (12.16)	

CD (0.05) for Weeks: (2.64); Orchards: (1.08); Weeks x Orchards: (3.75)

*Average of five traps; figures in parentheses square root transformed values

Vargas *et al.* (2010). The techniques used were male annihilation, sanitation along with GF-120 NF Naturalyte fruit fly bait sprays, Biolure® traps and parasitoids. The programme resulted in 90.0 and 60.7% reductions in fruit infestation by *C. capitata* and *B. dorsalis*, respectively.

The impact of male annihilation technique (MAT) along with other components of pest management on fruit infestation has been presented in Table 3. All the modules resulted in lower fruit infestation (0-5% in 2007; 0.8-2.4% in 2008) than the untreated orchard (14% in 2007; 7.2% in 2008). In both years, lowest fruit infestation was in M₄, where all the four treatments (MAT+ sanitation+ cover spray + soil drenching) were followed; however, it was also at par with M₂ (MAT + sanitation + soil drenching) and M₃ (MAT + sanitation + cover spraying).

Integrated module/treatment- M₄ (MAT+ sanitation + two cover sprays+ soil drenching) provided maximum mean protection, i.e. 94.5% followed by 87.3% in M₂ (MAT + sanitation+ soil drenching), 81.8% in M₃ (MAT+ sanitation + cover sprays) and 65.5% in M₁ (MAT+ sanitation). Integrated modules using MAT along with other approaches of control have also been found effective in controlling fruit flies in fruit crops by various workers. MAT along with other control measures like soil drenching, cover sprays, bait application technique (BAT) and fruit clean up and disposal has been found effective in eradicating *Bactrocera dorsalis* from Mauritius (Seewooruthun *et al.* 2000). Khan *et al.* (2005) found integrated module comprising methyl eugenol traps, hoeing, baiting and chemical sprays best for controlling fruit

Table 3 Fruit fly infestation in physiologically mature mango fruit in different IPM modules

Module	2007		2008		Mean reduction over control (%)
	Fruit infestation	Reduction over control (%)	Fruit infestation (%)	Reduction over control (%)	
M ₁	5.0 (2.20)*	64.3	2.4 (1.56)	66.7	65.5
M ₂	2.0 (1.37)	85.7	0.8 (0.99)	88.9	87.3
M ₃	2.0 (1.37)	85.7	1.6 (1.27)	77.8	81.8
M ₄	0.0 (0.71)	100.0	0.8 (0.99)	88.9	94.5
M ₅	14.0 (3.78)		7.2 (2.72)		
CD (P=0.05)	(0.99)		(0.85)		

*The figures in parentheses are $\sqrt{(n+0.5)}$ transformed values

M₁, MAT+ sanitation; M₂, MAT+ sanitation+ two soil drenching; M₃, MAT+ sanitation+ two cover sprays; M₄, MAT+ sanitation+ two cover sprays+ two soil drenching; M₅, unprotected mango orchard

flies in most perishable fruits. Vergese *et al.* (2006b) obtained 100% control of mango fruit fly, *B. dorsalis* in cv. Banganapalli with MAT, sanitation and cover spray with deltamethrin (0.5 ml/l) + azadirachtin (0.03) (2 ml/l). Even MAT and sanitation could bring the fruit fly infestation to 5.55% against 17.78 to 66.67% in control. In present studies also, MAT and sanitation provided 65.5% fruit protection from fruit flies. The present studies also get support from Singh *et al.* (2008) who reported IPM module consisting of MAT, BAT and field sanitation very effective against fruit flies in mango reducing damage up to 87-95%.

These studies indicate that the male annihilation technique has a great impact on the population of fruit flies in mango orchards. This technique is ecofriendly and has long term impact on population of fruit flies in an area. The male annihilation technique along with other management methods such as field sanitation, cover bait spraying and soil drenching can be an effective approach to manage fruit flies in mango.

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