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Response of fruit flies, *Bactrocera* spp. (Diptera: Tephritidae) to different shapes of methyl eugenol based traps in guava orchards of Punjab

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Abstract
Different shaped methyl eugenol based traps were evaluated against Oriental fruit fly, *Bactrocera dorsalis* (Hendel) and peach fruit fly, *Bactrocera zonata* (Saunders) in guava orchard from 30th SMW to 38th SMW during 2014-15. The results revealed that triangular traps (111.17 males/trap/week) had captured significantly more population followed by PAU fruit fly traps (67.39 males) followed by cylindrical traps (65.44 males) followed by spherical traps (50.28 males). The mean percentage of fruit fly damage was also lowest in triangular traps i.e. 14.47 Percent as compared to PAU fruit fly traps (16.33%), cylindrical traps (18.14%) and spherical traps (18.14%). However, cost: benefit ratio was quite low in triangular traps (1:28.20) as compared to cylindrical traps (1:68.10), spherical traps (1:82.95) and PAU fruit fly traps (1.92.00).

Keywords: guava, fruit flies, *Bactrocera* spp., methyl eugenol, traps

1. Introduction
Fruit flies are also known as Peacock flies or ornamental flies due to strutting behaviour and wing vibrating [1]. Fruit flies are medium sized, two winged flies (Dipterans) in which hind legs are modified as balancing organs during flight. They are economically important insect pests which attack wide variety of fruits, as well as a few vegetable crops. The Tephritidae (true fruit flies) include some of the world's most serious agricultural pests [2]. Of the 4500 known species of fruit flies worldwide, nearly 200 are considered as pests but 70 species are regarded as agriculturally important throughout the world [3, 4]. David and Ramani [5] reported 325 species in the Indian subcontinent of which 243 in 79 genera are from India alone. Oriental fruit fly, *Bactrocera dorsalis* (Hendal) and guava fruit fly, *B. zonata* (Saunders) are a serious pest of guava, which causes almost 100 Percent damage to rainy season guava crop [6]. These fruit flies have been managed mainly by conventional insecticides or cover sprays from the ground. However, the ecological and toxicological side-effects of the extensive use of such chemicals (e.g. environmental pollution, human health hazards, killing of natural enemies, pesticides residues), as well as the growing interest in pesticide free fruits, has turned attention to alternative control methods [7]. The most widely used technique of this kind is male annihilation technique (MAT) where methyl eugenol, a para-pheromone is used together with an insecticide impregnated into a suitable substrate. This technique has been successfully used for the eradication and control of several *Bactrocera* species [8-10]. Methyl eugenol specially attracts the males of *B. dorsalis*, *B. correcta* (Bezzi) and *B. zonata* [11]. This eco-friendly approach have great advantages like no labour cost, cheap as compared to chemical insecticides, insecticide residue free fruits and no ill-effect on natural enemies, human health and environment [6].
All previous studies have focused on the sole or combined effects of these traps without providing any information on the effect of shape of the trap on fruit fly catch. The aim of the present study was to compare various shapes of methyl eugenol based traps for controlling and mass trapping of *Bactrocera* spp. in guava orchards.

2. Materials and Methods
The present study was carried out during 2014-15 at farmers' orchard, village Jainpur, district Ludhiana (30° 55' N, 75° 54' E), Punjab. Four different shapes of the traps i.e. spherical, cylindrical, triangular and PAU fruit fly traps (based on empty water bottle) as control were

used. The traps used in MAT technique were consisted of immersing water absorbable plywood blocks (7.5 cm × 6.0 cm × 2.0 cm) in the solution of ethyl alcohol, methyl eugenol and malathion mixed in a glass jar in the ratio of 6:4:1 (v/v) for 72 hrs so that this solution was properly absorbed in the plywood blocks. Four holes were made with the help of a hot electric iron rod on the upper side of the PAU fruit fly trap, spherical trap (yellow plastic ball) and cylindrical trap (a plastic jar) for entry of fruit flies. There was no need for making holes in triangular traps. PAU fruit fly traps and spherical traps were cut from bottom with knife and plywood blocks were hanged inside the traps with two sides of wire coming out from the top of the traps. Tape was used to cover the cut portion of the spherical traps. In cylindrical traps, hole was made on the lid and plywood block was hanged inside the trap with wire coming out from two sides from the top of trap. In triangular traps, hole was made on top of the trap and plywood block was hanged with the help of wire. The baited traps were hanged with the trees in equidistance @ 4 traps each in one acre area, thus consisting of total 16 traps/acre and replicate four times. The traps were fixed in second week of July (30th Standard Meteorological Week) in guava orchards. The traps were kept in the orchards till the fruit harvesting was over.

As far as, collection of fruit flies was concerned, in case of PAU fruit fly trap, the lower cut portion of the trap was removed and all the fruit flies trapped were collected in a carry bag after every 7 days. Lower cut potion of the trap was again fixed with the trap. In cylindrical trap, tape was removed and all trapped fruit flies were collected in carry bag and new tape was used to cover the hole. In case of cylindrical trap, lid was removed from upper side and all the fruit flies trapped in the trap were collected in a carry bag. In triangular trap, the sticky sheet was replaced weekly with new sheet and sticky sheet having fruit flies was collected in a carry bag. The carry bags were labelled with the marker and fruit flies trapped/trap were counted in the laboratory at weekly interval.

For evaluating fruit infestation, sample of 50 fruits at random/treatment collected at weekly interval were sorted out as infested (based on ovipositor puncture) and healthy fruits. Percent fruit infestation was worked out. Trap catches and Percent fruit infestation were subjected to completely randomized block (CRD) analysis by CPCS1 after suitable conversion of the data [12].

3. Results

3.1 Trap Catch

Mean population of fruit fly males of *Bactrocera* spp. captured/trap/week in guava orchard using different shapes of fruit fly traps depicted that triangular traps had more population of fruit flies captured as compared to PAU fruit fly, cylindrical and spherical traps (Table 1). The study initiated in 30th SMW had high population i.e. 41.25 males in triangular traps, 14.25 in PAU fruit fly traps, 13.50 in cylindrical traps and 6.50 in spherical traps during the first week. The data recorded at weekly interval till 38rd SMW showed that the mean population of males captured showed progressive increase in spherical traps and triangular traps till 35th SMW and then the population started declining after 36th SMW. In cylindrical traps and PAU fruit fly traps, the mean population of male captured had a progressive increase till 36th SMW and then the population started declining after 37th SMW. The highest mean population was recorded in triangular traps (183.50 males) and spherical traps (122.75 males) in 35th SMW while in PAU fruit fly traps (124.75 males) and cylindrical traps (121.75 males), the highest mean population was recorded in 36th SMW. Pooled mean of all the weekly observations revealed that the number of fruit fly males captured/trap/week was significantly high in triangular traps (111.17) as compared to PAU fruit fly (67.39 males), cylindrical (65.44 males) and spherical (50.28 males) traps, which was significantly on par with each other.

3.2 Percent fruit Infestation

The impact of captured male fruit flies on infestation of fruits indicated that first fruit infestation was observed in 30th SMW (Figure 1) when 8.75 Percent infestation was recorded in PAU fruit fly traps and 9.00 Percent infestation was recorded in cylindrical traps when the fruits were near colour break stage. Triangular traps had 11.50 Percent fruit infestation whereas 12.75 Percent fruit infestation was observed in spherical traps. As the season progressed (with the initiation of colour break stage on fruits and later on with the onset of maturity of the fruits), the Percent infested fruits in treatment with PAU fruit fly traps andcylindrical traps showed the progressive increase till 33rd SMW and started decreasing after 34th SMW while in spherical traps and triangular traps, the Percent infestation increased till 34th SMW and started decreasing after 35th SMW. The highest fruit infestation was observed in 34th SMW i.e. 26.75 and 23.75 Percent in cylindrical trapsandPAU fruit fly traps, while in spherical traps (24.75%) and triangular traps (20.00%), it was in 34th SMW. Mean of all the weekly observations showed that Percent fruit infestation was lowest in triangular traps (14.47%) as compared to PAU fruit fly (16.33%), cylindrical (18.14%), and spherical (18.14%) traps, though there were non-significant differences.

3.3 Cost: Benefit Ratio

The yield/acre (MT) was significantly high in case of triangular traps (8.06 MT) as compared to PAU fruit fly traps (7.44 MT), spherical traps (6.85 MT) and cylindrical traps (6.08 MT). The net income/acre was highest (Rs. 1, 55,680) in triangular traps in comparison to PAU fruit fly traps (Rs. 1, 47,200). However, the cost: benefit ratio was quite high in PAU fruit fly traps (1:92) to that of 1:28.20 in triangular traps, which was almost 3.25 times more to that of triangular traps (Table 2).

4. Discussion

The study showed that although triangular traps had significantly high trap catch and low fruit damage, however, cost: benefit ratio was quite low in triangular traps as compared to other traps. Similarly, Bekker *et al.* [13] conducted a study to check the efficacy of two commercially available traps i.e. yellow Delta traps and yellow Bucket traps, used for monitoring of *B. oleae* (Rossi) (olive fruit fly). The yellow Delta traps caught significantly more *B. oleae* than the yellow Bucket traps, as well as significantly more *B. oleae* males than females. *Ceratitis capitata* (Wiedemann) and *B. biguttula* (Bezzi) were also trapped during the study. For both species, yellow Delta traps caught significantly more individuals than yellow Bucket traps. Alike, Thiyagarajan *et al.* [14] revealed that methyl eugenol based yellow sticky lure trap that have yellow poly pack board of size 30×20 cm in size in a vertical hanging position attracted highest number of fruit flies, *B. dorsalis* in mango and sapota orchard.

However, Stonehouse *et al.* [15] reported that square and oblong blocks were more effective in attracting *Bactrocera*

spp. than round and hexagonal blocks in mango and guava orchards. Rajitha and Viraktamath [16] reported that in guava, *B. correcta* was attracted to spheres and cylinders while *B. zonata* to bottle traps but *B. dorsalis* did not show any preference to trap shape. Rajitha and Viraktamath [17] reported that in mango ecosystem, *B. correcta* and *B. zonata* showed preference to spheres and bottle. But Chandaragi *et al.* [18] observed that bottle trap was found to have significantly higher trap catch in mango as compared to cylinder, sphere, PCI and open trap. Daniel *et al.* [19] has reported cylindrical traps as best for trapping cherry fruit fly, *R. cerasi* (Linnaeus). Whereas Rizk *et al.* [20] opined that Abdel-Kawi trap charged with 0.5 ml methyl eugenol was the most effective trap than bottle trap, glass McPhail trap and plastic McPhail trap.

5. Conclusion

Findings from above studies concluded that triangular traps had captured significantly high population of male fruit flies as compared to cylindrical traps, spherical traps and PAU fruit fly traps in guava orchard. Percent damage was lowest in triangular traps than cylindrical traps, spherical traps and PAU fruit fly traps. However, cost: benefit ratio was quite low in triangular traps as compared to other traps.

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Table 1: Mean population of *Bactrocera* spp. males captured in different shapes of traps in guava during 2014-15

Treatments	*Mean *Bactrocera* males/trap/week									
	July 23-29 (30)**	July 30-Aug. 5 (31)	Aug. 6-12 (32)	Aug. 13-19 (33)	Aug. 20-26 (34)	Aug. 27- Sep. 2 (35)	Sep. 3-9 (36)	Sep. 10-16 (37)	Sep. 17-23 (38)	Pooled mean
Cylindrical traps	13.50 (3.70)	18.00 (4.28)	44.75 (6.76)	59.00 (7.74)	70.25 (8.43)	85.50 (8.80)	121.75 (11.08)	92.00 (9.58)	84.25 (9.22)	65.44 (7.82)
Spherical traps	6.50 (2.73)	12.25 (3.46)	25.75 (5.14)	43.25 (6.62)	54.50 (7.44)	122.75 (11.08)	115.00 (10.74)	44.00 (6.70)	28.50 (5.42)	50.28 (6.63)
Triangular traps	41.25 (6.49)	62.75 (3.49)	58.00 (7.67)	69.25 (8.37)	125.00 (11.13)	183.50 (13.56)	176.25 (13.30)	151.00 (12.31)	133.50 (11.59)	111.17 (10.29)
PAU fruit fly traps	14.25 (3.88)	14.50 (3.91)	30.75 (5.62)	50.25 (7.14)	95.50 (9.67)	105.00 (10.28)	124.75 (11.19)	98.50 (9.96)	73.00 (8.60)	67.39 (7.44)
LSD	(0.95)	(1.64)	(0.81)	(0.90)	(1.98)	(2.93)	(1.12)	(1.30)	(0.61)	(2.21)

*Mean of 4 replications; **SMW-standard meteorological week; Figures in parentheses are √n+1 transformation

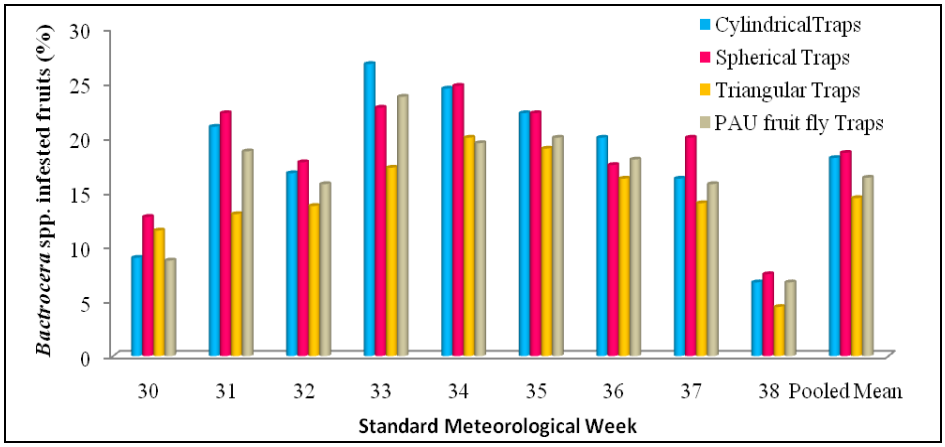

Fig 1: Per cent *Bactrocera* spp. infested fruits of guava with different shapes of fruit fly traps during 2014-15

Table 2: Cost: benefit ratio of different shapes of traps in guava during 2014-15

Treatments	Expenditure, Income and Cost: benefit ratio/acre				
	*Total Expenditure (Rs)	Yield/acre (MT)	Gross income (Rs)	Net income (Rs)	Cost: benefit ratio
Cylindrical traps	1760	6.08	121600	119840	1:68.10
Spherical traps	1632	6.85	137000	135368	1:82.95
Triangular traps	5520	8.06	161200	155680	1:28.20
PAU fruit fly traps	1600	7.44	148800	147200	1:92

*Based on 16 traps/acre; Number of trees/acre=132; average weight of fruit =96 g; @ Rs.20/kg fruit

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