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Management of fruit flies in rainy season guava through male annihilation technique using methyl eugenol based traps

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ABSTRACT

The results revealed that 16 traps/acre had significantly more population of captured males of *Bactrocera dorsalis* (Hendel) and *B. zonata* (Saunders) compared to 4, 8 and 12 traps/acre. More the number of males captured, less were the maggots/fruit and the fruits in 16 traps/ acre had significantly less number of maggots. Population of fruit flies started appearing in 28th SMW on guava crop and reached maximum during 39th SMW. A total of 80,663.99 males were trapped from 28th to 39th SMW. Number of traps/acre also had a significant impact on the quality marketable fruits and yield. Yield/ acre varied from 6.08 metric tonnes in 4 traps/acre to 8.06 metric tonnes in 16 traps/acre compared to only 0.22 metric tonne in untreated control. Population was positively correlated with relative humidity and sunshine but maximum temperature, minimum temperature, mean temperature, wind speed, rainfall, evaporation and number of rainy days had negative impact. The peak activity of fruit flies was found coinciding with the maturity of fruit.

Key words: Fruit flies, guava, male annihilation technique, methyl eugenol, traps.

INTRODUCTION

Guava ranks second amongst fruits in Punjab with an area of 7.84 thousand hectares. However, fruit flies, *Bactrocera* spp. are the major limiting factors in successful cultivation causing almost 100 per cent damage to rainy season crop (Sharma *et al.*, 8). In general, fruit flies are very difficult to manage due to the fact that they are polyphagous, multivoltine, adults have high mobility and fecundity, and all the developmental stages are unexposed (Vargas *et al.*, 16). Only adults are exposed while eggs and maggots remain protected in the host tissues, thus most of insecticidal treatments are ineffective. Application of insecticides disrupts the ecosystem and causes numerous hazards, which warrants the need of integrated approach for fruit fly management (Verghese *et al.*, 18).

Among the various alternate strategies available for the management of fruit flies, the use of methyl eugenol traps stands as the most outstanding alternative. Methyl eugenol, when used together with an insecticide impregnated into a suitable substrate, forms the basis of male annihilation technique (MAT) has been found very effective in monitoring and management of *Bactrocera* spp. on different fruit crops (Vargas *et al.*, 17). Singh and Sharma (12) compared the trapping efficiency of different types of methyl eugenol based traps in Kinnow mandarin in Punjab and found that mineral water bottle trap was more efficient as compared to other traps. In the past, though much work had been done on various management components (Vargas *et al.*, 15) including cultural practices, MAT, bait application technique (BAT) and chemical control but very less control of fruit flies was achieved by applying the individual control approach. Thus, keeping in view the importance of fruit flies on guava crop, the present investigation was undertaken to study the abundance and management of fruit flies on rainy season guava crop in Punjab.

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MATERIALS AND METHODS

Studies on abundance and management of fruit flies were carried out during 2010-2011 in the guava orchard of University Seed Farm, Ladhowal, Ludhiana by using methyl eugenol based MAT. One litre capacity mineral water bottle traps developed at Indian Institute of Horticultural Research, Bengaluru (Verghese *et al.*, 19) and further modified at PAU, Ludhiana were used. The traps used in MAT technique consisted of immersing water absorbable plywood blocks (7.5 cm x 6.0 cm x 2.0 cm) in a solution of ethyl alcohol, methyl eugenol (98%) and malathion mixed in a glass jar in the ratio of 6:4:1 (v/v) for 72 h so that the solution was properly absorbed in the plywood blocks. A hole in the block was made with the help of a drill to put wire for fixing/hanging on tree. Four holes were made with the help of a hot iron rod on the upper side of bottle for entry of fruit flies (Singh and Sharma, 12).

The baited bottles were fixed/ hanged with the trees at equidistant and there were four treatments

consisting of 4, 8, 12 and 16 traps/acre. Each treatment was replicated thrice. The traps were fixed in the last week of June in the orchard. These traps were kept in the orchard till the fruit harvesting was over. Bottles were fixed/ hanged at a height of 1-1.5 m from ground level, depending upon the height of tree, at a place receiving no direct sunlight. Red coloured reflecting tape was also tied on the tree for easy accessibility of traps. The lower cut portion of bottle (lid) was removed and all the fruit flies trapped in bottle were collected in carry bag after every 7 days and then, the lid was again re-fixed. The carry bags were labelled and fruit flies trapped/trap were counted when the number was low. However, when there was large number of fruit flies, the count was made on weight basis (av. fruit flies/g 223).

For fruit infestation, a sample of 50 fruits at random/ treatment was collected at weekly interval, and infested (based on the oviposition puncture) and healthy fruits were counted. Data were also recorded for number of maggots/fruit by dissecting the fruits. For different species of fruit flies, a random sample of 100 flies was taken and identified for the proportion of different species. Impact of number of traps on the quality of marketable fruits and yield was also assessed from 5 trees at full maturity. Yield/acre (tonne) was calculated. The data on various aspects were subjected to statistical analysis after suitable conversions of the data using the software CPCS1.

RESULTS AND DISCUSSION

Total males of *Bactrocera* sp. trapped/week in guava orchard through MAT depicted that 16 traps/ acre had significantly more population compared to 4, 8 and 12 traps/acre (Table 1). The studies from 28th standard meteorological week (SMW) to 39th SMW clearly showed that the population of males captured in different traps had a progressive increase and it reached at its maximum in 39th SMW. Pooled means showed that total No. of males trapped/week were significantly more in 16 compared to 4 traps/acre.

The average males captured/trap indicated that irrespective to the number of traps/acre, the males captured in 4, 8, 12 and 16 traps/acre were significant during different SMWs. However, the average number of males captured in different traps showed a progressive increase and reached at its maximum in 39th SMW (Table 2). Mean males/trap/ week increased from 59.67 in 4 traps during 28th SMW to 422.25 during 39th SMW. Similarly, there was a significant increase in number of males trapped in 16 traps, which varied from 28.46 to 270.12 over 28th to 39th SMW. The results showed that since the concentration of methyl eugenol was equal in all the traps, the males were equally attracted in all

Table 1. Population of *Bactrocera* spp. captured on guava through male annihilation technique.

Treatment (Trap/acre)	Total fruit fly males trapped/week*											
	July 9-15 (28 SMW)**	July 16-22 (29)	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)	Sep 24-30 (39)	Pooled Mean
4	238.67	360.67	478.00	683.33	812.00	988.00	1138.67	1250.33	1345.67	1469.33	1586.33	1689.00	1003.33
	(15.48)	(19.02)	(21.88)	(26.15)	(28.51)	(31.43)	(33.75)	(35.37)	(36.70)	(38.34)	(39.84)	(41.11)	(30.64)
8	272.00	435.67	628.67	838.33	1047.00	1241.33	1422.33	1609.00	1806.33	2004.33	2206.33	2405.00	1326.36
	(16.52)	(20.90)	(25.10)	(28.97)	(32.37)	(35.25)	(37.73)	(40.12)	(42.51)	(44.78)	(46.98)	(49.05)	(35.02)
12	334.33	601.00	919.00	1197.67	1490.33	1807.67	2078.33	2351.67	2627.33	2933.67	3199.00	3528.33	1922.36
	(18.31)	(24.53)	(30.33)	(34.62)	(38.62)	(42.53)	(45.60)	(48.50)	(51.27)	(54.17)	(56.57)	(59.41)	(42.04)
16	455.33	787.33	1131.33	1494.00	1845.67	2200.33	2525.33	2922.67	3300.67	3653.67	4001.33	4321.67	2386.61
	(21.35)	(28.07)	(33.65)	(38.66)	(42.97)	(46.91)	(50.26)	(54.07)	(57.50)	(60.45)	(63.26)	(65.74)	(46.91)
CD (p=0.05)	(1.08)	(0.75)	(0.98)	(0.96)	(1.06)	(1.56)	(1.06)	(0.77)	(0.73)	(0.78)	(0.81)	(1.22)	(9.69)

*Mean of 3 replications; **SMW = standard meteorological week; figures in parentheses are transformed values

Table 2. Average populations of *Bactrocera* spp. captured/trap on guava through male annihilation technique.

Treatment (Trap/acre)	Mean fruit fly males/trap/week*										Pooled Mean
	July 9-15 (28 SMW)**	July 16-22 (29)	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)	Sep 24-30 (39)	
4	59.67 (7.79)	90.17 (9.55)	119.50 (10.98)	170.83 (13.11)	203.00 (14.28)	247.00 (15.74)	284.67 (16.90)	312.60 (17.71)	336.42 (18.37)	367.35 (19.19)	396.58 (19.94)	422.25 (20.57)	250.84 (15.34)
8	34.00 (5.92)	54.46 (7.45)	78.59 (8.92)	104.79 (10.29)	130.88 (11.48)	155.17 (12.50)	177.79 (13.37)	201.14 (14.22)	225.79 (15.06)	250.53 (15.86)	275.79 (16.64)	300.63 (17.37)	165.80 (12.42)
12	27.86 (5.37)	50.07 (7.15)	76.58 (8.81)	99.80 (10.04)	124.19 (11.19)	150.64 (12.31)	173.19 (13.20)	195.97 (14.03)	218.94 (14.83)	244.46 (15.67)	266.58 (16.36)	294.02 (17.18)	160.19 (12.18)
16	28.46 (5.42)	49.21 (7.09)	70.71 (8.47)	93.37 (9.71)	115.36 (10.79)	137.52 (11.77)	157.80 (12.60)	182.66 (13.55)	206.29 (14.40)	228.36 (15.14)	250.09 (15.85)	270.12 (16.46)	149.16 (11.77)
CD (p = 0.05)	(0.35)	(0.26)	(0.33)	(0.36)	(0.41)	(0.63)	(0.40)	(0.28)	(0.25)	(0.26)	(0.26)	(0.35)	(0.25)

*Mean of 3 replications; **SMW = standard meteorological week; figures in parentheses are transformed values

the traps. The difference in total number of males captured among traps was only due to the variations in number of traps/acre. The results presented in Fig.1 showed that during the entire crop season of guava (12 weeks), a total number of 12,040, 15,916, 23,068 and 29,639 males were captured in 4, 8, 12 and 16 traps/ acre, respectively. MAT using methyl eugenol traps @ 4 traps/ acre in mango and guava has been found to be very effective in controlling fruit flies in different parts of India (Stonehouse *et al.*, 14). Viraktamath and Sureshbabu (20) reported that in guava, *B. dorsalis* had one peak at Dharwad conditions. There were three peaks of *B. dorsalis* in guava orchard, while *B. correcta* (Bezzi) had only one peak in 2004, but it had two peaks (Ravikumar, 6). Palam Trap was found effective in monitoring and management of 10 species of fruit flies including *B. dorsalis* and *B. zonata* on fruits and vegetables in Himachal Pradesh (Mehta *et al.*, 4) as also found in the present studies in which methyl eugenol attracted both the species. Sharma (9) also found methyl eugenol traps to be effective against *Bactrocera* complex on mango, guava, sapota and peach also as observed in the present studies.

The results indicated that the fruit fly adult population appeared about 2 weeks earlier (*i.e.* 28th SMW in Table 1) than the actual start of fruit infestation recorded in 30th SMW (Table 3). It was due to the fact that the infestation on fruits was related with the population build up and appropriate fruit maturity or initiation of colour break stage of fruit for the egg laying. At the beginning (30th SMW), the infestation in different treatments, *i.e.* 4 to 16 traps/acre was 2.00 to 3.33 per cent compared to untreated control (15.33%). With the initiation of colour break stage on fruit and later on with the onset of the maturity of fruits, per cent infested fruits in different treatments also showed a progressive increase. The maximum

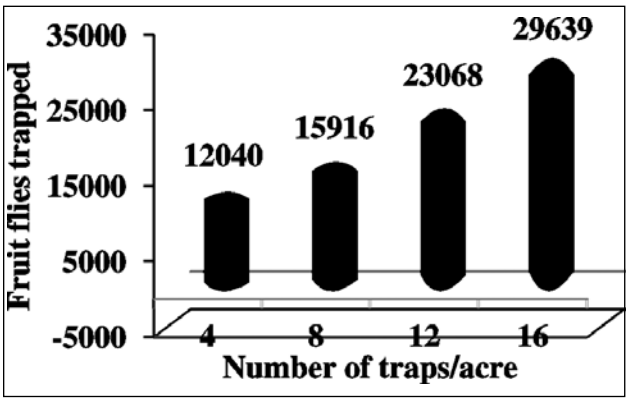

Fig. 1. Total *Bactrocera* spp. males trapped in guava (2010 & 11).

Table 3. Per cent *Bactrocera* spp. infested fruits of guava in male annihilation technique.

Treatment (Trap/acre)	Per cent infested fruits*									
	July 23-29 (30 SMW)**	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
4	3.33	6.67	8.67	12.00	14.67	22.67	26.00	30.67	34.67	17.71
	(10.40)	(14.92)	(17.09)	(20.22)	(22.47)	(28.40)	(30.60)	(33.54)	(36.03)	(23.79)
8	2.67	4.67	5.33	8.00	10.67	15.33	20.67	23.33	28.67	13.26
	(9.26)	(12.41)	(13.29)	(16.42)	(19.04)	(23.01)	(27.02)	(28.87)	(32.36)	(20.22)
12	2.00	2.67	3.33	6.67	8.67	11.33	15.33	17.33	21.33	9.85
	(8.13)	(9.26)	(10.40)	(14.92)	(17.09)	(19.65)	(23.03)	(24.59)	(27.49)	(17.21)
16	2.00	2.00	2.00	4.67	6.00	10.67	12.67	14.67	17.33	8.00
	(8.13)	(8.13)	(8.13)	(12.41)	(14.17)	(19.04)	(20.83)	(22.50)	(24.59)	(15.34)
Control	15.33	24.00	26.67	35.33	40.67	52.67	70.67	89.33	98.00	50.30
	(23.03)	(29.31)	(31.06)	(36.45)	(39.60)	(46.51)	(57.26)	(71.03)	(83.41)	(46.22)
CD (p = 0.05)	(2.38)	(2.53)	(2.55)	(2.25)	(2.48)	(2.55)	(3.98)	(4.06)	(5.36)	(3.73)

*Mean of 3 replications; **SMW = standard meteorological week; figures in parentheses are transformed values

fruit infestation was observed in 38th SMW, which varied from 17.33 per cent in 16 traps/acre to 34.67 per cent in 4 traps/acre. However, the fruit infestation in untreated control was significantly high (98.00%). Overall per cent fruit infestation was significantly low (8.00%) in 16 traps/acre compared to 17.71 per cent in 4 traps/acre, whereas in untreated control, it was 50.30 per cent. Singh (9, 10) observed that incidence of fruit fly and pupal counts/kg fruit increased as the season and maturity of fruits advanced which corroborate the present findings. Jalaluddin *et al.* (3) observed a distinct peak of *B. correcta* in guava orchards with the ripening of fruits from July to August. The present findings also showed some similarity with the findings of other workers (Dwivedi *et al.*, 1). The population build up was negatively correlated with temperature and rainfall. As the season advanced, the attack of *B. dorsalis* also increased during the fruiting period. Sharma (9) observed a low level of fruit fly population in methyl eugenol based trap during hot and dry summer months, when fixed in mango, guava, sapota and peach orchards. In the present findings, a clear peak was recorded during July-September in guava crop coinciding with the maturity of fruits, which corroborates the findings of other workers (Singh and Sharma, 12, 13).

To observe the impact of MAT on mating of females and subsequently on egg laying on fruits, the results indicated that more the number of males captured, less were the maggots/fruit (Table 4). Sixteen traps/acre had significantly less number of maggots/fruit compared to 4 traps/acre. After 38th SMW, due to change in climatic conditions, the number of maggots/fruit decreased. The possible reasons could be the decrease in temperature, host availability and harvesting of fruits over the time. The proportion *B. zonata* was low compared to *B. dorsalis*. Though the infestation of fruits decreased with the increase in traps/unit area but still some mating occurs. Furthermore, in the present studies, methyl eugenol has been found to be the most powerful male lure usually for the males of *B. dorsalis* and *B. zonata* both for monitoring and management as also reported by other workers (Singh and Sharma, 12, 13). This technique has been successfully used for the eradication and control of several *Bactrocera* species and could also be found useful in Punjab as the present findings showed a significant impact in reducing the damage and increasing the quality fruit yield. Eradication/suppression campaigns were made by using combination of methyl eugenol and insecticides against *B. dorsalis* by several workers but the present findings indicated that 16 traps/acre in guava were very effective in reducing fruit fly damage as also reported in Japan and in India.

Table 4. Mean number of maggots of *Bactrocera* spp. per fruit of guava in male annihilation technique.

Treatment (Trap/acre)	No. of maggots/fruit/week*									
	Aug 6-12 (32 SMW)**	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)	Sep 24-30 (39)	Oct 1-7 (40)	Pooled Mean
4	18.27 (4.39)	18.10 (4.37)	20.37 (4.62)	22.10 (4.80)	24.90 (5.09)	28.63 (5.44)	32.83 (5.82)	21.43 (4.74)	17.63 (4.32)	22.70 (4.84)
8	17.13 (4.26)	17.93 (4.35)	18.07 (4.37)	20.33 (4.62)	23.30 (4.93)	27.13 (5.30)	30.43 (5.61)	16.63 (4.20)	14.30 (3.91)	20.58 (4.62)
12	11.33 (3.51)	12.00 (3.60)	13.77 (3.84)	17.60 (4.31)	18.87 (4.45)	22.00 (4.79)	24.77 (5.08)	11.80 (3.57)	10.93 (3.45)	15.90 (4.07)
16	5.67 (2.58)	8.00 (3.00)	9.33 (3.21)	9.33 (3.21)	10.57 (3.40)	16.73 (4.21)	17.03 (4.25)	8.03 (3.00)	5.63 (2.57)	10.04 (3.27)
Control	24.37 (5.04)	25.87 (5.18)	26.73 (5.27)	36.70 (6.14)	38.97 (6.32)	48.43 (7.03)	50.33 (7.16)	25.17 (5.11)	22.57 (4.85)	33.24 (5.79)
CD (p = 0.05)	(0.23)	(0.27)	(0.24)	(0.24)	(0.26)	(0.25)	(0.19)	(0.24)	(0.19)	(0.62)

*Mean of 3 replications; **SMW = standard meteorological week; figures in parentheses are transformed values

The correlation between captured males of *Bactrocera* /trap and different abiotic factors (Table 5) revealed that minimum temperature (r = -0.83 to -0.87), wind speed (r = -0.59 to -0.60) and evaporation (r= -0.57 to -0.59) were having negative correlation with the male population captured in different treatments while sunshine (r= 0.42 to 0.44) and relative humidity (r = 0.07 to 0.028) were having a slight positive impact in different treatments. A significant positive correlation was observed between trap catches of *B. dorsalis* and *B. zonata* in guava with maximum and minimum temperature (Gupta and Bhatia, 2).

Sarada *et al.* (7) found that the fruit fly incidence in guava had significant positive correlation with maximum temperature and non-significant but there was positive correlation with minimum temperature. According to Rajitha and Viraktamath (5), *B. dorsalis* in guava had significant positive correlation with minimum temperature and morning and afternoon relative humidity, but had significant negative correlation with maximum temperature. Abiotic factors played an important role in the regulation of *B. correcta* population; however, in the current findings it was variable. Singh (11) reported that guava fruit infestation by *B. dorsalis* was positively correlated with rainfall, mean temperature and relative humidity while it had negative correlation with light intensity but in the present study, the male capture showed inconsistent correlation. Impact of number of traps/acre on the quality marketable fruits and yield of guava crop indicated that the number of traps/acre had a direct impact on quality marketable fruits/tree (Table 6). Yield/acre (MT) varied from 6.08 to 8.06 metric tonnes, respectively in 4 and 16 traps, whereas only 0.22 metric ton yield was recorded in untreated control. The results revealed that 16 traps/acre had significantly more population of captured males of *Bactrocera dorsalis* (Hendel) and *B. zonata* (Saunders) compared to 4, 8 and 12 traps/acre.

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Table 5. Correlation between captured males of *Bactrocera* spp. per trap and different abiotic factors on guava.

Treatment (Traps/acre)	Max temp (°C)	Min temp (°C)	Mean temp (°C)	RH (%)	Wind speed (km/h)	Sunshine (h)	Rainfall (mm)	Evaporation (mm)	No. of rainy days
4	-0.46	-0.83*	-0.04	0.028	-0.59*	0.42	-0.44	-0.58*	-0.40
8	-0.48	-0.87*	-0.03	0.007	-0.60*	0.44	-0.43	-0.58*	-0.41
12	-0.47	-0.86*	-0.04	0.009	-0.60*	0.44	-0.44	-0.57	-0.41
16	-0.48	-0.86*	-0.03	0.014	-0.60*	0.44	-0.43	-0.59*	-0.39

*Significant at (p = 0.05); critical value of r = 0.58

Table 6. Impact of number of traps on the quality of marketable fruits and yield of guava.

Treatments (Trap/acre)	No. of marketable fruits/tree*	Fruit yield (kg/tree)*	Yield/acre (MT)
4	480.00	46.08	6.08
8	540.40	51.88	6.85
12	587.00	56.35	7.44
16	635.80	61.04	8.06
Control	17.40	1.67	0.22
CD (p=0.05)	14.00	1.34	0.18

*Mean of 5 trees; number of trees/acre=132; average weight of fruit =96 g

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