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POPULATION BUILD UP OF FRUIT FLIES, *BACTROCERA* SPP. (DIPTERA: TEPHRITIDAE) IN RELATION TO HOST AVAILABILITY ASSOCIATED WITH CUCURBITS IN MID-HILL HIMALAYAS

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ABSTRACT

Fruit flies associated with cucurbits took steadily build up coincided with the fruiting period of crops. The lowest trap catches were observed before the fruit set ranged from 6.00 to 25. 67 and 33.00 to 131.67 at Palampur and Hamirpur, respectively. However, the highest trap catches were recorded after fruit setting ranged from 15.66 to 212.34 and 32.33 to 349.00 at Palampur and Hamirpur, respectively. There was a significant positive correlation between total trap catches and per cent fruit infestation of the crops(+0.843**& +0.977** on cucumber and +0.904**& +0.904** on bitter gourd and +0.918**& +0.567* on cucumber and +0.811**& +0.946** on bitter gourd during 2009 & 2010 at Palampur and Himirpur, respectively). The maggot density per infested fruit also showed strong positive correlation with per cent fruit infestation. During the two study years, at both the locations the highest weekly trap catches were observed during peak fruiting period of crops and remained low before fruiting period and last stage of crops,which indicates that host fruit availability acts as the primary regulating factor in the population dynamics of fruit flies.

KEY WORDS
fruit flies
Bactrocera spp.
Cucurbits
Population density, host

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INTRODUCTION

The dipteran family Tephritidae consists of over 4000 species, of which nearly 700 species belong to Dacine fruit flies (Fletcher, 1987). However, 250 species are of economic importance and distributed widely in temperate, sub-tropical and tropical regions of the world (Christenson and Foote, 1960). In India, fruit flies are identified as one of the ten most serious problems of the entire agriculture and because of the polyphagous nature of their larvae, many species cause high economic losses in fruits and vegetables. of 207 species of fruit flies in India, nine are identified to be the major and economically important (Sardana *et al*., 2005).

The fruit flies constitute an important group of pests infesting cucurbit vegetables. Two species namely *B. cucurbitae* and *B. tau* commonly called as melon fruit flies are the major species found infesting cucurbits. Besides, they have been found feeding on solanaceous crops like tomato and brinjal (Kapoor and Agarwal, 1983). Another fruit fly species, *B. scutellaris* has also been recorded on cucurbits (Sunandita and Gupta, 2007). The extent of losses caused by *B. cucurbitae* varies from 30 to 100 per cent depending on the cucurbit species and season (Dhillon *et al*., 2005). It has been reported to infest 95 per cent bitter gourd fruits in New Guinea and 90 per cent snake gourd and 60 to 87 per cent pumpkin fruits in Solomon Islands (Hollingsworth *et al*., 1997). About 50 per cent of cucurbits are partially or completely damaged by fruit flies in India (Gupta and Verma, 1992).In India Singh *et al*. (2000), however, reported fruit infestation of 31.27 per cent infestation on bitter gourd and 28.55 per cent on water melon. The melon fruit flies have more than 80 hosts and their economic importance can not be evaluated entirely from the standpoint of the direct damage to the various crops affected. Quarantine laws aimed at preventing the entry and establishment of melon flies and hence reduce the export potential of crop produce. Generally, the female fruit flies puncture the soft and tender fruits by their sharp ovipositor and lay the eggs under fruit tissues and watery fluid oozes from the puncture. Sometimes pseudo-punctures (punctures without eggs) have also been reported on fruit skin, which reduces the market value of the produce. The eggs are also reported to be laid into unopened flowers and the maggots successfully develop in the taproots, stems and leaf stalks (Weems and Heppner, 2001). After hatching, the maggots feed on the pulp of the fruits by making galleries and simultaneously the secondary infection also comes, resulting in rotting of fruits. Depending on the available resources, a population can grow continuously till it reaches the capacity level. But when the population reaches a level at which the cost of management of the pest equals the crop value lost due to pest injury, then application of management strategy is necessary. In order to understand what drives pest

numbers and apply sustainable management tools, it is necessary to understand the factors influencing the population density of the pest. The oviposition and feeding behavior of fruit flies is mostly host dependent as maggot development take place entirely inside the fruit and pupation occurred in soil, where they remain unaffected by insecticides. Fruit flies cause havoc in cucurbit growing areas of North India, even some farmers are avoiding to grow these vegetables because of this devastating pest. Therefore, the present investigation was carried out to study the influence of cucumber and bitter gourd fruit availability on the population build up of fruit flies infesting cucurbits at two different locations *viz.*, Palampur and Bara (Hamirpur) in mid-ill Himalayas of Himachal Pradesh, India. The objective of the present investigation was to know the contributionof host availability on population outbreaks of melon fruit flies.

MATERIALS AND METHODS

Studies on thepopulation build up of melon fruit flies in relation to fruit availability on cucumber and bitter gourd were carried out at Entomological Experimental Farm, CSKHPAU, Palampur situated at an altitude of 1290 meter above mean sea level between 32º6' North Latitude and 76º3' East Longitude and at farmer's field, Bara (Hamirpur) situated at 585 meter above mean sea level between 31º35' North Latitude and 76º16' East Longitude during crop growing seasons of 2009 and 2010.

Raising of crops

Seed sowing of cucumber variety "Khira 90" and bitter gourd variety "Solan Hara" was done in polythene bags containing the mixture of soil, sand and FYM and raised under greenhouse conditions. The transplanting of seedlings of both the crops was done under open field conditions during third week of April at Palampur and at farmer's field during third week of February in 2009 and 2010. The experiment was laid out in Randomized Block Design with plot size of 4.5 x 3.5 m. The distance from row to row and plant to plant was maintained at 1.5 m x 60 cm and 1.5 m x 90 cm for cucumber and bitter gourd, respectively. The recommended doses of fertilizers were applied and hand weeding was done to keep the weeds under check. The crops were raised as per the recommended package of practices (Anonymous, 2008).

Monitoring of adult fruit flies, *Bactrocera* spp.

In the present study, the population of male adult fruit flies was monitored with the help of pheromone traps at both the locations. The traps and sex attractants *viz.*, cuelure and methyl eugenol used in the present study were obtained from Pest Control India Pvt Ltd., Mumbai and Spectrochem Pvt. Ltd., New Delhi, respectively. The traps (Fligh-T™) consists of three parts, yellow coloured base, a translucent dom and a slot for insertion of the lure. The base of the traps were filled with the malathion (3mL/liter of water) and a cotton wad charged with 4 to 5 mL of cuelure and methyl eugenol, was inserted in the slot under the dom and the dom was fitted over the base. A nylon fishing line was used for hanging the trap and installed at 1.5 meter above the ground level just after the transplanting. The traps were recharged at weekly intervals with malathion and after every fortnight with cuelure and meyhyl eugenol.The adult males were collected at weekly intervals, separated, identified up to species level, counted and recorded throughout the growing season of the crops.

In order to know the fruit fly species associated with cucurbits, the infested cucumber and bitter gourd fruits were collected at weekly intervals from the commencement of pickings at both the locations. The infested cucumber and bitter gourd fruits were kept in rearing cages at the rate of five infested fruits of each crop per cage separately in the laboratory. A layer of mixture of soil and sand was put on the bottom side of the cage and sprinkled with water after every two days to maintain the favorable moisture for normal pupation and adult emergence .The emerged and trapped fruit flies were collected and identified up to the species level with the help of key (Ramani, 1997).

Fruit infestation

At weekly intervals, the entire marketable size fruits of each crop irrespective of healthy and infested fruits were plucked separately. At every fruit picking, twenty five fruits of each crop were randomly selected and infested and healthy fruits were sorted out to calculate the per cent fruit infestation as:

$$\text{Per cent fruit infestation} = \frac{\text{No. of infested fruits}}{\text{Total no. of fruits}} \text{X } 100$$

Estimation of maggot population

The maggot population was recorded on the basis of number of maggots per infested fruit. For estimation of maggot population, the infested fruits were brought in the laboratory in polythene bags. The infested fruits were cut open to count the total number of maggots per fruit after two to three days as described by Takeish (1992). The number of maggots per fruit was computed by observing fifteen randomly taken fruits. Infestation index based on the number of maggots and per cent fruit infestation was worked out as described by Mehta *et al.* (1998) as

$$\text{Infestation index} = \log\left(\frac{\text{Mean no. of maggots/fruits} \times \text{Per cent fruit infestation}}{100} + 1\right)$$

Correlation studies

The correlation of mean number of maggots per infested cucumber and bitter gourd fruit with per cent fruit infestation was worked out. The correlation of total weekly trap catches of fruit flies attacking cucurbits with per cent fruit infestation was also determined. The data was subjected to analysis with SPSS.

RESULTS AND DISCUSSION

The population dynamics is the aspect of population ecology dealing with factors playing a vital role in population densities. The biotic and abiotic factors might lead to modification in dispersal and development of insect species (Karuppaiah and Sujayanad, 2012). Favorable weather conditions and probability of pest outbreaks are furthermore determined by

Table 1: Trap catches *vis-a-vis* maggot population and fruit infestation by melon fruit flies, *Bactrocera* spp. on cucumber and bitter gourd at Palampur during 2009

Sampling date	Standard week	Number of fruit flies trapped/week*				Mean no. of maggots/infested fruit#		Fruit infestation (%)##		Infestation index	
		B. tau	*B. cucurbitae*	*B. scutellaris*	Total	Cucumber	Bitter gourd	Cucumber	Bitter gourd	Cucumber	Bitter gourd
April-29	17	3.33	-	5.00	8.33	-	-	-	-	-	-
May-6	18	5.00	-	12.67	17.67	-	-	-	-	-	-
13	19	5.67	-	7.00	12.67	-	-	-	-	-	-
20	20	13.00	-	34.67	47.67	-	-	-	-	-	-
27	21	8.00	-	15.33	23.33	-	-	-	-	-	-
June-3	22	82.00	-	25.00	107.00	52.53 (7.19)	-	44.00 (41.53)	-	1.28	-
10	23	66.33	-	14.67	81.00	47.60 (6.87)	-	40.00 (39.20)	-	1.30	-
17	24	46.67	4.33	28.33	80.66	44.27 (6.60)	-	36.00 (36.84)	-	1.22	-
24	25	76.00	1.67	11.33	92.00	42.80 (6.48)	-	41.33 (39.99)	-	1.26	-
July-1	26	21.33	7.00	4..67	31.66	36.53 (5.10)	23.00 (4.78)	36.00 (36.84)	28.00 (31.90)	1.15	0.87
8	27	38.67	1.00	9.33	54.66	26.07 (5.04)	22.67 (4.82)	30.67 (33.60)	24.00 (29.27)	0.94	0.80
15	28	67.00	2.00	23.67	92.67	53.07 (7.21)	23.00 (4.80)	49.33 (44.60)	33.33 (35.24)	1.43	0.93
22	29	85.33	-	42.00	128.99	62.33 (7.89)	17.80 (4.26)	56.00 (48.43)	30.67 (33.60)	1.55	0.80
29	30	107.00	5.00	55.33	170.33	-	24.33 (4.94)	-	37.33 (37.64)	-	1.01
August-5	31	75.33	-	38.67	115.00	-	28.00 (5.32)	-	34.66 (36.04)	-	1.02
12	32	119.00	12.00	63.00	194.00	-	28.73 (5.40)	-	42.67 (40.76)	-	1.12
19	33	131.67	5.00	71.67	212.34	-	33.93 (5.84)	-	50.67 (45.36)	-	1.26
26	34	70.00	1.67	45.00	123.67	-	24.93 (5.04)	-	38.67 (38.43)	-	1.02
September- 2	35	57.00	-	27.33	86.99	-	21.13 (4.67)	-	30.67 (33.60)	-	0.86
9	36	37.33	2.00	13.00	55.99	-	16.80 (4.18)	-	21.33 (27.48)	-	0.65
CD (P = 0.05)		20.70	2.16	8.16	-	0.95	0.61	3.19	2.43	0.13	0.52

#Figures in the parentheses are square root transformed values; ##Figures in the parentheses are arc sine transformed values; *Mean of 3 replications

the incidence and characters of biotic disturbances all together with availability of suitable host. All the organisms particularly insects respond to every deviation from normal environmental conditions (Khaliq *et al.*, 2014). Under abiotic stresses, their population dynamics may be affected to some extend up to a certain period of time. However, in biotic stresses certain plant characters such as anti-xenosis, anti-biosis, nutritional modifications and unavailability of natural host plants influence insect reproduction, fecundity, development, emergence and migration for a long period of time. It can be inferred from the present results on trap catches and *vis-a-vis* fruit infestation in cucumber and bitter gourd that irrespective of locations the crops were infested by three fruit fly species *viz.*, *B. tau, B. cucurbitae* and *B. scutellaris*. The adult flies emerged from infested fruits under laboratory conditions throughout the fruiting period of both the crops. It was observed that *B. cucurbitae* was not responsible for infestation at Palampur despite of its low trap catches in the field which could be migratory (Table 1 and 2). There was significant variation in weekly trap catches and incidence of different fruit fly species at two locations. There was no obvious pattern in the abundance having quite different abundance levels. At Palampur, the first abundance of *B. tau* and *B. cucurbitae* was noticed during 4th week (17 SW) of April (table 1& 2). At Bara (Hamirpur) the first incidence of all the three species was observed by the end of 2nd week (11 SW) of March (table 3 & 4). Previous studies have also indicated the pest become active from March-April. Narayanan and Batra (1960) reported that *B. cucurbitae* become active in March when temperature warms and Inayatullha *et al.* (1991) also observed its activity in March in Pakistan. Pareek and Kavadia (1986) recorded fruit infestation from the 2nd week of April in Rajasthan, which fall in line with the results of present investigation. However, Vargas *et al.* (1990) observed its activity throughout the year with availability of hosts in Hawaiian Islands. This difference could be attributed to different agro-ecological situation in Himachal Pradesh and crop cultivation as cucurbits are only grown in summer season here.

B. tau, B. cucurbitae and *B. scutellaris* were trapped throughout the cropping period. Both the study sites showed distinct periods of high and low abundance. The weekly trap catches of *B. tau* and *B. scutellaris* remained low up to the fruit setting stage of crops. At Bara (Hamirpur) however, in the first study year, the weekly trap catches of *B. tau* and *B. cucurbitae* was high even before the fruit setting of crops as compared to second study year. These differences between the two study locations could be due to warmer weather conditions of Bara (Hamirpur) than that of Palampur and secondly because of the early high temperature in first study year (2009) which was hot year, resulting in changed in crop pattern like earlier cultivation of some crops such as summer squash etc. which might be responsible for the early population build up of these flies.

Table 2: Trap catches *vis-a-vis* maggot population and fruit infestation by melon fruit flies, *Bactrocera* spp. on cucumber and bitter gourd at Palampur during 2010

Sampling date	Standard week	Number of fruit flies trapped/week′				Mean no. of maggots/infested fruit#		Fruit infestation (%)##		Infestation index	
		B. tau	*B. cucurbitae*	*B. scutellaris*	Total	Cucumber	Bitter gourd	Cucumber	Bitter gourd	Cucumber	Bitter gourd
April-29	17	2.33	-	3.67	6.00	-	-	-	-	-	-
May-6	18	2.33	1.00	5.00	8.33	-	-	-	-	-	-
13	19	11.00	1.33	12.33	24.66	-	-	-	-	-	-
20	20	7.00	1.00	11.00	19.00	-	-	-	-	-	-
27	21	1.33	-	7.67	9.00	-	-	-	-	-	-
June-3	22	9.00	3.00	8.67	25.67	-	-	-	-	-	-
10	23	11.00	1.33	22.33	39.32	23.20 (4.79)	-	28.00 (31.89)	-	0.86	-
17	24	35.33	4.00	17.00	59.33	30.00 (5.50)	-	29.33 (32.76)	-	0.99	-
24	25	72.67	3.33	27.67	105.67	38.06 (6.13)	-	36.00 (36.83)	-	1.15	-
July-1	26	122.00	5.00	34.00	161	43.73 (6.59)	21.80 (4.71)	40.00 (39.20)	36.00 (36.84)	1.26	0.94
8	27	142.00	7.00	43.33	193.33	51.00 (7.15)	26.73 (5.22)	44.00 (41.52)	44.00 (41.53)	1.36	1.87
15	28	125.33	4.00	10.00	147.33	46.00 (6.78)	25.06 (5.06)	40.00 (39.20)	40.00 (39.20)	1.28	1.04
22	29	98.00	4.00	19.33	122.66	37.86 (6.14)	21.93 (4.74)	34.66 (36.04)	32.00 (34.41)	1.14	0.90
29	30	72.67	3.00	12.67	88.34	34.80 (5.87)	20.73 (4.62)	30.66 (33.60)	29.33 (32.77)	1.05	0.85
August-5	31	55.67	1.00	37.33	95.33	-	17.80 (4.28)	-	20.00 (26.48)	-	0.65
12	32	42.33	-	8.33	51.66	-	15.80 (4.03)	-	16.00 (23.46)	-	0.53
19	33	35.00	1.67	26.67	67.34	-	11.80 (3.47)	-	12.00 (20.08)	-	0.37
26	34	22.00	1.00	65.66	88.66	-	9.20 (2.96)	-	12.00 (20.08)	-	0.31
September-2	35	18.33	3.00	2.00	27.66	-	6.27 (2.52)	-	10.67 (18.98)	-	0.22
9	36	7.00	-	5.33	15.66	-	7.20 (2.46)	-	9.33 (17.70)	-	0.21
CD (P=0.05)		13.44	1.24	6.27	-	0.76	0.64	3.68	4.49	0.71	0.13

#Figures in the parentheses are square root transformed values; ##Figures in the parentheses are arc sine transformed values; ′Mean of 3 replications

Both the locations had a varied pattern of flies abundance, with rapid rise in population numbers in June-July up to the first fortnight of August, when crops were at fruiting stage followed by an equal dramatic drop in trap catches leading into a period of low abundance from last week (34 SW) of August onwards at Palampur when the bitter gourd crop was at last phase of maturity. At Bara (Hamirpur) similar trend was observed, the trap catches abruptly increased from fruit setting stage, irrespective of the species the maximum population density was recorded during 4th week (17 SW) of April, 1st week of May and June, (18 and 22 SW) respectively and the second fortnight of July in 2009 (Table 3). During 2010 the highest trap catches were observed during first fortnight of May, last week (26 SW) of June and first fortnight of July when the crops were at full fruiting stage (Table 4). Thereafter, the population showed declining trend with the decrease in fruit setting. The results of present investigation clearly indicated that the host availability had a great impact on the population build up of fruit flies and thus an important predominant factor to regulate population density. Similar interpretations have been made for *Bactrocera* spp. by Drew *et al.* (1984) and Tan and Serit (1994) under tropical conditions. Fletcher (1974) who also reported that even in temperate areas, abundance of *B. tryoni* in orchard habitats is positively dependent on fruit availability

Incidence of fruit flies was monitored in fruits by recording the per cent fruit infestation and maggot population. During 2009, in cucumber the initial fruit infestation and maggot population was 44.00 per cent and 52.53 maggots per infested fruit during 1st week (22 SW) of June when corresponding total trap catch was 107.00 flies irrespective of species. The maximum infestation and maggot population was observed during 2nd and 3rd weeks (28 and 29 SW) of July when 49.33 and 56.00 per cent and 53.07 and 62.23 maggots per infested fruit, respectively were recorded which coincided with highest total trap catches of 119.00 and 131.67 flies per trap, respectively (Table 1).

During 2010, almost similar trend was noticed; the fruit infestation and maggot density ranged from 28.00 to 44.00 per cent and 23.20 to 51.00 maggots per infested fruit, respectively. The highest fruit infestation and maggot density was recorded during the second and first fortnight of June and July which coincided with the highest trap catches (table 2). During 2009, in bitter gourd the fruit infestation and mean number of maggots per infested fruit ranged from 21.33 to 50.67 per cent and 16.80 to 28.73 maggots, respectively. The maximum infestation and maggot density was recorded from last week (30 SW) of July to last week (34 SW) of August when the corresponding trap catches were also high (Table 1). In the second study year (2010), it ranged from 9.33 to 44.00 per cent and 7.20 to 26.73 maggots per infested fruit. However, the highest fruit infestation and maggot density was observed in the month of July which coincided with maximum trap catches (Table 2).

At Bara (Hamirpur), per cent fruit infestation and mean

Table 3: Trap catches *vis-a-vis* maggot population and fruit infestation by melon fruit flies, *Bactrocera* spp. on cucumber and bitter gourd at Bara (Hamirpur) during 2009

Sampling date	Standard week	Number of fruit flies trapped/week*				Mean no. of maggots/infested fruit#		Fruit infestation(%)##		Infestation index	
		B. tau	*B. cucurbitae*	*B. scutellaris*	Total	Cucumber	Bitter gourd	Cucumber	Bitter gourd	Cucumber	Bitter gourd
March-16	11	30.00	32.00	1.00	63.00	-	-	-	-	-	-
23	12	35.67	34.33	3.00	73.00	-	-	-	-	-	-
30	13	45.67	41.00	14.33	101.00	-	-	-	-	-	-
April-6	14	47.33	45.00	12.00	104.33	-	-	-	-	-	-
13	15	51.00	46.66	18.64	116.30	-	-	-	-	-	-
20	16	50.67	51.67	13.00	115.34	-	-	-	-	-	-
27	17	52.00	57.67	22.00	131.67	-	-	-	-	-	-
May-4	18	51.00	59.33	2.33	112.66	22.40 (4.62)	-	22.67 (28.40)	-	0.78	-
11	19	51.00	61.67	20.67	133.34	26.33 (4.10)	-	29.33 (32.77)	-	0.94	-
18	20	25.67	35.00	9.33	70.00	17.80 (4.04)	-	10.67 (18.98)	-	0.45	-
25	21	28.33	81.67	15.00	125.00	33.80 (5.81)	28.67 (5.35)	41.33 (39.99)	34.67 (36.05)	1.17	1.06
June-1	22	36.67	112.00	9.00	157.67	45.73 (6.75)	33.87 (5.79)	46.67 (43.07)	40.00 (39.20)	1.35	1.16
8	23	32.00	52.67	12.33	97.00	21.62 (4.59)	31.80 (5.60)	18.67 (25.56)	34.67 (36.05)	0.69	1.07
15	24	34.66	27.67	8.66	70.99	19.40 (4.31)	27.53 (5.18)	14.67 (22.47)	29.33 (32.77)	0.58	0.95
22	25	6.67	22.00	12.00	40.67	16.07 (3.81)	14.07 (3.57)	9.33 (17.70)	18.67 (25.56)	0.45	0.56
29	26	9.00	17.67	16.67	43.34	-	14.60 (3.72)	-	22.00 (26.00)	-	0.58
July-6	27	33.33	42.00	10.00	85.33	-	23.33 (4.84)	-	32.00 (34.41)	-	0.89
13	28	39.67	47.67	3.67	91.01	-	21.80 (4.68)	-	26.67 (31.06)	-	0.83
20	29	55.00	109.33	7.33	171.66	-	31.73 (5.59)	-	38.67 (38.43)	-	1.12
27	30	62.67	75.67	3.00	141.34	-	22.60 (4.76)	-	26.67 (31.06)	-	0.84
August-3	31	23.67	36.00	4.00	63.67	-	11.80 (3.23)	-	13.33 (21.36)	-	0.43
10	32	9.00	25.33	2.00	36.33	-	9.47 (2.93)	-	10.67 (18.98)	-	0.29
CD (P=0.05)		8.46	13.97	3.53	-	1.05	0.86	3.22	2.018	0.90	0.44

#Figures in the parentheses are square root transformed values; ##Figures in the parentheses are arc sine transformed values; *Mean of 3 replications

number of maggot per infested fruit varied similarly with the mean number of flies trapped which ranged from 9.33 to 40.00 per cent and 16.07 to 45.73 maggots in cucumber, respectively. The maximum fruit damage and high maggot density was noticed when the total trap catch irrespective of species was also significantly high. The high incidence level was recorded during 1st week (22 SW) of June. Similarly in case of bitter gourd, the per cent fruit damage and mean maggot density per infested fruit fluctuated with variation in trap catches. The high incidence level of both fruit damage and maggot population was observed during 2nd fortnight of May and 1st fortnight of June and then by the end of July which corresponded to the high respective trap catches and *vice-versa* (Table 3). Similar trend was observed in 2010 also, the highest trap catches resulted in high incidence of fruit damage and maximum maggot density. The highest incidence level was observed during 1st and 4th weeks (18 and 22 SW) of May and then from 1st (23 SW) to last fruit fruiting stage i.e. 3rd week (25 SW) of June in cucumber. Whereas, in case of bitter gourd the maximum fruit damage and high maggot density was recorded in the month of June and first fortnight of July (Table 4). These results draw considerable support from the results of Gupta and Verma (1992) who found population fluctuation in *B. cucurbitae* and recorded peak population in June-August on cucumber and August-September on bitter gourd with highest fruit infestation of 80.00 and 60.00 per cent, respectively. Narayanan and Batra (1960) also observed its peak activity during July-August resulting in heavy damage to cucurbits. Mann (1990) reported low fruit infestation in April and high during July-August in cucurbits. Pareek and Kavadia (1986) also recorded peak activity of *B. cucurbitae* and highest fruit infestation in May-June on long melon in Rajasthan.

The findings of present investigation clearly indicated that flies activity in traps increased with the availability of host fruits which in turn resulted in increase in fruit damage. There was a significant positive correlation between mean number of maggots per infested fruit and per cent fruit infestation. The total trap catches irrespective of species also exhibited significant positive correlation with per cent fruit infestation (Table 5). Inayatullah *et al.* (1991) also reported positive correlation between the extent of fruit infestation and the number of melon fly males trapped per day in squash and bitter gourd. Khattak *et al.* (1990) also reported trap catch of fruit fly in pear to be positively correlated with fruit infestation. Many other studies have also demonstrated positive correlation between fruit fly abundance and host availability (Aluja *et al.*, 1996; Hong and Hui, 2005; Papadoulos *et al.*, 2001). The infestation index was increased with increase in per cent fruit infestation and maggot population which coincided with the highest trap catches.

Fruit is an essential element to complete the fruit fly life cycle because larval development is totally dependent on fruit flesh. Therefore, there is a close relationship of fruit flies abundance with the host fruit availability. In

Table 4: Trap catches *vis-a-vis* maggot population and fruit infestation by melon fruit flies, *Bactrocera* spp. on cucumber and bitter gourd at Bara (Hamirpur) during 2010

Sampling date	Standard week	Number of fruit flies trapped/week´				Mean no. of maggots/infested fruit#		Fruit infestation (%)##		Infestation index	
		B. tau	*B. cucurbitae*	*B. scutellaris*	Total	Cucumber	Bitter gourd	Cucumber	Bitter gourd	Cucumber	Bitter gourd
March-14	11	3.00	25.67	4.33	33.00	-	-	-	-	-	-
21	12	5.00 4.67	29.00	5.00	34.00	-	-	-	-	-	-
28	13	7.33	38.67	8.33	54.33	-	-	-	-	-	-
April-4	14	9.67	44.33	12.67	66.67	-	-	-	-	-	-
11	15	13.00	51.00	15.00	79.00	-	-	-	-	-	-
18	16	20.67	74.67	27.67	123.01	-	-	-	-	-	-
25	17	17.67	72.67	32.00	122.34	-	-	-	-	-	-
May-2	18	107.00	45.00	35.67	187.67	33.20 (5.72)	-	38.67 (38.43)	-	1.14	-
9	19	25.66	183.00	43.33	251.99	15.27 (3.53)	-	21.33 (27.48)	-	0.63	-
16	20	32.00	43.00	16.00	91.00	21.60 (4.42)	-	22.67 (28.40)	-	0.77	-
23	21	39.67	55.33	12.67	107.67	27.60 (5.22)	15.47 (3.93)	26.67 (31.06)	18.67 (25.56)	0.93	0.59
30	22	48.33	72.67	22.67	143.67	30.27 (5.43)	17.27 (4.18)	32.00 (34.40)	22.67 (28.40)	1.02	0.69
June-6	23	61.00	105.33	33.33	199.66	34.13 (5.81)	22.80 (4.83)	34.67 (36.05)	25.33 (30.19)	1.10	0.83
13	24	72.67	158.33	55.00	286.00	37.13 (6.06)	25.07 (5.06)	37.33 (37.64	34.67 (36.05)	1.17	0.98
20	25	97.00	170.00	63.67	330.67	42.20 (6.50)	27.07 (5.26)	41.33 (39.98)	37.33 (37.64)	1.26	1.04
27	26	125.00	185.00	39.00	349.00	-	31.27 (5.50)	-	38.67 (38.43)	-	1.07
July-4	27	42.67	225.33	26.33	294.33	-	36.13 (6.06)	-	45.33 (42.30)	-	1.23
11	28	38.33	162.67	13.67	214.67	-	25.93 (5.14)	-	32.00 (34.41)	-	0.96
18	29	25.33	118.33	7.00	150.66	-	24.00 (4.96)	-	26.67 (31.06)	-	0.86
25	30	19.00	75.00	3.33	97.33	-	16.73 (4.16)	-	18.67 (25.56)	-	0.61
August-1	31	12.67	46.67	3.67	63.01	-	13.57 (3.58)	-	16.00 (23.46)	-	0.49
8	32	8.00	22.33	2.00	32.33	-	11.00 (3.36)	-	8.00 (16.07)	-	0.26
CD (P = 0.05)		12.58	29.57	7.14	-	0.95	0.58	2.91	3.45	0.65	0.85

#Figures in the parentheses are square root transformed values; ##Figures in the parentheses are arc sine transformed values; ´Mean of 3 replications

Table 5: correlation of fruit flies incidence with host availability

Parameters	Palamur				Bara (Hamirpur)			
	cucumber		bitter gourd		cucumber		bitter gourd	
	2009	2010	2009	2010	2009	2010	2009	2010
Mean number of maggots per infested fruit and fruit infestation (%)	+0.951**	+0.985**	+0.865**	+0.953**	+0.958**	+0.937**	+0.970**	+0.988**
Total trap catch and fruit infestation (%)	+0.843**	+0.977**	+0.904**	+0.904**	+0.918**	+0.567*	+0.811**	+0.946**

*Significant at 5% level of significance**Significant at 1% level of significance

some instances host fruit acts as the primary regulating factor on the seasonal incidence of fruit flies, while climate is the secondary regulating factor (Drew *et al.*, 1984; Tan and Serit, 1994).

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