Research Article

Population Densities of Melon Fruit Fly *Bactrocera cucurbitae* (Coquillett) in Vegetables Agro-Ecosystem in District Hyderabad, Sindh, Pakistan

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Abstract | Study on population magnitude of the Melon Fruit Fly *Bactrocera cucurbitae* (Coq.) was undertaken during 2015 on cucurbit crops in district Hyderabad. The studies were carried out at two discrete localities, Jeay Shah and Dehli Farm, in three different crops *i.e.,* bottle gourd (*Lagenaria siceraria*), bitter gourd (*Momordica charantia*) and ridge gourd (*Luffa acutangula*) using cue-lure baited traps. The male lure baited traps were arrayed at three meter height and replenished on fortnightly basis in experimentation sites. Results revealed that significantly highest (124.86) population was recorded on *L. acutangula* and lowest (104.725) on *L. siceraria* at both experimental sites throughout the course of experiment. Moreover, significantly higher population densities of *B. cucurbitae* were observed during the 4th week of May on *L. acutangula* (339.4±22.59) and lowest (11.0±0.45) during1st week of January. Similarly, in case of *M. charantia* and *L. siceraria* statistically higher densities (334.6±22.76, 333.2±20.13) of *B. cucurbitae* was observed on 4th week of May and lowest (9.4±1.60, 7.6±1.72) on the 1st week of January. The trapping of *B. cucurbitae* were positively correlated with the temperature while negatively correlated with relative humidity.

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Keywords | Population densities, *Bactrocera cucurbitae*, *Lagenaria siceraria*, Abiotic factors, Cue-lure.

Introduction

Insect pests are the most important factors, and are responsible for the low yield and poor quality of vegetables. Among them fruit flies are the serious pests of different vegetables and fruits. The Dipterian fruit flies belong to family Tephritidae, consists of more than 4,000 species, of which nearly 700 species belonging to Dacine fruit flies (Fischer and Busch, 1989). Among them Melon fly, *Bactrocera cucurbitae* (Coq.) is a fruit fly that infects up to 125 species of plants, mostly belong to the Cucurbitaceae and Solanaceae (Bezzi, 1913; Jain et al., 2008). Melon flies causes loss of 8 to 10 million US dollars to growers annually. Moreover, it confines the development of agriculture in many countries because of the quarrying business strict restrictions to prevent the spread of this noxious pest (Dhillon et al., 2005).

Vegetables are a major source of protein and minerals necessary for human nutrition and vitamins. Pakistan produced 8478.8 tons of vegetables on 611.7 hectares during 2013-14 and earned 12.039 billion worth. Improve productivity and quality of vegetables enhances food security, employment, as well as business opportunities. In Pakistan, vegetable growers randomly use a mixture of toxins/pesticides on vegetables to suppress fruit flies. Repeated application of pesticides

has resulted in losses havoc on human health and the environment, soil, water and wildlife (GoP, 2013-14).

A number of fruit fly species has been documented including *Bactrocera cucurbitae* which is the most harmful pests of pumpkin, sponge gourd, bitter gourd, Indian pumpkin and other fleshy vegetables. This species causes direct damage to vegetables that can lead to up to 90-100% yield loss. In addition to direct losses, and the incidence of this type could reduce the value of the trading and export opportunities due to the strict quarantine regulations (Naqvi, 2005)

Pheromone and para-pheromone traps are efficaciously used to investigate population magnitude of fruit flies in different regions of the world (Marwat and Baloch, 1986; Gillani et al., 2002). Cue lure traps provide a casual and effective way to study population densities of *B. cucurbitae* which is important for the successful anti-pest program (Alyokhun et al., 2000).

Various sex attractant mixtures such as pheromones and lures used to attract male fruit flies (Tephritidae) are signifying the potential importance of sex (male) attractants (Liu and Lin, 1993). Naturally one on one sex ratio of the fruit flies present; however, partial variation in *B. cucurbitae* sex ratio (male and female) population has been documented throughout different time spells (Bhagat and Koul, 1999). It is estimated that every male fly removed from the population of wild fly by the attractant will represent one female unmated (Sapkota et al., 2010). From years, for the checking and estimating fruit flies population densities the pheromones and lures has been used to attract adult male fruit flies hence proved effective as compared to food temptation (Jang et al., 2007). Additionally for detecting and mass capturing of melon flies cue-lure traps are successfully used in vegetables agro-ecosystem worldwide (Pawar et al., 1991; Nath and Bhusan, 2006). The environmental factors (such as temperature, humidity and rainfall) directly associated with population densities of melon fruit fly were obtained using cue lure baited traps. Fruit fly species captured using cue-lure tempted traps positively related with weather parameters such as temperature, humidity, rainfall (Lee et al., 1997; Jha et al., 2007).

Keeping in view the commercial significance of cucurbit vegetables and the losses sustained by Melon fruit fly incursion, it is imperative to study for the population fluctuation of melon fly, *Bactrocera cucurbitae* and impact of ecological factors on its capture to obtain sustainable pest management strategy against its invasion in cucurbit agro-ecosystem.

Materials and Methods

The field experiment was conducted for monitoring the population abundance of melon fruit fly *Bactrocera cucurbitae* on cucurbit crops of district Hyderabad. The experiment was conducted on bottle gourd (*Lagenaria siceraria*), bitter gourd (*Momordica charantia*) and ridge gourd (*Luffa acutangula*) grown, at Jeay Shah and Dehli farm. Effect of abiotic factors (temperature, relative humidity and rainfall) on melon fly were also recorded. The total areas of 5 acres were selected on each crop at discrete location for observing the *B. cucurbitae* population densities. Experiment was designed in Randomized Complete Design (RCD) having five replications with plant spacing (hill x row) of 0.5x2 m.

Male lure "Steiner Type traps" were made of plastic Jars that measured 20 cm in length and 8 cm in diameter were used for fly trapping. These traps had two holes on each side to allow the flies to enter inside. Male lure were suspended inside each trap, near the center, consisted of a small cotton wick soaked with 4 ml Cue-lure [4-(pacetoxyphenyl)-2-butanone] (CL) having 5% (Pyramid 10% AS) insecticide.

The traps were baited with Cue-lure and insecticide deployed at three meter height in all selected locations from 01.01.2015 to 31.12.2015. Male flies were attracted to lure, and quickly killed by the insecticide on the cotton wick. The captured male flies were collected and counted on weekly basis and cue lure was replenished at fortnightly interval.

Meteorological Data and Statistical Analysis

Meteorological data used in this study were provided by Regional AGRO-MET Centre Tando Jam, Sindh, Pakistan.

All statistical analyses were done with the help of Statistix® Version 8.1, Analytical Software, Inc., and Tallahassee, FL, USA.

Statistical analysis was calculated using two-ways analysis of variance ANOVA for different parameters Followed by Tukey's Post Hoc HSD Test for the significance of data.

Table 1: *Weekly population densities of B. cucurbitae from January to April, 2015 in relation with abiotic factors (Temperature, Humidity and Rainfall) in district Hyderabad.*

Month and year	Weeks	Location and Crop			Temperature (°C)		Relative Humidity (%)	Total Rainfall (mm)
		Dehli Farm *L. acutangula*	Jeay Shah *M. charantia*	Jeay Shah *L. siceraria*	Min.	Max.		
January 2015	1st week	11.0±0.45 u	9.4±1.60 t	7.6±1.72 o	8.79±0.55	24.50±1.00	64.86±4.67	0.00
	2nd week	13.4±0.93 u	9.6±2.09 t	9.0±2.21 o	10.21±0.57	26.29±1.25	66.43±1.24	0.00
	3rd week	10.4±2.14 v	9.6±0.93 t	7.6±0.81 o	8.07±0.46	23.57±0.61	63.00±1.52	0.00
	4th week	12.4±1.86 u	9.6±0.51 t	8.4±1.63 o	7.36±0.63	22.21±0.63	60.50±3.70	0.00
February 2015	1st week	15.2±1.39 u	10.8±1.53 t	8.8±1.36 o	9.71±0.53	26.29±0.95	58.14±1.58	0.00
	2nd week	20.6±2.52 t	13.6±1.78 t	10.4±1.21 n	11.79±0.87	28.93±1.32	60.93±1.43	0.00
	3rd week	23.6±4.07 t	14.6±1.03 s	12.8±1.32 n	16.21±0.36	31.21±0.82	57.00±2.65	0.00
	4th week	25.2±2.33 t	16.6±1.72 r	14.4±2.01 n	12.93±1.61	27.29±1.53	52.79±4.24	0.00
March 2015	1st week	28.0±2.70 s	17.8±2.84 r	12.8±1.85 n	12.00±1.15	27.21±1.65	51.14±4.05	0.00
	2nd week	30.2±2.96 r	21.4±3.09 q	15.2±1.02 n	11.57±1.07	28.57±0.54	47.79±2.35	0.00
	3rd week	40.6±4.07 p	39.0±5.55 o	35.6±4.71 l	14.71±1.26	33.93±1.28	45.14±1.47	0.00
	4th week	61.6±10.01n	57.6±9.85 n	56.0±10.14j	19.64±1.40	39.29±0.76	47.57±1.56	0.00
April 2015	1st week	111.0±8.77j	108.4±8.73j	101.8±7.55g	21.43±0.47	36.50±0.60	47.43±2.33	0.00
	2nd week	119.6±13.07 i	119.0±11.44 i	115.6±8.30g	20.93±0.23	38.57±0.43	38.57±2.14	0.00
	3rd week	170.2±18.62 e	160.6±19.33 f	156.2±19.01d	22.64±0.53	42.71±0.42	41.00±0.81	0.00
	4th week	218.0±18.74 c	216.4±15.49 d	207.8±11.02 c	23.43±0.52	40.93±0.53	46.29±4.54	0.00

Values in the columns followed by different letters are significantly differ at 5% level according to Tukey's Honest Significant Difference (HSD) test.

Table 2: *Weekly population densities of B. cucurbitae from May to August, 2015 in relation with abiotic factors (Temperature, Humidity and Rainfall) in district Hyderabad.*

Month and year	Weeks	Location and Crop			Temperature (°C)		Relative Humidity (%)	Total Rainfall (mm)
		Dehli Farm *L. acutangula*	Jeay Shah *M. charantia*	Jeay Shah *L. siceraria*	Min.	Max.		
May 2015	1st week	280.6±16.44 a	278.2±15.57 a	274.4±19.69 a	22.36±0.52	41.00±0.84	51.00±4.01	0.00
	2nd week	330.6±17.90 a	328.8±16.86 a	319.4±9.90 a	25.64±0.24	40.21±0.39	53.07±1.18	0.00
	3rd week	338.4±27.63 a	329.8±28.64 a	326.6±24.20 a	26.00±0.29	42.71±0.57	47.50±1.18	0.00
	4th week	339.4±22.59 a	334.6±22.76 a	333.2±20.13 a	26.57±0.32	43.57±0.68	49.36±1.69	0.00
June 2015	1st week	300.2±7.38 a	289.2±10.01 ab	287.2±19.46 a	25.79±0.61	39.57±0.82	56.00±1.29	1.34
	2nd week	284.0±8.86 ab	254.4±14.58 bc	251.2±13.83 b	26.79±0.18	38.71±0.32	57.36±0.89	0.00
	3rd week	231.0±24.36 b	224.4±25.75 cd	209.8±24.65 c	27.50±0.15	40.00±0.53	58.93±1.17	0.00
	4th week	203.6±8.93 de	195.8±9.77 d	181.6±11.06 d	27.64±0.14	38.93±0.35	42.91±1.63	0.00
July 2015	1st week	191.0±7.14 d	182.0±6.63 e	134.2±7.15 f	27.64±0.14	38.14±0.17	64.14±2.40	0.00
	2nd week	183.6±6.90 d	174.0±7.31 e	130.4±5.05 f	27.07±0.17	37.71±0.43	68.43±1.45	0.00
	3rd week	181.6±20.91 d	161.4±7.61 f	130.6±4.63 f	26.93±0.13	37.43±0.51	63.43±0.87	0.29
	4th week	153.0±12.51 f	150.8±14.9 g	106.2±5.30 g	25.14±0.54	33.79±1.00	82.00±3.79	18.43
August 2015	1st week	132.4±5.21 g	102.0±9.30 j	83.0±5.15 h	24.93±0.07	35.14±0.25	65.71±1.64	0.00
	2nd week	109.0±22.83 j	102.0±9.30 j	81.2±4.53 h	25.21±0.29	34.50±0.39	70.71±1.08	0.00
	3rd week	104.4±7.95 k	76.0±6.04 l	67.0±3.73 i	25.71±0.10	35.36±0.11	66.00±1.25	0.00
	4th week	99.4±5.50 k	73.4±5.76 l	66.4±5.04 i	25.43±0.13	35.50±0.39	67.71±1.29	0.00

Values in the columns followed by different letters are significantly differ at 5% level according to Tukey's Honest Significant Difference (HSD) test.

Results

The Melon fruit fly (*B. cucurbitae*) was found to be the most prominent pest of cucurbit crops and observed in maximum number in vegetables agro-ecosystem of District Hyderabad. The investigations on population densities of melon fruit fly in different cucurbit crops were conducted at various locations of District Hyderabad throughout the year 2015 by using Cue-lure traps (Table 1, 2 and 3). The overall highest mean number of melon flies were recorded on *L. acutangula* (124.86), followed by *M. charantia* and *L. siceraria* (114.11, 104.73), respectively, on all cucurbit crops in District Hyderabad. The present investigations on population fluctuation of *B. cucurbitae* in different cucurbit crops of District Hyderabad revealed that weekly lowest mean population of flies recorded on *L. siceraria* (7.6±1.72) at Jeay Shah site during first week of January 2015 (Table 1). The maximum and statistical significant incursion of *B. cucurbitae* was recorded from First week of May to second week of June 2015 in selected vegetables at discrete locations of District Hyderabad (Table 2). However, the higher number of Melon fruit flies were recorded during 4rth week of May on *Luffa acutangula* at Dehli Farm, but this peak was non-significant within the different species and location. Again the increased number of *B. cucurbitae* was recorded during first week of October on *Luffa acutangula* at Dehli Farm and gradually declined through December, 2015 (Table 3). Further variation in the infestation levels of the *B. cucurbitae* were influenced by fruit availability and weather factors (Figure 1, 2 and 3).

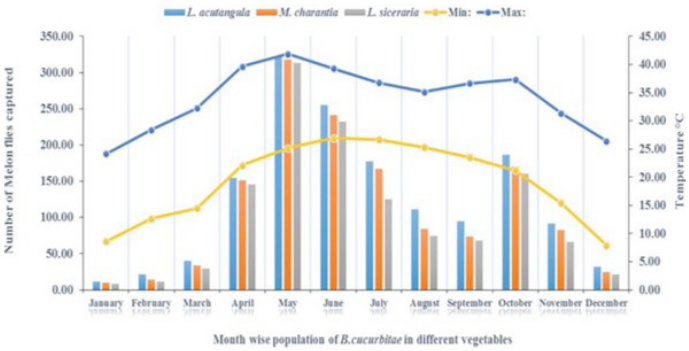

Figure 1: *Effect of temperature (Minimum and Maximum) on population magnitude of B. cucurbitae in vegetables agro-ecosystem of district Hyderabad.*

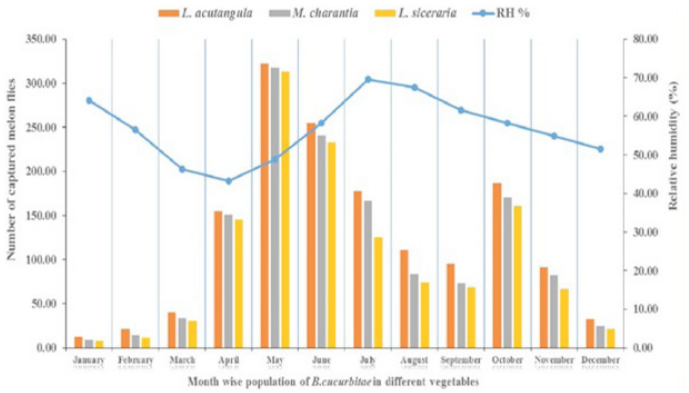

Figure 2: *Effect of relative humidity (%) on population magnitude of B. cucurbitae in vegetables agro-ecosystem of district Hyderabad.*

Table 3: *Weekly population densities of B. cucurbitae from September to December, 2015 in relation with abiotic factors (Temperature, Humidity and Rainfall) in district Hyderabad.*

Month and year	Weeks	Location and Crop			Temperature (°C)		Relative Humidity (%)	Total Rainfall (mm)
		Dehli Farm *L. acutangula*	Jeay Shah *M. charantia*	Jeay Shah *L. siceraria*	Min.	Max.		
September 2015	1st week	97.8±3.43 k	66.0±6.04 m	57.2±8.69 j	23.21±0.34	35.57±0.49	64.43±1.02	0.00
	2nd week	94.6±4.65 k	61.0±10.04 m	55.0±13.6 k	23.64±0.09	37.29±0.58	60.43±2.07	0.00
	3rd week	91.8±6.67 k	74.0±7.65 l	69.6±7.47 i	24.50±0.39	36.79±0.86	61.00±2.16	0.14
	4th week	96.2±7.08 k	93.2±3.60 k	91.4±2.11 h	22.64±0.32	36.93±0.42	60.29±0.75	0.00
October 2015	1st week	234.4±4.46 b	198.6±17.0 d	195.0±4.47 c	21.50±0.65	39.00±0.73	60.86±3.51	0.00
	2nd week	201.0±5.34 d	193.2±4.22 e	185.6±8.45 d	22.64±0.34	37.79±0.58	59.14±1.56	0.00
	3rd week	169.0±20.19 e	156.0±10.7 g	141.2±30.5 e	21.00±0.27	38.14±0.91	54.14±2.45	1.43
	4th week	142.2±10.27 f	132.8±6.67 h	120.0±12.0 g	19.79±0.38	34.36±1.65	58.57±1.49	0.00
November 2015	1st week	123.4±9.90 h	114.2±11.3 j	90.2±18.0 h	18.57±1.43	33.21±1.00	57.00±3.17	0.00
	2nd week	89.2±3.34 l	80.8±3.29 l	67.4±10.6 i	15.29±0.57	31.79±0.66	58.57±1.94	0.00
	3rd week	78.8±2.44 m	73.8±2.94 l	57.8±4.79 j	14.71±0.61	31.50±0.43	53.57±2.55	0.00
	4th week	73.6±10.21 m	61.20±8.45 m	50.0±4.23 k	13.21±0.34	28.96±0.49	50.29±3.39	0.00
December 2015	1st week	42.0±4.36 o	38.2±4.40 o	33.2±3.93 l	9.93±0.20	29.64±0.44	51.29±2.24	0.00
	2nd week	35.8±3.06 q	28.2±5.86 p	22.2±2.80 m	9.21±0.47	25.79±0.91	54.14±2.92	0.00
	3rd week	29.6±3.37 r	20.8±3.67 r	18.0±0.95 n	5.74±0.35	25.79±1.30	46.43±1.45	0.00
	4th week	20.8±2.65 t	12.2±1.39 t	10.6±2.18 n	6.69±0.45	24.50±0.37	54.29±2.96	0.00

Values in the columns followed by different letters are significantly differ at 5% level according to Tukey's Honest Significant Difference (HSD) test.

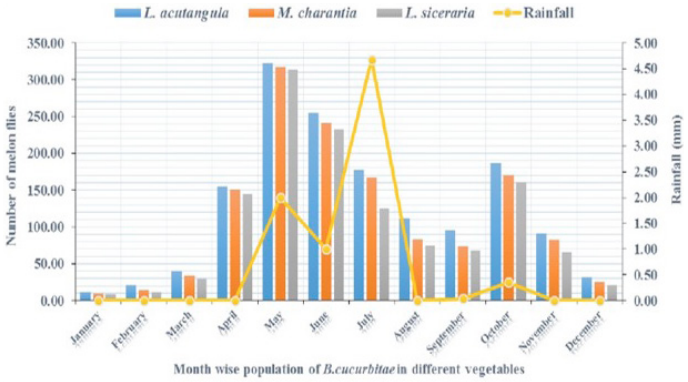

Figure 3: *Effect of rainfall (mm) on population magnitude of B. cucurbitae in vegetables agro-ecosystem of district Hyderabad.*

The significantly positive correlation was recorded between temperature (minimum and maximum) and *B. cucurbitae* population. Whereas, rainfall (mm) positively correlates with fruit fly capture at all experimental sites in District Hyderabad. The relative humidity (%) negatively correlates with melon flies population throughout the year (Table 4).

Table 4: *Showing Pearson's correlation between weather parameters (Temperature, Humidity and Rainfall) and B. cucurbitae population on cucurbit crops in district Hyderabad.*

Location and crop	Meteorological factors (Pearson's Correlation)			
	Temperature (°C)		Relative Humidity (%)	Rainfall (mm)
	Min.	Max.		
Dehli Farm *Luffa acutangula*	0.8012*	0.8819*	-0.0762	0.2161
Jeay Shah *Momordica charantia*	0.7645*	0.8637*	-0.1212	0.2164
Jeay Shah *Lagenaria siceraria*	0.7306*	0.8543*	-0.1815	0.1133

*: *Positively significant at ($p < 0.001$) according to Pearson's correlation significance test.*

Discussion

The present study was designed to investigate the population densities of *B. cucurbitae* in vegetables agro-ecosystem in District Hyderabad. Our studies confirmed that population densities of *B. cucurbitae* fluctuated due to several reasons throughout the year among them ecological factors (for instance, temperature, relative humidity and rainfall) and availability of food (vegetation and alternative host plants) during cropping season and off season played vital role in the occurrence of melon fruit fly. This study shows the occurrence of *B. cucurbitae* species activities throughout the year. However, maximum number of the fly species was recorded during mid-May to mid-June 2015. The population variations of adult male *B. cucurbitae* species were significantly different between the locations and within the different species cucurbit agro-ecosystem of district Hyderabad. We observed that the population abundance of melon fly started to increase from 1st week of May and reached to their peak during second week of June than gradually started to decline after 4th week of October at Dehli farm and Jeay Shah commercial vegetable growing areas. Our experimental results were partially similar with the findings of Lee et al. (1992) and Mahmood and Mishkatullah (2007) who reported increased population of *B. cucurbitae* from July to October. Ye (2001) also reported that high abundance of *B. cucurbitae* occurs only from May through November each year in Yunnan Province of China.

In this study we observed that ecological aspects such as temperature, humidity and rainfall were positively as well as negatively associated with population dynamics of melon flies. The high temperature significantly positively co-related with the *B. cucurbitae* population while humidity has negative effect on it. When correlation between rainfall and melon fly captures were observed for the studied areas exhibited a temperately positive relationship with the melon fly capture in vegetables agro-ecosystem in district Hyderabad. Similar results were reported by Syed (1971), Ye (2001) and Vargas et al. (2003) stated that maximum number of *B. cucurbitae* was recorded in the warm months of each year whereas relative humidity was observed as a crucial factor which impacts *B. cucurbitae* incidence.

Our findings documented that with favourable climatic conditions Melon flies activity amplified to distinct peaks during different months of the year. Similarly, Ramsamy et al. (1987) and Liu and Lin (1993) observed the crucial commotion of *B. cucurbitae* when the prevailing climatic condition was favourable during different months of the year. In another study Kawashita et al. (2004) investigated the peak population of melon flies from April to July and mid-June to mid-November. The fruit fly population abundance using cue-lure baited traps in our study also matches with the studies carried out by Ramsamy (1989) and Joshi et al. (1995) who observed the inactive period of *B. cucurbitae* during January. Interestingly our re-

sults are similar with that of Khan et al. (1993), who obtained the same adult population trend per trap in bottle gourd crop in a field study in Pakistan.

Conclusion

In present studies *Luffa acutangula* was observed more susceptible host for *B. cucurbitae* in terms of infestation. Initially high population of *B. cucurbitae* started from the first week of March on *L. acutangula* followed by *M. charantia* and *L. siceraria,* respectively and gradually increased during winter season while reached to its highest peak from May to mid-June on selected locations in vegetables agro-ecosystem in district Hyderabad. It was observed that high temperature encourage the population build-up of *B. cucurbitae* in vegetables agro-ecosystem. Further rainfall also positively affected the population of melon fruit fly while relative humidity had negative affect on it. Thus, it was concluded that high temperature enhances the insect activity.

Author' Contribution

ZAA conducted experiments, analyzed the data and wrote the article. NB designed and supervised the entire work. NHK conceived and designed study. WAQ assisted in experiments. NAS interpreted the results.

Conflict of Interests

Authors have declared no conflict of interests.

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