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Population dynamics of fruit flies in bitter gourd (*Momordica charantia* L.) and its relationship with weather factors

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Abstract
Bitter gourd (*Momordica charantia* L.) is one of the important cucurbitaceous vegetable grown in India. Among the cucurbits, it is considered a high-quality vegetable because of its nutritive value especially ascorbic acid and iron. The study was undertaken to investigate the population dynamics of *Bactrocera* spp. (Diptera: Tephritidae) round the year. Significant variation in occurrence of the pest was recorded during the period of investigation. First incidence of *Bactrocera* spp. was observed from 31st SM and continued upto 52nd SM in parapheromone Methyl Eugenol and Cuelure) traps. Peak incidence of the pest was recorded during 39th SM and 42nd SM with 135 fruit flies/trap/week. *B. zonata* and *B. dorsalis* incidence had significant positive correlation (r) of with minimum and maximum temperature (r = 0.563 and r = 0.564 respectively) during *Kharif* 2018. The *B. cucurbitae* traped had positive correlation with minimum (r = 0.752), maximum temperature (r = 0.788) and relative humidity during *Kharif* 2018. Findings of this study helps in understanding the population dynamics of fruits flies in bitter gourd and developing forewarning strategies to combact the pest in advance.

Keywords: Bitter gourd, fruit fly, incidence, cuelure, methyl eugenol

Introduction
Bitter gourd is an important cucurbitaceous vegetable grown in India. Each part of this crop has been reported useful having some specific medicinal value (Allwood and Drew, 1996) [1]. Fruit flies are important insect pests of fruits, vegetables and other ornamental plants (Bharathi *et al.*, 2004) [5]. Melon fruit fly, *Bactrocera cucurbitae* (Coq.) (Diptera: Tephritidae) is one of the main tropical fruit fly causing considerable damage in cucurbits. *B. cucurbitae* has been observed to infest a wide range of crops in the Cucurbitaceous family. Infestation by melon fruit fly in bitter gourd was reported from 41 to 89 per cent (Rabindranath and Pillai, 1986). Melon fruit fly infests 95 percent of bitter gourd fruits in Papua New Guinea, 90 per cent snake gourd and 60 to 87 per cent pumpkin fruits in Solomon Island while 31.27 per cent in India, respectively (Hollingsworth *et. al*., 1997; Singh *et. al*., 2000) [9, 10]. Yield loss varies from 30–100% (Nath and Bhusan 2006) [2]. It is very much difficult to manage the pest through the application of chemical pesticides due to their peculiar biological features.
Among the various, alternate strategies available for the management of fruit flies, the use of male attractant traps stands as the most outstanding alternative. Various parapheromones are known which are used against fruit flies. Monitoring of pest population round the year is one of the most important basic information in formulating Integrated Pest Management concept for sustainable agriculture. The Cuelure traps have been reported to attract *Bactrocera cucurbitae* males and this sex attractant is more effective than food lure (Pawar *et. al*., 1991, Liu and Lin, 1993; Zaman, 1995) [3, 8, 4]. Keeping in view, present investigation was undertaken to study the population dynamics of fruit flies and its relation with weather factors.

Materials and Method
The study was conducted at the Agricultural Research Farm of Acharya Narendra Dev University of Agriculture and Technology, Kumarganj Ayodhya, India (26.54°N, 81.93°E). The seasonal incidence of fruit flies was monitored at weekly intervals in the cropping season 2018–2019. Cuelure and methyl eugenol baited bottle traps were used for the monitoring of population. The traps used for monitoring fruit flies consisted of a one-litre plastic mineral water bottle (10 cm base diameter and 25 cm in height) with a screw lid.

The bottles have two rectangular entry slits (4.5cm×2.5 cm) evenly spaced on the bottom side. A wooden plywood block (5.0cm×5.0cm×1.2 cm.) was saturated with ethanol, Cuelure, Methyl eugenol and insecticide (Malathion 50 EC) at a ratio of 6:4:1. The block was soaked in the solution for one week and hung from a wire in the bottle trap near the entry slits. These parapheromone (Cuelure and Methyl eugenol) baited traps were used for monitoring the adult fruit flies activity throughout the year (2018–19). Three traps, 10m apart from each other were installed in the bitter gourd field for monitoring the fruit flies.

Traps were inspected at weekly intervals in the morning hours. Recording the total number of adults was done by counting the trapped adults (live and dead) inside the bottle trap. Then, the bottle was recapped for further trapping. The Cuelure and methyl eugenol baited wooden blocks were replaced at monthly interval. Twenty plants were randomly selected from the plot (20m× 20m) for recording the healthy and damaged fruits, at weekly intervals as soon as the infestation started. The meteorological parameters from what had been the current week of observation, collecting and examining as well as the preceding first, second, and third weeks were considered for this study. Correlation (r) between the meteorological parameters (minimum and maximum temperature, relative humidity and rainfall) and adult fruit fly catch was carried out to know the effect of weather parameters on population dynamics of fruit flies.

Results and Discussion

Seasonal abundance of fruit fly caught through cuelure in bitter gourd crop

Fig. 1 summarizes seasonal fruit fly population fluctuations During the period of investigation mean population of *B. cucurbitae* was 29.68 fruit fly per trap per week. Its peak population was observed during 41th SM 70.00 flies per trap per week. The appearance of *B. tau* caught in cuelure bottle trap was noticed during 31st SM with mean population of 10.50 flies per trap per week. Thereafter, its peak population was observed during 32nd SM with 15.50 flies per trap per week. A decreasing trend was observed in 33rd SM up to 52nd SM. The mean population of *B. tau* during whole growing season was 3.75fruit fly per trap per week. Moderate high adult fly activity was noticed twice a year *viz.*, once during *Kharif* (33rd SW to 47th SW) and once during the summer (12th SW to 18th SW) season. Pankaj *et al.* (2002) [13] recorded the minimum (0.67 fruit fly trap) and maximum (2.83 fruit flies/trap) population of this species, respectively in 21st and 27th SM, while Manzar and Srivastava during, (2004) reported that minimum and maximum population of fruit flies per trap per week is 297.3 and 96.6 in 23rd and 20th SM during, 2002 and 2003, respectively. The Cue lure traps have been reported to attract *B. cucurbitae* males from mid-July to mid-November (Fang and Chang 1984; Ramsamy *et al*., 1987; Liu and Lin 1993; Zaman 1995) [7, 6, 8, 4].

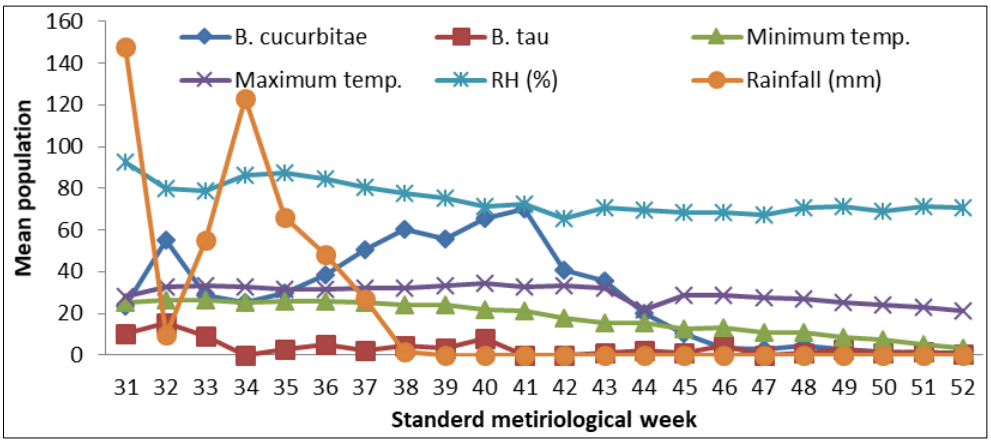

Fig 1: Seasonal incidence of *B. Cucurbitae* and *B. tau*, in cue lure Bottle traps during *Kharif* seasons 2018

Fruit fly population relationship with weather parameters

Fig. 2. summarizes seasonal fruit fly population fluctuations During the period of investigation In 2018–19, the first appearance of *B. zonata*, and *B. dorsalis*, caught in methyl eugenol bottle trap was observed during 31st SM with mean population of 26.20, 8.25 flies per trap per week, respectively. The first appearance of *B. correcta* and *B. diversa* caught in methyl eugenol bottle trap was observed during 36th SM with mean population of 26.20, 8.25 flies per trap per week, respectively. Thereafter, its population showed increasing trend and reached to its peak of 90.50 flies per trap per week during 39th SM. A decreasing trend was observed in 43rd SM up to 52nd SM. The mean population of *B. zonata* during entire growing season was 41.37 fruit fly per trap per week, its population showed increasing trend and reached to its peak of 65 flies per trap per week during 40th SM. A decreasing trend was observed in 43rd SW up to 52nd SW. The mean population of *B. dorsalis* during entire growing season was 23.29 fruit fly per trap per week its population showed increasing trend and reached to its peak of 10.25 flies per trap per week during 45th SM. A decreasing trend was observed in 51th SM up to 52nd SM. The mean population of *B. correcta* during all growing season was 0.81 fruit fly per trap per week, its population showed increasing trend and reached to its peak of 10.50 flies per trap per week during 44th SM. A decreasing trend was observed in 51th SW up to 52nd SW. The mean population of *B. diversa* during throughout growing season was 1.24 fruit fly per trap per week. Deepa *et al.* during, (2009) [15] recorded peak population of *B. zonata* found in 42th SM and 10th SM during, 2006 and 2007, respectively. Deepa *et al.* (2013) recorded peak population of *B. dorsalis* found in 4th week of April (17th SM) during, 2006 and 2007 in Kanpur. Deepa *et al.* during, (2009) [15] recorded its peak population of *B. correca* found in 50th and 14th SM during, (2006) and (2007) in Kanpur. The mean population of *B. diversa* during growing season was 1.24 fruit fly/trap/week. Similar result was also reported by Singh *et al.* (2007) [14].

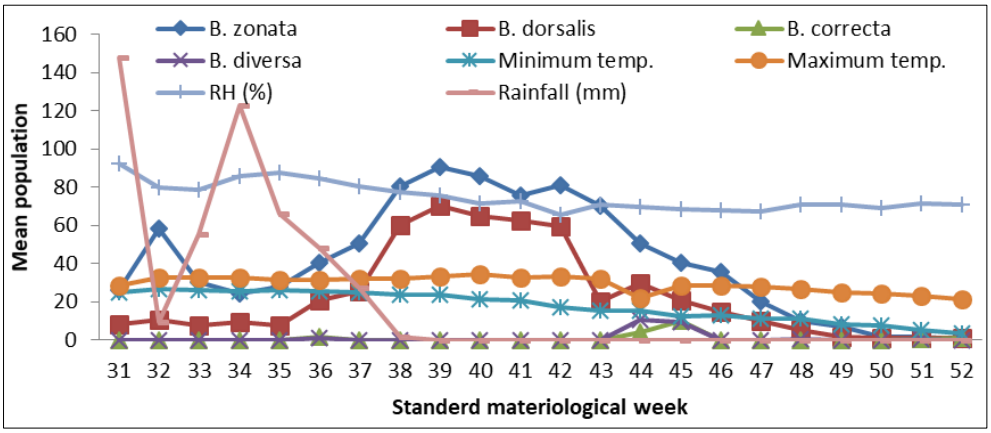

Fig 2: Seasonal incidence of *B. zonata*, *B. dorsalis*, *B. correcta* and *B. diversa* in cue lure Bottle traps during *Kharif* seasons 2018

Relationship between population of fruit flies and weather parameters

The prevalence of abiotic factors during 2018-19 indicated that the flies caught in the methyl eugenol bottle trap (*B. zonata*) population had highly positive significant correlation with minimum temperature (r = 0.563**) and non-significant with maximum temperature (r = 0.719**), but *B. dorsalis* population had highly positive significant correlation with maximum temperature (r = 0.564**) and non-significant with minimum temperature (r = 0.387) however, it was negatively correlated with relative humidity (-0.040) and rainfall (-0.208) and also negatively correlated with relative humidity (-0.159) and rainfall (- 0.284) *B. zonata* and *B. dorsalis* respectively in *kharif* season. The data revealed that *B. correcta* and *B. diversa* population had negatively non-significant correlation with minimum temperature (-0.155) (-0.155) and as well as maximum temperature (-0.221) (-0.355), however, it was negative with Relative humidity (-0.211) (-0.248) and rainfall (-0.139) (0.166) respectively during *kharif* season of 2018. Indicated that the fly catch in the Cue lure bottle trap had revealed that *B. cucurbitae* population had highly positive significant correlation with minimum temperature (0.752**) and as well as maximum temperature (0.788**), however, it was non-significant with relative humidity (0.289) and rainfall (0.015). In contrary Raghuvanshi *et al.* (2012) [16] found the similar result throughout the year in cue-lure baited traps. and *B. tau* population had positive significant correlation with minimum temperature (0.517*) and non-significant with maximum temperature (0.300), however, it was positive significant with relative humidity (0.463*) and non-significant with rainfall (mm) (0.286) in *kharif* season of 2018. In contrary Hasyim *et al.* during (2008) [8] found the similar result throughout the year in cue-lure baited traps.

Table 1: Relationship between population of fruit flies and weather parameters in bitter gourd during 2018

Fruit fly species	Weather parameters			
	Temperature (ºC)		Relative Humidity (%)	Rainfall (mm)
	Min.	Max.		
	Caught in Methyl Eugenol trap			
B. zonata	0.563**	0.719	-0.040	- 0.208
B. dorsalis	0.387	0.564**	-0.159	-0.284
B. correcta	-0.167	-0.221	-0.211	-0.139
B. diversa	-0.155	-0.355	-0.248	-0.166
	Caught in Cue Lure trap			
B. cucurbitae	0.752**	0.788**	0.289	0.015
B. tau	0.517*	0.300	0.461*	0.360

**Significant at 1% and *Significant at 5%

Conclusion

Survey for the fruit fly species complex in the bitter gourd ecosystems observed species were *B. zonata*, *B. dorsalis*, *B. correcta*, and *B. diversa*. Caught in methyl eugenol and *B. cucurbitae* and *B. Tau* caught in cuelure trap In present investigation B. cucurbitae was the major fruit fly in bitter gourd with presence of and B. Tau but *B. zonata B. dorsalis*, *B. correcta*, and *B. diversa*, was never found to lay egg in bitter gourd fruits during the stage. Studies undertaken on the incidence of bitter gourd fruit fly revealed that it was prevalent in the vegetable throughout the year. Peak population density was recorded During rainy months (39 SW at 23.90-33.40 ^{0}C, 42 SW 17.50-33.50 ^{0}C) the flies were more active *B. zonzta* and *B. cucurbitae* respectively as compared to that winter (52 SM 3.05-21.10 ^{0}C) months in the bitter gourd ecosystem. *B. correcta B. dicersa* and *B. tau* was very low throughout the rainy season 2018. The population of *B. zonata*, *B. Cucurbitae*, *B. tau* and *B. dorsalis*, *B. cucurbitae* exhibited significant positive correlation with minimum temperature and maximum temperature. The population of *B. tau* showed significant positive correlation with average relative humidity.

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