

## Impact Assessment of Pheromones Traps and Lures for Fruit fly, *Bactrocera* spp. in Bundelkhand region

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**ABSTRACT:** The following eight species of fruit fly, *Bactrocera cucurbitae* and *B. caudate* in cue lure and *B. affinis*, *B. caryeae*, *B. correcta*, *B. diversa*, *B. dorsalis*, and *B. zonata* caught in methyl eugenol baited traps. Rabi season, characterized by the active presence of *B. cucurbitae*, *B. correct*, *B. diverse*, and *B. dorsalis*, zaid by *B. caudata*, *B. zonata*, and *B. affinis* and kharif by *B. caryeae*. The cue lure performance held the highest caught 80.16%, and the bottle fruit fly trap trapped the highest number of fruit flies (48%) during zaid season, and it trapped 153.1 FFs after a rupee investment. There was a correlation between *B. correcta*, *B. cucurbitae*, *B. diversa*, and *B. dorsalis* population with abiotic factors that prevalence was negative with maximum and minimum temperatures, wind, and rainfall. Fruit fly management is challenging because of their feeding habits, high reproduction rates, habitat variation, and polyphagous nature. One management tactic will not be able to handle fruit flies. Therefore, must use many tactics collectively. It is discussed in this paper how to manage fruit flies using male annihilation techniques that can assist in structuring a great fruit fly management program.

**Keywords:** Abiotic factors, Fruit fly, Lures, Population, Traps.

### INTRODUCTION

Fruit flies, *Bactrocera* species (Tephritidae: Diptera), are sometimes called 'true fruit flies'. These insects fall under the quarantine insect pest where control is difficult after lay eggs and can cause economic loss to cucurbits, vegetables, and fruit crops when they fruit. Regarding fruit flies' impact on crops, cucurbitaceous vegetables were down 79%, fruits 14%, and solanaceous vegetables 6% (Adhikari *et al.*, 2020). Larvae feed on fruit flesh in their third and final instars using the anterior mouth hooks laid under the fruit peel. Furthermore, larval feeding and infection allow bacteria and fungi to enter the fruit (Abd-Elgawad, 2021). In addition to buds and stems, larvae can feed on seedlings, saplings, and succulent tap roots of host plants (Weeks *et al.*, 2020). Of the nearly 4,400 species of fruit fly found throughout the world (Norrbom, 2004). The Indian subcontinent is home to 200 species (Madhura and Verghese, 2003). Cucurbitae is an economically important species for cucurbit cultivation (Atwal and Dhaliwal, 2002), and *B. dorsalis*, *B. zonata*, and *B. correct* for fruit crops (Verghese and Devi, 1998). By feeding on the pulp of the fruit, the larvae of the fruit fly lay their eggs under the skin and produce maggots that pollute and destroy the fruit (Marc *et al.*, 2010). In addition to the frequent outbreaks of fruit flies in horticulture, climate change makes these outbreaks more frequent (Sultana *et al.*, 2017). It will require various management techniques to manage fruit flies effectively, as proposed by Reddy *et al.*, (2020). Should be used different methods of control in combination, such as cultural control, physical custody, behavioral control, mechanical control, biological control, chemical control, etc. Semiochemicals have proven helpful in monitoring and reducing fruit fly populations as part of an integrated pest management program (Ballo *et al.*, 2020). Monitoring fruit flies is accomplished through bait application technique (BAT) and male annihilation technique (MAT) (Souder, 2020). According to Sulaeha *et al.* (2020), monitored fruit fly in watermelon in the South of Sulawesi via pheromone traps baited with methyl eugenol and cue lure. Several studies have been carried in India and abroad to assess the relative performance of species-specific baited traps and to figure out the species variation in fruit flies, these aspects of Bundelkhand (UP) have little information about them. Therefore, keeping these aspects in mind, this study is planned around four major areas viz., seasonal dynamics of fruit flies; effective and economic traps for catching fruit flies; and the correlation between fruit fly populations and abiotic factors, as well as species diversity.

### MATERIAL AND METHODS

The experiment was carried on Jhansi's Research Farm of Rani Lakshmi Bai Central Agriculture University, in the 2019-20 academic years. To catch the adult male flies used two types of traps, McPhail fruit fly traps, and bottle fruit fly traps, as well as two types of lures: methyl eugenol and cue lure. Installed pheromone traps using bamboo poles at 15m above ground level and 25m apart from each other in a vegetable and fruit crop with the help of plastic ropes. During the study period, recharged the traps with lures the first week of kharif, zaid, and rabi's seasons. The fruit flies were collected separately every weekend identified using a fruit fly key provided by Dr. C.A. Viraktamath, Principal Investigator, ICAR Network Project on Insect Bio-systematic, Department of Entomology, GKVK, Bangalore.

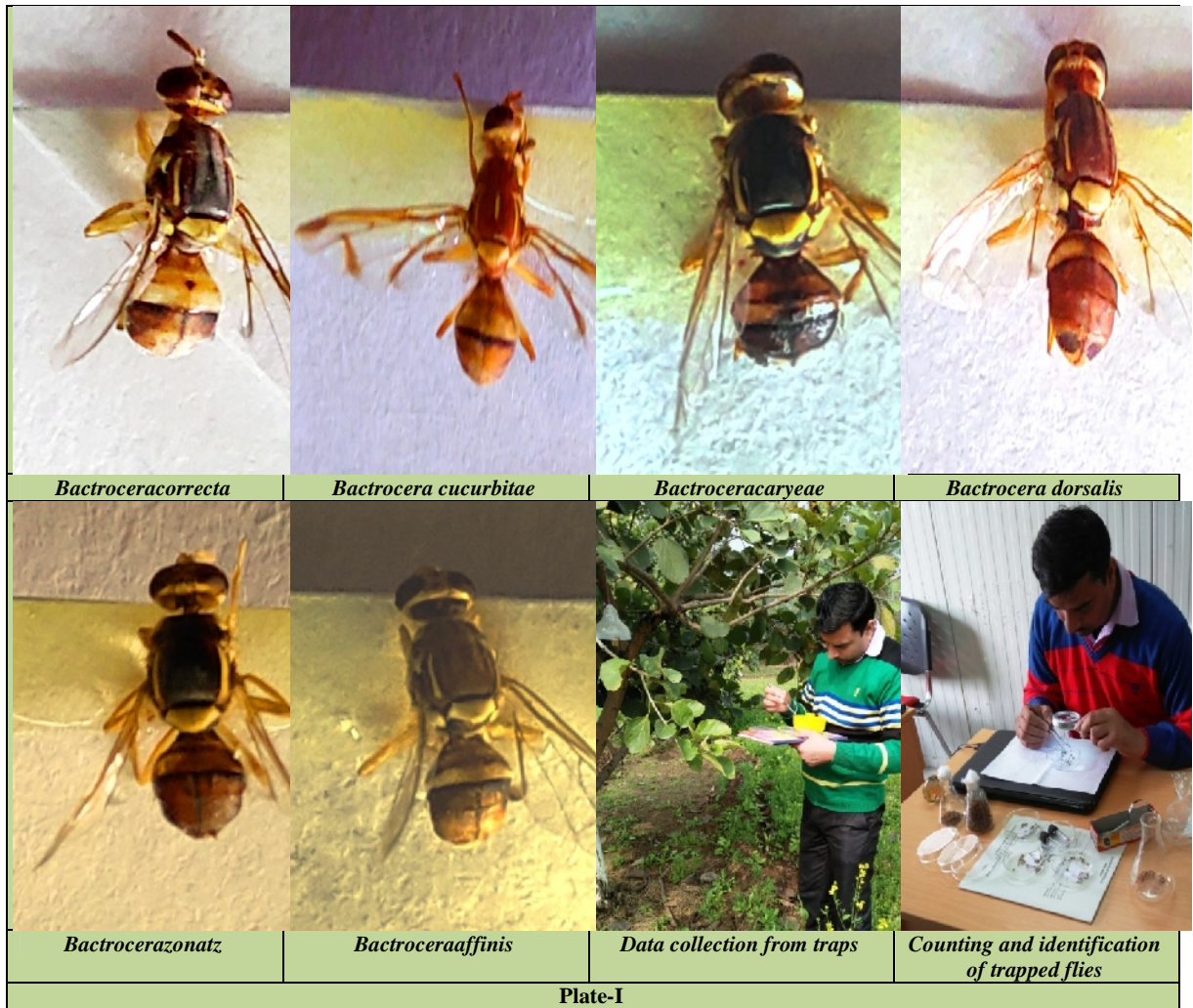
## RESULT AND DISCUSSION

### A. Species diversity in fruit fly, *Bactrocera* spp.

The following eight species of fruit fly, *Bactrocera cucurbitae* and *B. caudata* in cue lure (CL) and *B. affinis*, *B. caryeae*, *B. correcta*, *B. diversa*, *B. dorsalis* and *B. zonata* caught in methyl eugenol (ME) baited traps (Plate I). Accordingly, the contributed of the different fruit fly species was 43.05, 43.0, 9.15, 2.87, 1.01, 0.36, 0.33 and 0.22 percent (Table 2) of *B. zonata*, *Bactrocera cucurbitae*, *B. affinis*, *B. dorsalis*, *B. correcta*, *B. diversa*, *B. caryeae*, and *B. caudata*, respectively. Our research is also supported by Pal *et al.*, (2012b) and Singh, *et al.*, (2007) and recognized five species of fruit fly namely, *Bactrocera affinis*, *B. correcta*, *B. diversa*, *B. dorsalis*, *B. zonata* in methyl eugenol, and four species namely, *B. caudate*, *B. cucurbitae*, *B. nigrofemorialis*, *B. yercaudiae* in cue lure baited traps were recorded. Zida *et al.*, (2020) were reported twenty-nine tephritid species belonging to 10 genera were identified from Western Burkina Faso during 2017 to 2019.

**Table 1: Seasonal population dynamics of trapped fruit fly, *Bactrocera* species in para-pheromon baited traps.**

Mean population of fruit fly, <i>Bactrocera</i> spp.								
SW	<i>B. cucurbitae</i>	<i>B. caudata</i>	<i>B. caryeae</i>	<i>B. zonata</i>	<i>B. affinis</i>	<i>B. dorsalis</i>	<i>B. diversa</i>	<i>B. correcta</i>
<b>Rabi season</b>								
42	69.1	-	-	-	-	2.8	0.2	0.3
43	86.7	-	-	-	-	3.2	0.2	1.2
44	100.5	-	0.3	-	-	4.1	0.5	1.8
45	112.8	-	0.4	-	-	4.9	0.8	2.1
46	105.2	-	0.4	-	-	5.1	0.6	2.4
47	95.7	-	0.6	-	-	5.6	0.9	2.0
48	83.7	0.1	0.8	-	-	4.0	0.7	1.2
49	69.4	0.1	0.5	-	-	5.7	0.8	2.3
50	61.2	-	0.4	-	-	5.5	0.9	2.6
51	51.8	0.2	-	-	-	5.8	0.5	2.3
52	50.1	-	0.3	-	-	4.9	0.7	2.5
1	38.7	0.1	0.2	-	0.1	5.6	0.9	1.9
2	30.1	0.1	-	0.3	-	6.9	1.1	1.7
3	28.1	0.2	0.1	0.5	0.2	7.8	0.6	2.0
4	29.0	0.1	-	0.8	0.3	6.4	0.8	2.6
5	30.5	-	-	1.2	0.5	5.2	0.5	2.5
6	30.8	-	-	15.1	1.2	3.1	0.7	1.4
7	31.0	-	-	16.9	2.0	2.1	0.3	0.8
8	30.0	-	-	14.8	4.2	1.2	-	0.4
9	28.4	-	-	18.3	6.8	0.5	0.1	0.2
10	20.1	0.1	-	23.4	10.4	0.5	-	-
<b>Zaid season</b>								
11	16.7	-	-	35.9	15.8	0.1	-	-
12	15.8	0.1	-	49.7	18.9	-	-	-
13	14.1	0.2	-	52.6	19.3	-	-	-
14	13.5	0.3	-	71.6	22.0	-	-	-
15	13.9	-	-	75.8	21.5	-	-	-
16	13.1	0.1	-	80.1	23.0	-	-	-
17	12.7	0.2	-	78.9	22.8	-	-	-
18	14.2	-	-	84.5	20.8	-	-	-
19	12.1	0.1	-	81.9	21.6	-	-	-
20	13.7	-	-	78.8	21.1	-	-	-
21	11.9	0.2	-	81.1	21.5	-	-	-
22	10.8	-	-	77.1	18.7	-	-	-
23	10.4	0.1	-	76.9	14.3	-	-	-
24	9.8	-	-	68.7	10.1	-	-	-
24	1.8	-	-	4.1	0.4	-	-	-
<b>Kharif season</b>								
25	5.7	-	-	58.0	6.9	-	-	-
26	4.9	-	0.1	54.4	3.8	-	-	-
27	3.8	-	0.3	53.8	2.6	-	-	-
28	4.4	-	0.5	47.8	1.4	-	-	-
29	4.8	0.1	0.6	43.5	0.9	-	-	-
30	5.7	0.1	0.4	35.6	0.2	-	-	-
31	6.1	0.3	0.2	33.1	-	0.1	-	-
32	5.2	0.6	0.6	28.5	-	0.1	-	-
33	5.1	0.7	0.5	11.5	-	0.2	-	-
34	5.9	0.6	0.7	9.7	-	0.4	-	-
35	6.3	0.8	0.4	5.2	-	0.4	-	-
36	6.9	0.5	0.8	3.1	-	0.6	0.1	-
37	7.0	0.6	0.7	1.2	-	0.5	0.1	0.1
38	8.2	0.5	0.5	0.8	-	0.9	0.1	-
39	9.1	0.3	0.6	0.2	-	1.2	0.1	0.12
40	9.8	-	0.4	0.1	-	1.9	0.1	0.1
41	5.2	-	0.1	0.1	-	0.7	0.1	0.1



Researchers at the Atomic Energy Research Establishment campus, Savar, Dhaka, Bangladesh, used cue lures, methyl eugenol, and zingerone-baited pheromone traps to monitor fruit flies. A total of 135, 034 specimens were caught across 15 species. The most common species was *Bactrocera dorsalis*, which made up 58 percent of total trapped flies (Hossain *et al.* (2019).

**B. Population dynamic of trapped fruit flies, *Bactrocera* spp.**

*Bactrocera affinis* trapped in cue lure baited traps and covered 9.15 percent (Table 2) of the total trapped population, Pal and Singh (2012) recorded 7.69%. It was the most active in the *Zaid* season followed by *Rabi* and *Kharif* season, with a peak population (23 fruit flies (FF's)/trap/week) from 16<sup>th</sup> standard week (SW) (Table 1).

The population was the first time recorded from 1<sup>st</sup> SW of *Rabi* season and last from 31<sup>st</sup> SW of *Rabi* season with 0.1 FF/trap/week and 0.2 FF's/trap/week, respectively. Pal and Singh, (2012) recorded *B. affinis* was most active during *Zaid* season, and the population range was 0.47-109.05 FF's/trap/week followed by *Kharif* and *Rabi* seasons. The occurrence of this species has also been reported from Faizabad (Singh *et al.*, 2007).

**Table 2: Species contribution in total trapped fruit fly population.**

Fruit fly species	Numbers of trapped fruit flies	Contribution (%)
<i>Bactrocera zonata</i>	14715	43.051
<i>Bactrocera cucurbitae</i>	14697	42.999
<i>Bactrocera affinis</i>	3129	9.154
<i>Bactrocera dorsalis</i>	980	2.867
<i>Bactrocera correcta</i>	347	1.015
<i>Bactoceradiversa</i>	124	0.363
<i>Bactrocera caryeae</i>	114	0.334
<i>Bactoceracaudata</i>	74	0.217
Total	34180	

Adults of *B. caryeae* recorded during the *Rabi* and *Kharif* season, but it did not withstand the *Zaid* season. This species was most active during *Kharif* season followed by *Rabi*, but the population range was recorded 0.1-0.8 FF's/trap/week from both the Pal *et al.*, *Biological Forum – An International Journal* (SI-AAEBSSD-2021) 13(3b): 148-154(2021) 150



seasons. The total number of captured flies was 0.33 percent. The population range was recorded viz., 0.1-0.2; 0.1-0.3, and 0.1-0.8 FF/trap/week from *Rabi*, *Zaid*, and *Kharif* season, respectively. This species was noticed from only eight, eight, and eleven weeks of *Rabi*, *Zaid*, and *Kharif* season, respectively. It was recorded 0.21% of total trapped flies during the study period. The activity of this fruit fly was highest in *Kharif* followed by *Rabi* and *Zaid* seasons and the maximum population was noticed 0.97FF/trap/week in 37<sup>th</sup> SW and covered 1.27% of the total CL trapped flies population (Pal and Singh, 2012).

*Bactrocera correcta* was most active during *Rabi* season, and the population range was 0.2-2.6 FF's/trap/week. It was completely absent throughout the *Zaid* season, but it was recorded only three standard weeks during *Kharif* season. The population of *B. correcta* was 1.02 percent of the total trapped fruit flies. Pal and Singh (2012) recorded the maximum mean population of this species as 0.33 fruit fly/trap/week was recorded in 43<sup>rd</sup>SW. Jalaluddin *et al.*, (2001) recorded its peak population from July-August 1994 -95 while Deepa *et al.* (2009) found its peak activity in 50<sup>th</sup>SW 2006 and 14<sup>th</sup> of 2007 in Kanpur. *Bactrocera cucurbitae* was single fruit fly species that was active throughout the year, and it was the predominant species that covered 43% of the total trapped fruit flies. The maximum population of *B. cucurbitae* was recorded from 45<sup>th</sup>SW with 112.8 FF's/trap/week during *Rabi* season and noticed the minimum population (1.8 FF's/trap/week) at last week of *Zaid* season. This species was most active in *Rabi* season, followed by *Zaid* and *Rabi* season. During *Zaid* season, recorded its population range 1.8-16.7 FF's/trap/week. The population was recorded from *Kharif* season viz., 5.7, 4.9, 3.8, 4.4, 4.8, 5.7, 6.1, 5.2, 5.1, 5.9, 6.3, 6.9, 7.0, 8.2, 9.1, and 9.8 from 26<sup>th</sup> to 41<sup>st</sup> SW, respectively. Pal and Singh (2012) were recorded that the population of *B. cucurbitae* throughout the year with a population range of 1.53-13.41 fruit flies/trap/week in *Kharif*, 1.94-36.28 fruit flies/trap/ week in *Rabi*, and 0.05-15.42 fruit flies/trap/week in *Zaid* seasons. According to Nahid *et al.* (2021), fruit flies *Bactrocera cucurbitae* Coquillett were more abundant in summer than autumn. In summer, more larvae were found per fruit than in autumn (24.9 fruit-1). Pankaj *et al.* (2002) recorded the minimum (0.67 fruit fly /trap) and maximum (2.83 fruit flies/trap) population of this species, respectively in 21<sup>st</sup> and 27<sup>th</sup> SWs while Manzar and Srivastava (2004) reported minimum and maximum population, respectively, 297.3 and 396.6 fruit flies/trap in 23<sup>rd</sup> SW in 2002 and 20<sup>th</sup>SW in 2003. Vengesh *et al.*, (2020) captured four species of fruit fly, *Bactrocera caryeae* and *B. dorsalis*, and *B. correct* (Bezzi), with a minor population of *B. nigrofemorialis* as well. There was a peak fruit fly activity (56.50 FF's/trap) in August, followed by a small population of fruit fly activity (3.50 FF's/trap) in December.

Noticed the response of *Bactrocera diversa* from first week of *Rabi* season and active throughout the season, but it was absent during *Zaid*, were seen it from last 5<sup>th</sup>SW of *Kharif* season. The maximum population was recorded as 2.6 FF's/trap/week, contribute only 0.36 percent in total trapped flies' population. This species was present in *Kharif* and *Rabi* seasons with a maximum mean population of 0.14 fruit fly/trap /week in 42<sup>nd</sup>SW of 2008 & 2009 and 0.11 fruit fly/trap /week in 10<sup>th</sup>SW of 2008-09 and 2009-10 (Pal and Singh (2012). This species was reported from Faizabad earlier also (Singh *et al.*, 2007). Started the population of *Bactrocera dorsalis* just after installed traps in the field, where population was recorded as 2.8 FF's/trap/week. The population range was 0.5-7.8 FF's/trap/week during *Rabi* season. Still, its population was recorded the only first week of *Zaid* season and it was again recorded from 32<sup>nd</sup> SW of *Kharif* season after 20 weeks interval. Contributed 2.87 percent of the total trapped fruit fly population. Gupta *et al.*, (1990) captured *B. dorsalis* in traps baited with methyl eugenol from the 2<sup>nd</sup> week of April to the 2<sup>nd</sup> week of November, and peak of adult activity occurred during 3<sup>rd</sup> and 4<sup>th</sup> week of June month. Noticed the activity during the *Kharif* and *Rabi* seasons. Still, it was not active during the *Zaid* season, where caught maximum mean population as 0.28 fruit fly/trap/weeks was trapped first in 41<sup>st</sup> and second in 43<sup>rd</sup> SW in *Kharif* season and 0.36 fruit fly/trap/weeks in 48<sup>th</sup> SW. Deepa *et al.* (2009) reported peak population of this species in 4<sup>th</sup> week (17<sup>th</sup> SW) of April 2006 and 2007 from Kanpur while Gupta *et al.*, (1990) found its peak activity in the 3<sup>rd</sup> week of June (25<sup>th</sup>SW) on apricot, 4<sup>th</sup> week of June (26<sup>th</sup>SW) on plum and 2<sup>nd</sup> week of July (28<sup>th</sup>SW) on peach in the mid-hill region of Himachal Pradesh. According to Senathipathi *et al.* (2020), *Bactrocera dorsalis* and *B. correcta* were most active during August and last least in February.

The fruit fly, *Bactrocera zonata*, was the predominant species and trapped in ME baited traps. It was 43.05 percent of total trapped flies during study period. This species was active in all the seasons, but it was most active during *Zaid* season followed by *Kharif* and *Rabi* season. Recorded the population range as 0.3-23.4, 4.1-84.5, 0.1-58.0 FF's/trap/week from *Rabi*, *Zaid*, and *Kharif* season, respectively. The peak population (84.5 FF's/trap/week) was recorded from 18<sup>th</sup> SW of *Zaid* season. Gupta *et al.* (1990) studied the seasonal fluctuation of *B. zonata* was trapped in methyl eugenol baited traps, and it was more active than *B. dorsalis*. Pal and Singh (2012) noticed the activity of *B. zonata* throughout the study period except from 47<sup>th</sup> to 1<sup>st</sup> SW during *Rabi* season. The maximum population was recorded during *Zaid* season, followed by *Kharif* and *Rabi* seasons. The maximum mean population, in respective seasons, were 40.89 fruit flies/trap/week in 29<sup>th</sup>SW, 15.16 fruit flies/trap/week in 13<sup>th</sup>SW and 1226.33 fruit flies/trap/week in 20<sup>th</sup> SW. Manzar and Srivastava (2004) recorded a maximum population of 395.6 fruit flies /trap in 23<sup>rd</sup>SW during 2002 and 432.3 fruit flies/trap in 20<sup>th</sup>SW during 2003 in Kanpur while Deepa *et al.* (2009) working in above area observed its peak activity in 42<sup>nd</sup> SW of 2006 and 10<sup>th</sup> SW of 2007. According to Sowmiya *et al.* (2020), fruit flies in snake gourds observed in Kumaravadi village, Tiruchirappalli during the *Kharif* and *Rabi* seasons of 2019-20 are seasonal fluctuate. Traps containing methyl eugenol captured *B. dorsalis*, *B. zonata*, and *B. correct* fruit fly species. In *Kharif*, there were 25.80 fruit flies per trap, whereas, in *Rabi*, there were 12.3 fruit flies per trap. ICAR-RCER Patna, India, was found to trap more *Bactrocera zonata* (83.00%) in the rainy season than other species (*B. dorsalis*, *B. cucurbitae*, and *B. tau*). A higher percentage of *B. correct* was trapped (47.25%) during the same season than *B. zonata*, *B. dorsalis*, and *B. cucurbitae* (Jana and Idris, 2021).

### C. Seasonal performance of lure and traps against fruit fly, *Bactrocera* spp.

Recorded the seasonal performance of lure and traps based on total trapped fruit flies according to seasons. A total of 34169 fruit flies (FF's) (Table 3) were trapped during study period and 56.77 percent was caught in Methyl eugenol (ME) where, 43.23 per cent attracted in cue lure (CL), and this difference was 13.54 per cent. The fruit fly population was approximately equally trapped (42%) during *Rabi* and *Zaid* season, where, in case of *Kharif* season, it was 15.40 per cent. The seasonal performance of ME was trapped 2579, 12651 and 4169 FF's from *Rabi*, *Zaid* and *Kharif* season as 13.29, 65.21 and 21.49 per cent, respectively. Cue lure (CL) caught 14770 FF's within 11839 FF's from *Rabi*, 1839 FF's from *Zaid* and 1092 FF's from *Kharif* season that was 80.16, 12.45 and 7.39 per cent, respectively (Table 2). Methyl eugenol was most effective during *Kharif* and summer season, but cue lure was most effective during *Rabi* season (Pal *et al.*, 2015).

In case of trap performance, trapped the maximum fruit flies (55.65%) in McPhail fruit fly traps (MFFT) followed by Bottle fruit fly trap (BFFT) (44.35%) and this difference was 11.3 per cent. MFFT was trapped 8766 FF's (46.1%) during *Zaid* season followed by *Rabi* (37.6%) and *Kharif* (16.3%) season. By this trap, 8.5 per cent more flies were caught in *Zaid* than *Rabi* season and 29.8 per cent more than in *Kharif* season. Rakshak fruit fly trap was trapped 35.1, 17.3, and 15.2% more fruit flies followed by bottle fruit fly trap during *Kharif*, summer and *Rabi* season, respectively (Pal *et al.*, 2015). Performance of traps has been evaluated earlier also (Patel and Patel, 1998; Jhala *et al.*, 2008, Shukla *et al.*, 2008 and Chua, 2009). For fruit fly monitoring, Bali *et al.*, (2021) assessed five trap devices, including the Decis® trap, Biodelear, BioLure, and McPhail trap baited with Biodelear and BioLure. BioLure baited Tephri traps performed better than other trap-attractant combinations at high temperatures. Decis® traps captured fewer adults in both seasons.

**Table 3: Seasonal performance of traps and lure against fruit fly, *Bactrocera* spp. during 2019-20.**

Season	Total trapped fruit flies in numbers		Total trapped fruit flies in %		Total trapped FFs	Per cent (%) of trapped FFs	Total trapped fruit flies in numbers		Total trapped fruit flies in %	
	ME	CL	ME	CL			MFFT*	BFFT®	MFFT*	BFFT®
<i>Rabi</i>	2579	11839	13.29	80.16	14418	42.20	7146	7272	37.6	48.0
<i>Zaid</i>	12651	1839	65.21	12.45	14490	42.41	8766	5724	46.1	37.8
<i>Kharif</i>	4169	1092	21.49	7.39	5261	15.40	3104	2157	16.3	14.2
Total	19399	14770			34169		19016	15153		
Grant total	34169		56.77	43.23			34169		55.65	44.35

\*McPhail fruit fly traps, ®Bottle fruit fly traps

**D. Seasonal economic performance of lure and traps against fruit fly, *Bactrocera* spp.**

Analyzed result on economic performance of traps and lure based on trapped fruit flies after per rupee investment. First discuss on investment, a total of rupees 62.0 invested on McPhail fruit fly traps (MFFT) baited with ME and rupees 85.0 was baited with CL where as rupees 32.0 cost was of Bottle fruit fly trap (BFFT) baited with ME and rupee 55.0 when baited with CL. A total of 11363 FF's were trapped in MFFT baited with ME and 7653 FF's in case of CL, whereas, 1137, 7751, 2475 FF's in ME and 6009, 1015, 629 FF's in CL baited MFFT were trapped during *Rabi*, *Zaid* and *Kharif* season, respectively. In case of BFFT, traps baited with ME were trapped 1442, 4900, 1694 FF's and 5830, 824, 463 FF's when traps baited with CL from *Rabi*, *Zaid* and *Kharif* season, respectively. MFFT baited with ME was trapped 18.3, 125.0, & 39.9 FF's whereas 70.7, 11.9 and 7.4 FF's in case of CL from *Rabi*, *Zaid* and *Kharif* season, respectively. BFFT with ME were caught 45.1, 153.1, 52.9 FF's whereas 106.0, 15.0, 8.4 FF's with CL. Sums of 251.1 FF's were caught after per rupee investment from *Rabi*, *Zaid* and *Kharif* season, respectively. An overall, Bottle fruit fly trap was most economically important and caught 83.71 FF's after per rupee investment followed by MFFT with ME, BFFT with CL and MFFT with CL whereas 61.09, 43.13 and 30.01 FF's. Bottle fruit fly traps baited with CL, dispensed through cotton wick and replenished at three month interval proved most economical and trapped 394.12 FF's on per rupee investment during summer season (Pal *et al.*, 2012a).

**Table 4: Seasonal economic performance of traps against fruit fly, *Bactrocera* species.**

Season	Total trapped fruit flies				Investment /trap				Trapped FFs/rupee investment			
	MFFT*		BFFT®		MFFT*		BFFT®		MFFT*		BFFT®	
	ME	CL	ME	CL	ME	CL	ME	CL	ME	CL	ME	CL
<i>Rabi</i>	1137	6009	1442	5830	62	85	32	55	18.3	70.7	45.1	106.0
<i>Zaid</i>	7751	1015	4900	824	62	85	32	55	125.0	11.9	153.1	15.0
<i>Kharif</i>	2475	629	1694	463	62	85	32	55	39.9	7.4	52.9	8.4
Total	11363	7653	8036	7117	186	255	96	165	61.09	30.01	83.71	43.13

\*McPhail fruit fly traps, ®Bottle fruit fly traps

**E. Correlation coefficient**

The abiotic factors play an important role in the abundance of fruit fly. Fruit fly population was correlate with maximum & minimum temperature, maximum & minimum relative humidity, wind speed and rainfall. The population of *B. affinis* was founded positive correlation with temperature and rainfall while it was negative with relative humidity (Table 5).

**Table 5: Correlation coefficient between fruit fly species and abiotic factors.**

Fruit fly species	Temp. (0C)		RH (%)		Wind (Km/hr)	Rainfall (mm)
	Maxi.	Mini.	Maxi.	Mini.		
<i>B. affinis</i>	0.5426	0.2191	-0.8776	-0.7433	0.3966	-0.2089
<i>B. caryeae</i>	-0.0388	0.2178	0.5443	0.51075	-0.0478	0.2917
<i>B. caudata</i>	0.1072	0.3473	0.2752	0.2977	0.3661	0.1125
<i>B. correcta</i>	-0.7581	-0.7929	0.3549	0.2414	-0.5917	-0.2932
<i>B. cucurbitae</i>	-0.4101	-0.5436	0.1683	0.0294	-0.4925	-0.3354
<i>B. diversa</i>	-0.7406	-0.7698	0.3615	0.2662	-0.6331	-0.2927
<i>B. dorsalis</i>	-0.7860	-0.7980	0.3983	0.2937	-0.6615	-0.2871
<i>B. zonata</i>	0.6926	0.5117	-0.7706	-0.5696	0.60925	0.0922

A negative correlation was recorded between *B. caryeae* population with maximum temperature and wind speed whereas it was positive with other abiotic components. *Bactrocera caudata* population was found positive correlation with all the abiotic components. The population of *B. correcta*, *B. cucurbitae*, *B. diversa* and *B. dorsalis* was founded negative correlation with maximum and minimum temperature, wind speed and rainfall, whereas *B. zonata* population was positive correlation with its. Based on the correlation matrix, minimum and maximum temperatures and sunshine hours are significantly correlated with *B*

*zonata*. Conversely, relative humidity (R.H.) and rainfall have a negative correlation with *B. zonata* abundance (Khan *et al.*, 2021). Jalaluddin *et al.* (2001) found significant positive correlation with minimum and maximum temperatures (°C), morning RH (%) and rainfall (mm) and low negative correlation with sunshine hours and population of *B. correcta*. Gupta *et al.* (1990) found positive significant correlation with rainfall in 1986 and negative non-significant during 1987. Verghese and Devi (1998) found significant positive correlation with minimum temperature. Peng, (2006) also reported temperature and raining days influence the population of *B. dorsalis*. Gupta *et al.* (1990) found positive significant correlation with rainfall in 1986 and negative non-significant during 1987. Agarwal and Kumar (1999) found positive correlation with minimum and maximum temperatures and rainfall and negative correlation with RH (%). According to the results of the correlated analysis conducted by Vignesh *et al.* (2020), fruit fly incidence is positively correlated with maximum and minimum temperature, and negatively correlated with morning and evening relative humidity (RH). The incidence of *Bactrocera* species, which Senathipathi *et al.*, (2020) correlate with maximum and minimum temperatures and morning, relative evening humidity (RH), and rainfall. Sowmiya *et al.*, (2020) found a negative correlation between relative humidity and rainfall during both seasons, and other factors showed a positive correlation. There was a significant positive correlation between *B. dorsalis* catches and climatic factors, such as maximum temperatures, minimum temperatures, relative humidity, sunshine duration, except for the mean monthly rainfall, which was not significant (Khan *et al.*, 2021).

## CONCLUSION

In the Bundelkhand region, a fruit fly that causing economic loss to farmers, mainly due to an increase in their species, increase in crop area, and adoption of incorrect methods for fruit fly management by the farmers. The research focused on farmers has been told about a cheap and good fruit fly management method.

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