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Population dynamics of fruit fly (*Bactrocera* spp.) in guava orchard and identification of critical management periods based on weather correlation

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Abstract

A field study was conducted during 2025–26 in guava (*Psidium guajava* L.) orchards at Acharya Narendra Deva University of Agriculture and Technology (ANDUAT), Kumarganj, Ayodhya, district is geographically located between 26.47° North latitude and 82.12° East longitude, at an elevation of about 113 meters above sea level, within the Gangetic alluvial plains of eastern Uttar Pradesh, India. To investigate the population dynamics of fruit flies (*Bactrocera* spp.) in relation to different seasons and weather parameters. Monitoring was conducted using methyl eugenol bait traps (ethanol + methyl eugenol + Spinosad 45 SC), with weekly trap catches recorded across summer, monsoon, and winter seasons. Results revealed that *Bactrocera* spp. remained active year-round but exhibited distinct seasonal peaks. The highest population was observed during the monsoon season (maximum 342 flies/trap/week in early July), followed by moderate activity in summer (peak 81.67 flies/trap/week in late March), while winter recorded the lowest incidence (2.33–87.33 flies/trap/week). Correlation analysis indicated that temperature was the most critical abiotic factor, showing positive associations in monsoon and winter, whereas rainfall consistently suppressed adult activity across seasons. The study concludes that early monsoon and late summer represent the most vulnerable periods for guava orchards, necessitating timely adoption of integrated pest management (IPM) strategies such as trap-based monitoring, orchard sanitation, and bait application to minimize fruit damage and economic losses.

Keywords: *Psidium guajava* L., *Bactrocera* spp., Tephritidae, Summer, Monsoon and Winter Season, Population dynamics, Correlation, intrgated pest management

Introduction

The guava (*Psidium guajava* L.) belongs to the Myrtaceae family and it is a widely cultivated climate resilient fruit native to tropical America. Among fruit crops of the country, guava holds the fourth rank in area and production after mango, banana and citrus fruits. According to the Horticulture Statistics Division, Government of India, the total area under guava cultivation in India was 361 ha during 2023 [18]-24, with a production of 5368.1 metric tonnes and a productivity of 14.9 MT/ha (Anonymous 2026). In Uttar Pradesh, the area under guava was 53.62 ha, with a production of 1032.65 metric tonnes and a productivity of 19.26 MT/ha (Anonymous 2026). The crop is robust, highly productive and profitable. The fruit is nutritionally very rich and a good source of Vitamin A, B and C and other micronutrients like pectin, Calcium, Phosphorus etc. With a distinct flavor. The quality of fruit is of better grade during winter season than in monsoon season, hence during monsoon season crops are avoided in certain areas to get a better yield in winter. The fruit can be consumed fresh or in the form of different products *viz* jelly, jam, nectar etc. A major problem faced by guava orchard being large scale cultivation results in steady invasion of pests in the orchards. Several insect pests pose threat to production of guava crop, which results in its poor yield in spite of larger area under cultivation. Guava is reportedly attacked by fruit fly (*Bactrocera* spp.*)*, scales, red striped thrips, mealybugs, mites, stink bugs, guava moth, guava whitefly etc. (Kumar *et al.*, 2020; Sharma *et al.*, 2024) [11, 21]. Tephritid Fruit flies belongs to genus *Bactrocera* is one of the most devastating insect pests that attack crops belonging to more than 30 families, majority of them are of considerable economic importance **(**Patel *et al.,* 2019; Yadav *et al.*, 2025) [17, 26]. Their ability of high dispersal capacity, movement, fecundity and high reproductive rate has made these fruit flies, the dreaded pests of various fruits and vegetables namely, Peach, mango, guava, citrus, tomato, cucumber, etc., which causes significant damage to the crops resulting from the substantial reduction in qualitative and quantitative yield. The market value of guava fruit decreases by 20-46% as a result of heavy infestation of *Bactrocera* spp. (Rani *et al.*, 2017; Joshi *et al.*, 2022; Mehta *et al.*, 2026) [4, 13, 19]. The guava fruit flies, *Bactrocera* spp., *viz. B. dorsalis, B. zonata and B. correcta* are the major limiting factors in successful cultivation causing almost 100% damage to rainy season guava crop (Umesh *et al.*2025) [23], but only a few species of the genus *Bactrocera* are recurrently found in orchards. In order to manage this pest effectively with need-based management practices, population dynamics studies of this pest in the guava ecosystem play crucial role (Kaur *et al.*, 2021; Verma *et al.*, 2025) [9, 25]. Keeping in view the above facts in to consideration, the study on population dynamics of fruit flies in the orchards of guava was undertaken in eastern Uttar Pradesh.

Materials and Methods

The experiment was conducted during different flowering bahar seasons 2025–26 in a well-maintained guava orchard located at the Main Experiment Station, Department of Fruit Science, A.N.D.U.A.&T., Kumarganj, Ayodhya (U.P.). This trial was conducted over an area of 1000 m^2 (10×10) that exhibit guava plants of variety, which were raised under planting system, three methyl eugenol traps were installed at a height of 1.5–2.0 m above ground level in the shade canopy of guava plants on February 2025. The trapped population of fruit flies (*Bactrocera* spp.) inside the methyl eugenol traps were counted and monitored regularly at weekly intervals. To construct the traps, transparent plastic bottle of 1 liter volume with dimensions of 27.6 cm length and 7.64 cm width was used with eight evenly spaced access holes on the lower curvature and an additional entry above the shoulder of bottle was provided for inserting and removing the lure block (Figure 1). A hole in the bottle cap was made for hanging the trap. Rectangular plywood blocks were soaked in a lure mixture containing ethanol, methyl eugenol, and Spinosad 45 SC in the ratio of 6:4:1(Figure 1). Spinosad group of insecticides alter the function of nicotinic and GABA-gated ion channels, causing rapid excitation of the insect nervous system, leading to involuntary muscle contractions, tremors, paralysis, and death (Raisch *et al.* 2023) [18]. Blocks were kept in sealed containers for seven days for proper absorption before use. Adult fruit flies trapped were counted on weekly basis, and lure blocks were replaced every 25–30 days. Meteorological data such as maximum and minimum temperature, morning relative humidity, rainfall were recorded from the nearest agrometeorological observatory, department of Agricultural meteorology, A.N.D.U.A.&T., Kumarganj, Ayodhya (U.P.) to understand the role of various weather parameters on *Bactrocera* spp. population. Considering this, correlation analysis was conducted between weekly *Bactrocera* spp. population and weather parameters recorded in this study. Pearson's correlation coefficient (r) was used to assess the influence of climatic factors on *Bactrocera* spp. population dynamics. The data were analysed using the OPSTAT software (http://opstat.somee.com/opstat).

Fig 1: A) Trap installation B) Insert septa in traps C) Data recorded D) Septa dipping in mixture.

Result and discussion

Population dynamics of fruit fly (*Bactrocera* spp.) on guava

The population dynamics of *Bactrocera* spp. in guava fruits is presented in the tables 1,2 and 3, which revealed that its activity persisted throughout the year with marked seasonal fluctuations. The population showed distinct peaks and declines during different seasons (summer, monsoon and winter), which were strongly influenced by prevailing weather parameters such as temperature, relative humidity and rainfall. Similar seasonal patterns of *Bactrocera* spp. abundance have been reported previously in guava and other fruit crops, where climatic factors govern adult emergence, flight activity and reproductive behaviour (Umesh *et al.* 2025; Kumar *et al.* 2021) [12, 23].

Summer season (SMW 9–22: February–June)

Summer season (SMW 9–22), the population initiated at 20.67 flies/trap/week in late February and gradually increased, reaching a peak of 81.67 flies/trap/week in late March (SMW 13). Thereafter, the population declined sharply with rainfall events in mid-April (30.6 mm) and late May (57.4 mm), indicating that precipitation suppressed adult activity. Correlation analysis (Table 1) confirmed a significant negative association with minimum temperature (r = –0.527) and rainfall (r = –0.507), while maximum temperature and relative humidity showed weak influence. These findings suggest that moderate thermal conditions favored activity but extremes and rainfall reduced catches (Table 4). The results from the present investigation were closely aligned with previous findings of *Bactrocera* spp.

(Kumar *et al*. 2021; Umesh *et al*. 2022; Roy *et al*. 2020; Duan *et al*. 2021) [2, 10, 12, 20], These results suggest that *Bactrocera* spp. population during summer is mainly driven by temperature rise and rainfall occurrence.

(Roy *et al*. 2020; Duan *et al*. 2021) [2, 20] the present result positive association of *Bactrocera* spp. incidence with temperature and rainfall has been reported in guava and other fruit crops.

Table 1: Studies on population dynamics of fruit flies (*Bactrocera* spp.) through methyl eugenol traps summer season (2025) [23].

Sr. No	SMW	Date	Mean population of Fruit flies/ trap/week	Weather parameters			
				Temperature (°C)		RH (%)	Rainfall (mm)
				Min.	Max.		
1	9	26 fab - 04 Mar	20.67	12.50	27.60	59.80	0.00
2	10	05 Mar - 11 Mar	38.00	12.00	28.90	63.40	0.00
3	11	12 Mar - 18 Mar	46.33	14.50	35.00	68.30	0.00
4	12	19 Mar - 25 Mar	61.33	15.00	34.90	64.00	0.00
5	13	26 Mar - 01 Apr	81.67	14.80	35.50	63.60	0.00
6	14	02 Apr - 8 Apr	63.67	16.70	37.90	64.50	0.00
7	15	09 Apr - 15 Apr	30.33	21.20	34.10	67.70	30.60
8	16	16 Apr - 22 Apr	40.00	22.70	37.10	60.50	0.00
9	17	23 Apr - 29 Apr	36.00	20.60	39.60	57.90	0.00
10	18	30 Apr - 06 May	38.33	24.40	35.70	67.70	0.00
11	19	07 May - 13 May	24.67	25.20	38.20	65.30	16.60
12	20	14 May - 20 May	30.00	25.50	39.10	65.20	0.00
13	21	21 May - 27 May	18.00	24.50	35.80	67.40	57.40
14	22	28 May - 03 Jun	12.33	25.20	37.30	66.40	18.80
SMW= Standard meteorological week, R.H.= Relative humidity							

Monsoon season (SMW 23–39: June–September)

The studied guava monsoon seasons, fruit fly populations surged dramatically, with the highest peak of 342.00 flies/trap/week recorded in early July (SMW 27). This period coincided with warm temperatures (27–36 °C) and moderate humidity (70%), conditions highly favorable for fruit fly buildup. However, heavy rainfall events (141.8 mm in SMW 28 and 255.4 mm in SMW 32) caused temporary declines, though populations remained relatively high throughout the season (Table 2). Correlation analysis revealed positive associations with both minimum ($r = 0.314$) and maximum temperature ($r = 0.331$), while rainfall showed a negative correlation ($r = –0.330$), highlighting that warm, humid conditions promote activity but excessive rainfall disrupts dispersal and trap attraction. A secondary peak was observed around the 27th SMW (342 flies/trap/week) (Table 4). (Shelly *et al.* 2016; Ghanim *et al.* 2020; and Hafsi *et al.* 2022) [5, 6, 22]. These findings suggest that although temperature supported *Bactrocera* spp. population during monsoon season, excessive humidity and rainfall conditions may have reduced adult activity and trap catches. (Shelly *et al.* 2016; Ghanim *et al.* 2020; Hafsi *et al.* 2022) [5, 6, 22] the observations have been documented where heavy rainfall and high humidity reduce trap efficiency and adult movement.

Table 2: Studies on population dynamics of fruit flies (*Bactrocera* spp.) through methyl eugenol traps monsoon season (2025) [23].

Sr. No	SMW	Date	Mean population of Fruit flies/ trap/week	Weather parameters			
				Temperature (°C)		RH (%)	Rainfall (mm)
				Min.	Max.		
1	23	04 Jun - 10 Jun	136.00	26.00	38.20	67.60	0.00
2	24	11 Jun - 17 Jun	164.67	28.40	39.50	66.10	0.00
3	25	18 Jun - 24 Jun	146.67	26.60	33.90	74.30	55.60
4	26	25 Jun - 01 Jul	152.33	26.80	36.80	75.40	35.20
5	27	02 Jul - 08 Jul	342.00	27.00	36.50	70.10	0.19
6	28	09 Jul - 15 Jul	204.00	25.40	33.30	73.40	141.80
7	29	16 Jul - 22 Jul	216.67	25.70	34.30	69.90	46.20
8	30	23 Jul - 29 Jul	218.00	26.90	33.20	78.20	39.80
9	31	30 Jul - 05 Aug	176.67	25.30	31.70	83.20	130.60
10	32	06 Aug - 12 Aug	132.67	25.40	32.60	78.40	255.40
11	33	13 Aug - 19 Aug	150.00	26.30	34.70	71.30	12.20
12	34	20 Aug - 26 Aug	128.67	25.70	31.10	77.50	53.20
13	35	27 Aug - 02 Sep	104.33	25.70	32.70	77.90	74.60
14	36	03 Sep - 09 Sep	116.33	25.80	32.70	77.00	2.40
15	37	10 Sep - 16 Sep	82.67	26.10	31.70	80.60	98.80
16	38	17 Sep - 23 Sep	54.33	25.20	31.20	82.40	20.60
17	39	24 Sep - 30 Sep	38.33	26.30	34.60	70.90	2.40
SMW= Standard meteorological week, R.H.= Relative humidity							

Winter season (SMW 40–8: October–February)

During the winter season (SMW 40–8, October–February), fruit fly activity was comparatively lower, with catches ranging from 2.33 to 87.33 flies/trap/week. The population gradually increased from October, peaking at 87.33 flies/trap/week in late November (SMW 47), before declining steadily through December and January, reaching a minimum of 2.33 flies/trap/week in late January (SMW 4). The winter peak coincided with moderate temperatures (26–27 °C) and relatively low humidity (70%), while the decline was associated with cooler conditions (16–20 °C). Correlation analysis indicated weak positive associations with maximum temperature (r = 0.287) and rainfall (r = 0.106), suggesting that winter populations are primarily governed by thermal conditions, with limited influence of humidity and rainfall (Table 3,4). The catches ranged between 50-90 flies/trap/week from 43th to 51th fruiting week (Pandey *et al.,* 2022; Pandey *et al.,* 2023) [15, 16]. However, the population started declining after the 52th week. Minimum activity was observed from the 4th week. (Vargas *et al.* 2015; Duan *et al*. 2021; and Hafsi *et al.* 2022) [2, 6, 24] similar observations have been recorded in *Bactrocera* spp. studies where populations remain very low during cold season. This indicates that temperature was the most important factor regulating *Bactrocera* spp. population during winter season. Increase in both minimum and maximum temperature resulted in increased *Bactrocera* spp. trap catches Jaiswal *et al.,* (2021) [9]. These results confirm that *Bactrocera* spp. population during winter is mainly limited by low temperature rise in these parameters favours population build-up. (Vargas *et al.* 2015; Duan *et al.* 2021; Hafsi *et al.* 2022) [2, 6, 24] which findings have been reported that *Bactrocera* spp. activity decreases sharply under low temperature conditions.

Table 3: Studies on population dynamics of fruit flies (*Bactrocera* spp.) through methyl eugenol traps Winter season (2025 [23]- 26).

Sr. No	SMW	Date	Mean population of Fruit flies/ trap/week	Weather parameters			
				Temperature (°C)		RH (%)	Rainfall (mm)
				Min.	Max.		
1	40	01 Oct - 07 Oct	8.67	25.90	32.50	77.10	14.00
2	41	08 Oct - 14 Oct	10.67	19.00	30.40	74.70	0.00
3	42	15 Oct - 21 Oct	23.33	18.70	31.00	75.20	0.00
4	43	22 Oct - 28 Oct	52.33	20.50	30.60	75.00	0.00
5	44	29 Oct - 04 Nov	75.00	19.20	27.60	78.30	30.00
6	45	05 Nov - 11 Nov	80.00	15.20	29.40	72.80	0.00
7	46	12 Nov - 18 Nov	85.67	9.80	27.80	68.80	0.00
8	47	19 Nov - 25 Nov	87.33	11.40	26.70	70.70	0.00
9	48	26 Nov - 02 Dec	84.00	12.70	27.70	71.50	0.00
10	49	03 Dec - 09 Dec	78.33	6.70	24.30	68.00	0.00
11	50	10 Dec - 16 Dec	56.67	7.90	24.30	70.50	0.00
12	51	17 Dec - 23 Dec	38.33	8.40	16.10	80.60	0.00
13	52	24 Dec - 31 Dec	22.67	8.10	20.50	75.20	0.00
14	1	1 Jan - 7 Jan	6.33	7.10	17.20	79.10	0.00
15	2	8 Jan - 14 Jan	4.00	5.20	19.70	78.50	0.00
16	3	15 Jan - 21 Jan	2.67	6.10	22.00	74.10	0.00
17	4	22 Jan - 28 Jan	2.33	9.70	24.00	74.20	4.00
18	5	29 Jan - 04 fab	6.67	10.50	20.90	75.90	5.20
19	6	05 fab - 11 fab	8.33	7.60	25.30	58.70	0.00
20	7	12 fab - 18 fab	10.67	12.40	26.70	54.90	0.00
21	8	19 fab - 25 fab	12.00	10.70	27.10	58.70	0.00
SMW= Standard meteorological week, R.H.= Relative humidity							

Table 4: Correlation co-efficient (r) of fruitfly/ trap trapped with weather parameters in guava orchard at Main Experiment Station ANDUA&T Kumarganj, Ayodhya during 2025 [23]-26.

Fruit fly	Temperature (°C)		R.H. (%)	Rainfall (mm)
	Min.	Max.		
Summer Season	-0.527	0.079	-0.098	-0.507
Monsoon Season	0.314	0.331	-0.33	-0.025
Winter Season	0.099	0.287	0.011	0.106

Overall seasonal trend

Overall, the study demonstrates that fruit fly populations in guava orchards are season-specific, with the highest abundance during the monsoon season, moderate activity in summer, and lowest incidence in winter. Temperature emerged as the most critical abiotic factor, showing positive associations in monsoon and winter, while rainfall consistently suppressed activity across seasons. These findings highlight late March (summer peak) and early July (monsoon peak) as the most vulnerable periods for guava orchards, underscoring the need for timely integrated pest management (IPM) interventions during these windows to minimize fruit damage and economic losses. Warm temperature during summer and monsoon favoured multiplication, while low temperature during winter season suppressed population (Roy *et al.*, 2020; Duan *et al.,* 2021; Dubey *et al.,* 2021; Dubey *et al.,* 2022) [3, 4, 9, 20]. Such seasonal dynamics are commonly reported in *Bactrocera* spp. under tropical fruit cropping systems. The present study concludes that *Bactrocera* spp. (*Bactrocera* spp.) population remained active throughout the year but showed distinct seasonal peaks. The peak population was recorded during early monsoon (May–June) under warm and humid conditions, whereas the lowest population was recorded during winter (January-February) due to low temperature. Therefore, the most critical period for *Bactrocera* spp. management in guava orchard lies between early monsoon (May), where timely adoption of integrated pest management strategies is essential to minimize fruit damage,

The present findings are in agreement with Kumar *et al.* (2021) [12], who observed that the population peak of fruit flies was from June to August. Kumar *et al.* (2022) [10] recorded that number was higher from May to August and their population was at the peak in July in guava (264.20 males/trap/week). Nankinga *et al.* (2014) recorded that the high population frequency of B. zonata (116.67-307.58) captured per trap per week was from June to August, accounting for 8.05-18.59% fruit infestation. Similarly, in mango the maximum (213-224 *Bactrocera* spp.) in Meerut district of Uttar Pradesh. It started to decline afterwards and remained at 348 in September. The lowest population was recorded at 26, 3, 2 and 1 for November, December, January and February, respectively (Vargas *et al.* 2015; Shelly *et al.* 2016; Hafsi *et al.* 2022) [6, 22, 24].

Conclusion

The weekly trap catch data clearly showed that *Bactrocera* spp. population dynamics significantly throughout the year and remained closely associated with seasonal weather conditions. The *Bactrocera* spp. activity was recorded during all three seasons (Summer, Monsoon and Winter b), but the highest infestation level was observed during Monsoon season, followed by summer season. Correlation analysis indicated that minimum and maximum temperature were the most important abiotic factors influencing *Bactrocera* spp. population. During Monsoon and Winter season, both temperatures showed positive correlation with trap catches, while in Monsoon season, maximum temperature played a significant role. Relative humidity showed a significant positive and negative (Summer season) impact during Monsoon and Summer season, suggesting that excessive humidity suppresses adult activity. Rainfall showed significant negative effect during Summer and Winter season.

Overall, the study concludes that early Monsoon season are the most critical periods for *Bactrocera* spp. management. Therefore, timely implementation of integrated pest management strategies such as trap-based monitoring, sanitation, and bait application is essential during these months to reduce fruit infestation and economic losses.

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