Original Research Article

Population Dynamics of *Bactrocera zonata* (Saunders) on Mango and Correlation with Weather Parameters

ABSTRACT

The population dynamics of fruit fly *Bactrocera zonata*Saunders (Diptera: Tephritidae) was carried out by installing "Nauroji-Stonehouse Fruit Fly Trap" in the mango orchard of organic farm, Navsari Agricultural University, Navsari, Gujarat, India during the period 2021-22. The population of *B. zonata* prevailed throughout the year in mango orchard with its peak activity from 14th SMW to 31st SMW which coincided with the fruiting and harvesting period of fruits. The population was maximum in 27th SMW and minimum during second SMW. The populationdecreased from August to January. There was a significant positive correlation of population of *B. zonata* with maximum temperature, minimum temperature, average temperature, evening relative humidity, average relative humidity, rainy days, rainfall and wind velocity. However, there was a nonsignificant correlation of population of *B. zonata* with morning relative humidity and duration of bright sunshine hours.

Keywords:*Bactrocera zonata*, mango, population dynamics, correlation, south Gujarat

1. INTRODUCTION

Mango, *Mangifera indica* (L.) (Anacardiaceae) is one of the appetizing fruit crops of tropical as well as subtropical regions of India and is known as “king of fruits” due to its delicious taste, attractive colour, savouring flavor, high nutritive value and health promoting qualities (Lakshminarayana, 1980; Majumdar and Sharma, 1990; Scherrer, 2007). It is native to Indo-Burma region and the national fruit of India, Pakistan and the Philippines. India ranks first among world’s mango producing countries accounting for about 50 per cent of the world’s mango production and ranks third for the export of mango.The area under mango cultivation in India is 2.29 million hectares with production of 20.44 metric tonnes and productivity of 8.90 metric tonnes per hectare (Indian Horticulture Database, 2019-20). In India, Gujarat ranks eighth in area occupying 1,53,180 ha, fifth in production with 1.44 million metric tonnes of production and productivity of 8.11 metric tonnes per hectare. The highest mango producing district of Gujarat is Valsad which occupies 34,620 ha area with production of

3,35,850 tonnes followed by Navsari occupying an area of 32,180 ha with production of 312, 100 tonnes in the year, 2016-17 (Anonymous, 2018).

The mango crop is attacked by about 492 species of insects, 17 species of mites and 26 species of nematodes at the world level (Pena *et al.*, 1998). Of these, 188 species of insects have been reported from India (Tandon and Verghese, 1985). One of which is the damage caused by Tephritidae fruit fly pests (Ekesi *et al.*, 2011; Badii *et al.*, 2015), which mostly attack both fruits and vegetables found all over the world (White and Harris, 1992). They are regarded as the quarantine pests (Jena *et al*., 2022a; Jena *et al*., 2022b; Jena *et al*., 2022c). They are economically important and their favorable hosts are mango, sapota, guava, peach as well as other fruits (Gafoor *et al*., 2010).The annual loss of fruits and vegetables by fruit flies is about 144.40 million US dollars (Stonehouse *et al*., 2002). In India, it has been reported to cause crop loss up to Rs. 29,460 million per annum in mango, guava, sapota and citrus (Mumford, 2001; Mishra *et al.*, 2012). Whereas in south Gujarat, damages to the tune of 16 to 40 and 4 to 2 per cent have been reported in mango and sapota, respectively (Patel and Patel, 2005).

Among various species of *Bactrocera*, three species *viz*., *Bactrocera* (*Dacus*) *dorsalis* (Hendle), *B. zonata* and *B. correcta* (Bezzi) are considered as economically important pests infecting mango crop (Choudhary *et al*., 2012 and Verghese *et al.*, 2006). Among them, *B. zonata* is the most abundant in south Gujarat causing huge crop loss. It is native to South and Southeast Asia. The first record of this insect in Iraq in 1972 from fruit samples imported from Bahrain (El-Haidari *et al*., 1972), then confirmed as peach fruit fly *D. zonatus*. It has been reported to infect fruits of peach, mango, watermelon and Alfalfa then insect disappeared from the Iraqi environment (Al-Ali, 1977). After that, *B. zonata* was recorded in orchard of Alhafrya city and caused severe damage to citrus fruits (Abdulrazak *et al*., 2016). The damages that caused by peach fruit fly may be reached 100% of fruit without control (Hardy, 1997; Jena *et al*., 2022a). *B. zonata* is a polyphagous fruit pest which infect more than 40 fruit crops such as guava, mango, peach, papaya and citrus fruits (Alzubaidy, 2000; Stonehouse *et al*., 2002). Since it prefers soft and tender fruits of peach and guava, it is commonly referred to as “peach fruit fly” or “guava fruit fly”. It is one of the main species of the *zonata* group. *B. zonata* occasionally outnumbers *B. dorsalis* on mango (Kapoor, 2005).

Fruit flies, *B. zonata* are invasive pests of horticultural crops worldwide due to high reproductive rate, shorter generation and doubling time, extreme polyphagy, lack of co-

evolved natural enemies, conducive environmental conditions in India, availability of host/alternative around the year, lack of competitors, high mobility and dispersive powers, strong competitor-displaced native fruit flies species, wider adaptability to new environments (Mohamed *et al*., 2012; Prokopy, 1977; Sharma *et al*., 2011; Jena *et al*., 2022a). Moreover, the damaging stage is the maggot which remains unexposed to the chemical pesticides. Therefore, management of *B. zonata* remains a challenging task. Hence, development of an integrated management package becomes imperative. Looking to the apparent importance of the pest, the investigation on population dynamics of *B. zonata* and correlation with weather parameters was carried outin the mango orchard.

Comment [A1]: Very long Introduction! Please give an essential information

2. MATERIALS AND METHODS

The present investigation on population dynamics of *B. zonata* on mango was carried out starting from April 2021 to March 2022 at the mango orchard, organic farm, Navsari Agricultural University, Navsari, Gujarat. For this study mango orchard of one hectare with *var*. Kesar was selected which was kept free from the insecticidal spray.

In this study ten Methyl eugenol based "Nauroji Stonehouse Fruit Fly Traps" were installed by keeping trap to trap distance of 30 m for monitoring the fruit fly round the year. The data on number of adult males of *B. zonata* caught per ten traps were recorded at weekly interval. The influence of weather parameters *viz*., maximum temperature, minimum temperature, morning and evening relative humidity and rainfall were worked out by statistical correlation and regression analysis.

Comment [A2]: Where did you inspire? In literature?? Please indicate an author!

3. RESULTS AND DISCUSSION

The data collected during the year 2021-22 are presented in table 1 and depicted in figure 1 and 2. The data revealed that the population of *B. zonata* was observed throughout the year with its peak activity from 14th SMW to 31st SMW which coincided with fruiting and harvesting period of mango. In line with the present findings, Dale (2002) reported that the population remained throughout the year and highest fly population coincided with the maturity and harvesting period of mango in mango orchard at north Gujarat. The maximum activity coincided with the fruiting season in guava orchard at north Gujarat (Dale, 2002); the population recorded throughout the year in sapota orchard, north Gujarat (Dale, 2002); the highest fruit fly infestation (36.67%) coincided with ripening cum harvesting period of mango at Navsari Agricultural University, Navsari, Gujarat (Patel *et al.*, 2013); the population

prevailed throughout the year and coincided with the maturity and harvesting period of sapota at Navsari Agricultural University, Navsari, Gujarat (Amol *et al*., 2014); the fruit fly population prevailed throughout the year and coincided with the maturity and harvesting period of sapota at Gandevi, south Gujarat (Nandre and Shukla, 2014); the maximum population coincided with fruiting period of mango at N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat (Bansode and Patel, 2018);the fly was active throughout the year in the mango orchard, College of Agriculture, Navsari Agricultural University, Bharuch, Gujarat (Patel *et al*., 2019); the maximum population coincided with fruiting period of guava at N. M. College of Agriculture, Navsari, Gujarat (Bansode and Patel, 2020), which are also akin with the present findings.

During present studies, the activity of *B. zonata* was higher during April to July in south Gujarat with maximum activity in 27th SMW (592) and minimum in the second SMW (216). The population of *B. zonata* decreased from 32nd SMW to first SMW. A more or less similar finding was made by Dale (2002) who revealed that *D. zonata* population was higher in the month of July and August, while the lowest population in the month of January and December in mango orchard at north Gujarat; the maximum activity in the month of September whereas lowest activity in the month of May in guava orchard at north Gujarat (Dale, 2002); the population peaked in the month of July and August whereas the lowest in the month of January and March in sapota orchard north Gujarat (Dale, 2002); the highest infestation (36.67%) was on 22nd SMW in mango orchard at Navsari Agricultural University, Navsari, Gujarat (Patel *et al*., 2013); the maximum activity (172.10 flies per trap) during March to August and lower during month of December and January (11.10 to 21.30 flies per trap) in sapota orchard at Navsari Agricultural University, Navsari, Gujarat (Amol *et al*., 2014); the maximum activity (172.10 flies per trap) during March to August and lower during December and January (11.10 to 21.30 flies per trap) in sapota orchard at Gandevi, south Gujarat (Nandre and Shukla, 2014); the maximum population during the month of April to July and the population decreased during December to February at N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat (Bansode and Patel, 2018); the maximum catches (128.60 fruit flies/trap) in 28th SMW *i.e.*, ninth to 15th July, while minimum catches (4.47 fruit flies/trap) in third SMW *i.e*., 15th to 21st January at the mango orchard, College of Agriculture, Navsari Agricultural University, Bharuch, Gujarat (Patel *et al*., 2019); the maximum population during the month of June to November with peak activity during II week of September and the fly population decreased during January to April

at N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat (Bansode and Patel, 2020).

Table 1. Population of *B. zonata* in different SMW in mango orchard (2021-22)

Sl. No.	SMW	Number of *B. zonata* caught/10 traps	Sl. No.	SMW	Number of *B. zonata* caught/10 traps
1	14	429	27	40	295
2	15	346	28	41	307
3	16	442	29	42	311
4	17	452	30	43	317
5	18	476	31	44	280
6	19	452	32	45	314
7	20	436	33	46	324
8	21	433	34	47	329
9	22	426	35	48	296
10	23	490	36	49	252
11	24	530	37	50	266
12	25	516	38	51	245
13	26	562	39	52	235
14	27	592	40	1	260
15	28	498	41	2	216
16	29	473	42	3	290
17	30	482	43	4	234
18	31	487	44	5	288
19	32	441	45	6	270
20	33	392	46	7	286
21	34	380	47	8	276
22	35	342	48	9	302
23	36	371	49	10	326
24	37	340	50	11	368
25	38	352	51	12	402
26	39	316	52	13	372

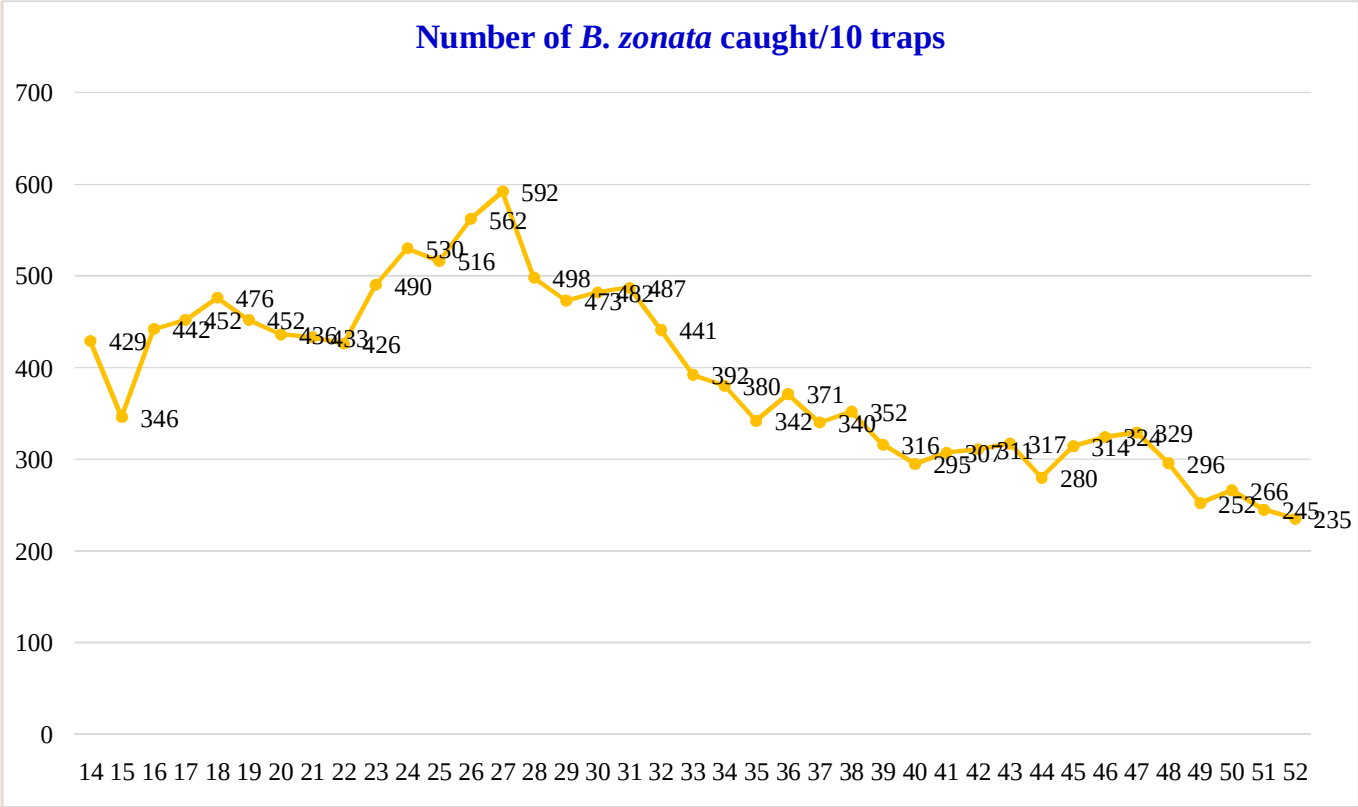

Figure 1. Population of *B. zonata* from 14th to 52nd SMW in mango orchard

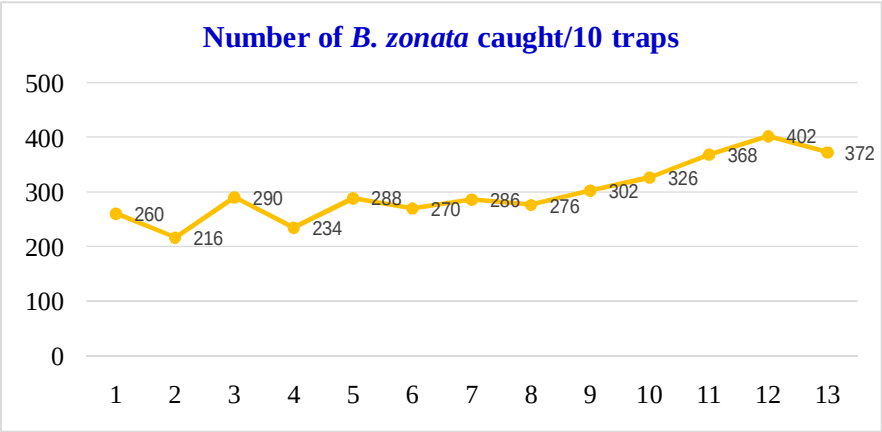

Figure 2. Population of *B. zonata* from 1st to 13th SMW in mango orchard

3.1 CORRELATION AND MULTIPLE REGRESSION STUDIES BETWEEN POPULATION OF *B. zonata* IN MANGO ORCHARD AND WEATHER PARAMETERS

The data on population of *B. zonata* recorded during the period April, 2021 to March, 2022 were correlated with different weather parameters and have been presented in table 2. Data indicated a significant positive correlation of population of *B. zonata* with maximum temperature, minimum temperature, average temperature, evening relative humidity and average relative humidity, rainy days, rainfall and wind velocity. However, there was a nonsignificant correlation of population of *B. zonata* with morning relative humidity and duration of bright sunshine hours.

The present findings are less or more concurrence with those of Dale (2002) who reported that there was a significant positive correlation with temperature (minimum and average), relative humidity (minimum, maximum and average), rainfall and rainy days while a significant negative correlation of fruit fly population with sunshine hours in mango orchard at north Gujarat; a significant positive correlation with minimum temperature, relative humidity (maximum, minimum and average) and rainy days whereas, negative correlation with maximum temperature, sunshine hours and rainfall in guava orchard at north Gujarat (Dale, 2002); a significant positive correlation with temperature (minimum and average), relative humidity (maximum, minimum and average), rainfall and rainy days, whereas negative correlation with maximum temperature and sunshine hours in sapota orchard north Gujarat (Dale, 2002); the fruit fly infestation increased with increase in

temperature, relative humidity, wind velocity and evaporation at Navsari Agricultural University, Navsari, Gujarat (Patel *et al*., 2013); a positive correlation with temperature (maximum, minimum and average), relative humidity (maximum, minimum and average), rainfall and wind velocity at N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat (Bansode and Patel, 2018); a significant positive correlation between minimum temperature, morning relative humidity, evening relative humidity, wind velocity and rainfall with fruit fly population while a significant negative correlation with sunshine hours at the mango orchard, College of Agriculture, Navsari Agricultural University, Bharuch, Gujarat (Patel *et al*., 2019); a positive correlation with temperature (maximum, minimum and average), relative humidity (maximum, minimum and average), rainfall and wind velocity at N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat (Bansode and Patel, 2020).

Table 2: Effect of weather parameters on population of *B. zonata* in mango orchard (April, 2021 to May, 2022)

Weather parameters		Correlation coefficients	Regression Coefficients
(X_1)	**Max.Temp.(^oC)**	0.33*	-2.285
(X_2)	**Min. Temp.(^oC)**	0.83**	20.490
(X_3)	**MeanTemp.(^oC)**	0.77**	--
(X_4)	**M.R.H.(%)**	0.04	0.600
(X_5)	**E.R.H.(%)**	0.50**	-1.669
(X_6)	**MeanR.H.(%)**	0.41**	--
(X_7)	**Rainy days (day)**	0.38**	0.069
(X_8)	**Rainfall (mm)**	0.37**	7.091
(X_9)	**Wind velocity (km/hrs)**	0.66**	16.036
(X_{10})	**Bright sunshine hours (hrs)**	-0.21	6.939
R^2	**Coefficient of determination**	--	0.55
CV	**Coefficient of variation (%)**	--	55.55
R value	**Multiple Correlation Coefficient**	--	0.74
a value	**Intercept**	--	65.45

N=52, *Significant at the level of 5%, **Highly Significant at the level of 5%

The coefficient values of multiple regression analysis are presented in table 2. The various parameters utilized for prediction of population of *B. zonata* gives 78.90 per cent coefficient of determination due to temperature, relative humidity, rainy days, rainfall, wind velocity and sunshine hours. Therefore, it can be stated that the variation (R^2 = 0.789) in population of *B. zonata* was due to the above factors.

Regression equation for the prediction of population of *B. zonata* on mango is as below,

$$Y = -43.369 - 2.285\ X_1 + 20.490\ X_2 + 0.600\ X_4 - 1.669\ X_5 + 0.069\ X_7 - 7.091\ X_8 + 6.939\ X_9 - 47.670\ X_{10}$$

Where Y = Predicted population of *B. zonata*

X_1 = Maximum temperature

X_2 = Minimum temperature

X_4 = Morning relative humidity

X_5 = Evening relative humidity

X_7 = Rainy days

X_8 = Rainfall

X_9 = Wind velocity

X_{10} = Bright sunshine hours

So, looking to the relationship of abiotic factors with population of *B. zonata*, it may be inferred that population of *B. zonata* was positively influenced by temperature (maximum, minimum and average), relative humidity (evening and average), rainfall, rainy days and wind velocity but negatively related to the duration of sunshine hours. This implies that the increase in temperature, relative humidity, rainy days, rainfall and wind velocity also increase the fruit fly population and *vice-versa*. However, the population of *B. zonata* is not influenced by the morning relative humidity and sunshine hours.

This interpretation is sustained by the fact that the population of *B. zonata* was higher during April, 2021 to July, 2022 which coincided with the fruiting and harvesting period of mango fruit, when the weather parameters *viz*., temperature, relative humidity, rainy days, rainfall, wind velocity and sunshine hours were in the range of 20.50 to 37.80°C, 50.40 to 96.60 per cent, 0.00 to 18.00 days, 0.00 to 414.00 mm, 3.30 to 9.00 km/hrs and 0.30 to 10.40 hrs, respectively.

Comment [A3]: How did you obtain this result?

4. CONCLUSION

The population of *B. zonata* prevailed throughout the year but the peak activity occurred during April to July which coincided with the maturity and harvesting period of the mango fruit. The population of *B. zonata* was directly influenced by different weather parameters, temperature, relative humidity, rainfall, rainy days, wind velocity and the duration of bright sunshine hours. The knowledge on population dynamics of fruit flies help in deciding the timing of application of appropriate management practices.

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