Research Article

Preference monitoring of *Bactrocera* spp. through installation of methyl eugenol traps at different heights in Jujube orchard

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Abstract

An experiment was conducted during the years (2016 to 2017) on preference monitoring of *Bactrocera* spp. through installation of methyl eugenol traps at different heights in jujube orchard. The pheromone traps baited with lure toxicant mixture (95% methyl eugenol + Thiodan insecticide) were installed at (T1) = ground surface, (T2) = 1 m height. (T3) = 2 m height and (T4) = 3 m height. The effect of different heights of methyl eugenol pheromone traps on the male-adult *B. zonata* and *B. dorsalis* catches was statistically significant ($P < 0.05$); and the fruit fly catches in traps varied significantly during 26-12-16 to 10-04-17 ($P < 0.05$). The highest *B. zonata* catches (61.38) were monitored in traps installed at 2m height; while the weekly *B. zonata* trap catches simultaneously decreased to (51.35), (43.03) and (38.09) at trap heights of 3 m, 1m and 0 m (surface), respectively. The average weekly trap catches of *B. zonata* were 83.7. The maximum weekly *B. dorsalis* catches (0.49) were found in traps installed at 2 m height; while the weekly *B. dorsalis* trap catches decreased to 0.43, 0.36 and 0.29 when the traps were installed at 3 m, 1 m and 0 m (surface) heights, respectively. The average weekly trap catches of *B. dorsalis* were 7.65. It was concluded that the methyl eugenol pheromone traps were most effective when installed at 2 m height; while traps installed at 3 m and 1 m height could not catch *B. zonata* and *B. dorsalis* more than the surface installed traps. The *B. zonata* starts its rapid development from the April with certain fluctuation.

Keyword: Preference; Monitoring; *Bactrocera*; Methyl eugenol; Traps; Jujube orchard Pakistan, Syria, Australia and Malaysia.

Introduction

Jujube, *Ziziphus jujuba* Mill., locally called 'ber' and belongs to the family Rhamnaceae, is an indigenous fruit of China and South Asia, produced in temperate regions such as China, India,

Jujube requires a hot and dry climate. It can survive temperatures of up to 50°C and with such a tolerance for heat it is of little surprise that it does not do well when temperatures approach freezing. Jujube

fruits are deciduous and can tolerate cold winters to 28°F. They have a low chilling requirement allowing them to produce fruit in areas having mild winters. Long, hot summers are necessary to ripen good fruit crops. Pollination is done by bees and flies. In Pakistan, jujube is extensively cultivated, but thrive best under ecological conditions of Hyderabad, Khairpur, Multan, Sargodha and Lahore Divisions. Hyderabad is famous for producing quality fruit for export to Middle East. The tree is hard, drought resistant and can thrive in poor alkaline tracts without much irrigation and care, and survive on soils where other fruit trees cannot [1]. Ber or jujube, a common fruit grown in the warm subtropical regions of Pakistan, belongs to the genus *Zizyphus* of family Rhamnaceae [2]. In Pakistan, Ber is produced over an area of 5425 hectares with an annual production of 27950 tones [3].

Fruit flies of genus *Bactrocera* are commonly associated to mango, citrus and guava orchards [4]. Fruit flies (Diptera: Tephritidae) are considered the most destructive insect pests of fruits and vegetables in the world. The hosts of these flies belong to a wide variety of families of plants and include many major commercial crops [5]. Without flies control, direct damage has been reported from 30 to 80% depending on the fruit, variety, location and fruit season [6]. Fruit fly, *Bactrocera* spp. (Diptera: Tephritidae) are one of potential pests that is very detrimental to horticultural production reducing crop yield either through quantitatively or quality [7]. Among 400 species of fruit flies distributed all over the world, *Bactrocera zonata* (Saunders), *Bactrocera dorsalis* (Hendel) is the most destructive pest [8]. They over winter at adult stage and impose damage by infesting fruits. Female flies lay eggs in soft and tender fruit tissues and subsequently maggots nourish inside the host fruit [9]. In Pakistan 11 species of genus *Bactrocera*, out of total 43 species, have been marked out from Pakistan.

Among these are *B. zonata*, *B. dorsalis* and *B. cucurbitae* are the most prominent [10] infesting apple (*Malus domestica*), bitter gourd, (*Momordica charantia*), guava (*Psidium guajava*), ber (*Zizyphus mauritiana*), mango (*Mangifera indica*), muskmelon (*Cucumis melon*) and snake gourd (*Trichosanthes cucumerina*) [11].

Severity of damage is caused by three fruit fly species namely, *Bactrocera zonata* (Saunders), *Carpomya vasuviana* (Costa) and *Bactrocera cucurbitae* (Coquillett), from the time of fruit setting up to harvesting. All above mentioned fruit fly species inflict colossal losses which ultimately confine the fruit production involve deployment of large numbers of Jackson traps baited with highly attractive male-specific lures [12]. For example, methyl eugenol (ME; 4-allyl-1, 2-dimethoxybenzene-carboxylate) and cue-lure (C-L; 4-(*p*-acetoxypheyl)-2-butanone) are used for detection of oriental fruit fly, *Bactrocera dorsalis* (Hendel) and melon fly, *Bactrocera cucurbitae* (Coquillett), respectively. However, an important environmental concern of these trapping systems is that detection traps are currently deployed in association with toxic liquid insecticide formulations such as naled [13].

The current study was carried to determine the population dynamics of various fruit flies' species in term of identification on different varieties of beer. The importance of the present survey for fruit flies in beer orchard was exploited for managing the population densities of fruit flies through integrated pest management program. In different orchards of jujube, the study was useful in managing the population densities of fruit flies and their integrated pest management (IPM) programs.

Materials and Methods

The experiment was conducted during the year 2016-17 for the monitoring of *Bactrocera* spp. on an area of 10 acres of jujube orchard farm, Agriculture Research Institute (ARI) Tandojam. The male adult population of fruit flies was recorded

weekly through pheromone trap baited with lure toxicant mixture (95% methyl eugenol+ 5%Thiodan insecticide).

The experiment was conducted to observe the fruit fly catches by hanging fruit fly traps at different heights on jujube trees.

Treatments

T₁ = Pheromone traps installed on ground surface

T₂ = Pheromone traps installed at 1-meter height

T₃ = Pheromone traps installed at 2 meters height

T₄ = Pheromone traps installed at 3 meters height

The experiment was replicated five times. The pheromone traps were replenished after 15 days to keep fresh chemical for attraction of the fruit flies. Killed male flies in traps were counted and species were identified at weekly interval. The collected data was statistically analysis using statix. 8.1 version.

Results

The study was conducted during season, 2016-17. To examined the preference monitoring of *Bactrocera* spp. on an area of 10 acres of jujube orchard. The trial was conducted at the area of Agriculture Research Institute (ARI) Tandojam. The experiment included five replications and four applications viz., T₁ = Pheromone traps installed on ground surface, T₂ = Pheromone traps installed at 1-meter height, T₃ = Pheromone traps installed at 2 meters height and T₄ = Pheromone traps installed at 3 meters height. The treatment observations were recorded on different weeks from (26-12-16 to 10-04-17).

Weekly population of *B. zonata* at different heights under varied temperature and humidity at Jujube Orchard Tandojam

The (Table 1) showed the observations that effect of different heights of methyl eugenol pheromone traps (treatments) on the male-adult *B. zonata* catches was statistically significant ($P<0.05$); and the *B. zonata* catches in traps varied significantly during different weeks of

2016-17 ($P<0.05$). The treatment effect showed that highest *B. zonata* catches (83.7) were monitored in traps installed at 2 m height (T₃); while the *B. zonata* trap catches simultaneously decreased to (74.66), (66.69) and (62.54) at trap heights of 3 m (T₄), 1 m (T₂) and 0 m (surface, T₁), respectively. The average weekly traps catch of *B. zonata* were 3.72 and the methyl eugenol pheromone traps were most effective when installed at 2 m height; while traps installed at 3 m and 1 m height could not catch *B. zonata* male adults more than the surface installed traps. The record of sixteen weeks male-adult monitoring of *B. zonata* shows that the insect population was higher in T₃ (83.7) and while the least trap catches were observed in the T₄ (74.66), T₂ (66.69) and T₁ (62.54). The *B. zonata* starts its rapid development from the 03-04-17 and sustains up to the 10-04-17 towards with certain fluctuation. This indicates that there is linear association of *B. zonata* population with the temperature, when its sky-high population was recorded during 2017; while the population declined in the weeks of low temperature. During the years of study 2016-17 the mean temperature was 23.03°C, suggesting a linear relationship of temperature with the insect population buildup. The interactive effect between different parameters indicated that the highest *B. zonata* weekly population on average was 83.7 in 10-04-17 when the methyl eugenol pheromone traps were installed at 2 m height (T₃); while the minimum insect population of (16.07) was monitored in 23-01-17 at 0 m (surface) height (T₁).

Pearson's correlation among *B. zonata* population and abiotic factors

Correlation estimates between *B. zonata* population and abiotic factors (temperature and relative humidity) was worked out and presented in (Table 2). There was significant and positive correlation ($R^2=0.8476^*$) between *B. zonata* population and temperature. Whereas, negative and non-significant correlation ($R^2= -0.5343^{NS}$)

was analyzed among the *B. zonata* population and relative humidity. This indicates that the *B. zonata* population was linearly increased by the elevation of

temperature and the *B. zonata* population did not fluctuated by the relative humidity up down.

Table 1. Weekly population of *B. zonata* at different heights under varied temperature and humidity at Jujube Orchard Tandojam

Week	T1= Surface	T2= 1-meter height	T3= 2-meter height	T4= 3-meter height	Temperature (°C)	R.H %
26-12-16	31.9	38.71	59.51	49.91	25	51
02-01-17	52.35	58.94	79.85	69.97	25	47
09-01-17	36.21	41.94	60.47	49.85	23	48
16-01-17	26.11	31.84	50.37	39.75	22.8	47
23-01-17	16.07	21.74	40.33	29.71	20	49
30-01-17	22.97	26.84	45.43	34.61	21.3	46
06-02-17	19.87	23.74	42.33	31.51	19.5	46
13-02-17	33.97	38.84	57.43	46.61	21	49
20-02-17	26.92	31.59	49.18	39.56	21.7	47
27-02-17	26.92	31.59	49.18	39.56	23	45
06-03-17	37.01	41.69	59.24	49.66	22.4	44
13-03-17	47.11	51.79	69.34	59.76	22	42
20-03-17	52.31	56.99	74.54	64.96	24.2	44
27-03-17	56.54	60.89	78.64	68.86	25	45
03-04-17	60.64	64.79	82.54	72.76	25.6	44
10-04-17	62.54	66.69	83.7	74.66	27	42
Mean	38.09	43.03	61.38	51.35	23.03	46
SE	3.78	3.75	3.72	3.81	0.53	0.63

Table 2. Pearson's correlation among *B. zonata* population and abiotic factors

Variable	<i>B. zonata</i> population
Temperature	0.8476**
Relative humidity	-0.5343 ^{NS}

Weekly population of *B. dorsalis* at different heights under varied temperature and humidity at Jujube Orchard Tandojam

The (Table 3) showed the observations that effect of different heights of methyl eugenol pheromone traps (treatments) on the male-adult *B. dorsalis* catches was statistically significant ($P < 0.05$); and the *B. dorsalis* catches in traps varied significantly during different weeks of 2016-17 ($P < 0.05$). The treatment effect showed that highest *B. dorsalis* catches (4.96) were monitored in traps installed at 2 m height (T3); while the *B. dorsalis* trap catches simultaneously decreased to 3.89, 3.16 and 2.66 at trap heights of 3 m (T4), 1 m (T2) and 0 m (surface, T1),

respectively. The average weekly traps catch of *B. dorsalis* were 0.49 and the methyl eugenol pheromone traps were most effective when installed at 2 m height; while traps installed at 3 m and 1 m height could not catch *B. dorsalis* male adults more than the surface installed traps.

The record of sixteen weeks male-adult monitoring of *B. dorsalis* shows that the insect population was higher in T₃ (7.65) and while the least trap catches were observed in the T₄ (6.22), T₂ (4.74) and T₁ (3.53). The *B. dorsalis* starts its rapid development from the 03-04-17 and sustains up to the 10-04-17 towards with certain fluctuation. This indicates that there is linear association of *B. dorsalis*

population with the temperature, when its sky-high population was recorded during 2017; while the population declined in the weeks of low temperature. During the years of study 2016-17 the mean temperature was 23.03°C, suggesting a linear relationship of temperature with the insect population buildup. The interactive

effect between different parameters indicated that the highest *B. dorsalis* weekly population on average was 7.65 in 03-04-17 when the methyl eugenol pheromone traps were installed at 2 m height (T3); while the minimum insect population of 1.7 was monitored in 30-01-17 at 0 m (surface, T1).

Table 3. Weekly population of *B. dorsalis* at different heights under varied temperature and humidity at Jujube Orchard Tandojam

Week	T1= Surface	T2= 1-meter height	T3= 2-meter height	T4= 3-meter height	Temperature (°C)	R.H%
26-12-16	1.88	2.34	4.31	3.05	25	51
02-01-17	1.85	1.95	3.75	2.5	25	47
09-01-17	1.95	2.05	3.95	2.63	23	48
16-01-17	1.93	2.03	3.92	2.61	22.8	47
23-01-17	1.91	2.01	3.89	2.59	20	49
30-01-17	1.7	2.05	2.8	2.4	21.3	46
06-02-17	1.79	2.16	2.95	2.53	19.5	46
13-02-17	1.77	2.14	2.93	2.51	21	49
20-02-17	1.78	2.15	2.94	2.52	21.7	47
27-02-17	1.85	1.95	3.85	2.53	23	45
06-03-17	4.48	5.12	7	5.88	22.4	44
13-03-17	4.72	5.4	7.39	6.2	22	42
20-03-17	4.68	5.35	7.33	6.15	24.2	44
27-03-17	3.35	4.5	7.25	5.9	25	45
03-04-17	3.53	4.74	7.65	6.22	25.6	44
10-04-17	3.5	4.71	7.59	6.17	27	42
Mean	2.66	3.16	4.96	3.89	23.03	46
SE	0.29	0.36	0.49	0.43	0.53	0.63

Pearson's correlation among *B. dorsalis* population and abiotic factors

Correlation estimates between *B. dorsalis* population and abiotic factors (temperature and relative humidity) was worked out and presented in (Table 4). There was significant and positive correlation ($R^2 = 0.5112^*$) between *B. dorsalis* population and temperature.

Whereas, negative and non-significant correlation ($R^2 = -0.7645^{NS}$) was analyzed among the *B. dorsalis* population and relative humidity. This indicates that the *B. dorsalis* population was linearly increased by the elevation of temperature and the *B. dorsalis* population did not fluctuated by the relative humidity up down.

Table 4. Pearson's correlation among *B. dorsalis* population and abiotic factors

Variable	<i>B. dorsalis</i> population
Temperature	0.5112**
Relative humidity	-0.7645 ^{NS}

Discussion

The present research was conducted for the monitoring of *Bactrocera* Spp. on an

area of 10 acres of jujube orchard farm was conducted at the area of Agriculture Research Institute (ARI) Tandojam,

during 2016-2017. During the present finding it was examined that *B. zonata* starts its rapid development from the 03-04-17 and sustains up towards with certain fluctuation. This indicated that there is linear association of *B. zonata* population with the temperature, when its sky-high population was recorded during week of April while the population declined in the weeks of low temperature. Essam *et al.* [14] determined the effectiveness of the field performance of fiber blocks were impregnated with the solution of Sumithion 95% (mixed with methyl eugenol in the ratio of 1:4), Sumithion 50% under field conditions. Efficiency (as lured and killed male fruit flies) of all application deceased over time regardless of the area. The data showed that Sumithion (mixed with methyl eugenol in the ratio of 1:4) and sticky double sheets were significantly impactive than other applications. It was suggested that Sumithion mixture can be used successfully in *B. zonata* male annihilation technique. Similarly, Kumar and Ktmath [15] examined that attraction of diverse species of fruit flies to diverse coloured traps in jujube orchard. Data showed that yellow and transparent traps attracted significant highly number of *B. correcta* in guava followed by green and orange coloured traps in guava (3.79 and 3.75 fruit flies/trap/week, respectively) black coloured traps in mango (3.88 fruit flies/trap/week) were attractive to *B. dorsalis*. *B. zonata* was attracted to red coloured traps (3.75 fruit flies/trap/week) in mango ecosystem. When total fruit flies irrespective of species were considered, yellow colour traps were most attractive in guava (71.91 fruit flies/trap/week) while black colour traps (8.68 fruit flies/trap/week). From another study Hasnain *et al.* [16] observed to evaluate the fruit fly capture in traps at different heights by using methyl eugenol. The results showed that the maximum average male fruit flies (515) were caught at the height of 5 feet, whereas, the minimum

(315) were caught at the ground level. These results suggest that for the monitoring of fruit flies, the methyl eugenol traps should be hanged at the height of 5 feet from ground level to get the maximum counts of fruit flies.

Conclusion

It could be concluded that methyl eugenol pheromone traps were most effective when installed at 2 m height; while traps installed at 3 m and 1 m height could not catch *B. zonata* and *B. dorsalis* more than the surface installed traps. The *B. zonata* starts its rapid development from the month of April; while *B. dorsalis* starts flaring up in April and then reached its peak population. The *B. dorsalis* is basically the mango fruit fly and its population were more associated with the mango season rather to associate its population with the abiotic factors. Generally, the *B. zonata* population was markedly higher than the population of *B. dorsalis*.

Authors' contributions

Conceived and designed the experiments JA Vistro & BK Solangi, Performed the experiments: M Saleem, I Solangi & MA Lashari, Analyzed the data: AR Khan & ZA Mastoi, Contributed reagents/ materials/ analysis tools: A Rehman & GH Alizai, Wrote the paper: JA Vistro & BK Solangi.

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