The Journal of Animal & Plant Sciences, 24(1): 2014, Page: 172-178
ISSN: 1018-7081

# ASSESSMENT OF INSECTICIDES RESISTANCE IN FIELD POPULATION OF *BACTROCERA ZONATA* (SAUNDERS) (DIPTERA: TEPHRITIDAE)

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## ABSTRACT

Insecticides resistance against fourteen field populations of *Bactrocera zonata* (Saunders) (Diptera: Tephritidae) from Chichawatni, District Sahiwal, Pakistan to six insecticides *viz.,* trichlorfon, malathion (Organophosphates), bifenthrin, lambda-cyhalothrin (Pyrethorids) , methomyl (Carbamate) and spinosad (Microbial) was assessed by topical assay under laboratory conditions. In insecticides bioassay, trichlorfon was observed susceptible to high resistance level (1.01-fold to 41.13-fold), bifenthrin and malathion were found susceptible to moderate resistance level (1.00-fold to 14.27-fold and 1.00-fold to 20.37-fold), lambda-cyhalothrin and spinosad were showed susceptible to low resistance (1.00-fold to 9.57-fold and 1.20 -fold to 9.95-fold), while effect of methomyl were remained as susceptible to all the tested populations. From the results it is concluded that methomyl was remained susceptible to all the tested populations, while other five tested insecticides have developed the resistance against *B. zonata* populations, which required adopting new strategies to overcome resistance in this pest.

**Key word:** Field populations, *Bactrocera zonata*, organophosphates, pyrethorids, microbial insecticide resistant, carbamate susceptible.

## INTRODUCTION

Tephritidae (Diptera) contains more than 4000 species in which about 700 species of sub family Dacinae has been expressed all over the world (Fletcher, 1987). There are about 250 species which are distributed in sub-tropical, temperate and tropical regions of the world (Robinson and Hopper, 1989). Among 250 species, 44 species belongs to genus *Bactrocera* (Syed, 1969; Kapoor *et al.,* 1980). Eleven species of fruit flies have been marked out from Pakistan; the most prominent among them are *Bactrocera zonata, B. cucurbitae and B. dorsalis* (Abdullah and Latif, 2001; Abdullah *et al.,* 2002; Stonehouse *et al.,* 2002). *B. zonata* has been observed as a serious pest in guava, mango and citrus orchards with an estimated 50-55% infestation only in guava fruits in Pakistan (Syed, 1970). *B. zonata* was observed dominant in different parts of the province of Baluchistan, Pakistan when surveyed by observing infestation caused by this species in guava, musk melon and cucumber (Anonymous, 1987). Growers have been facing many problems for controlling of fruit flies. They are unable to manage the protection measures of fruit flies; if its infestation is reduced then gross annual saving is expected to be estimated Rs. 4915 million in Pakistan (Stonehouse *et al.,* 1997). Control of fruit flies has been tried in various ways such as mechanical, cultural, biological and chemical. MAT (Male Inhalation Technique) with methyl eugenol and cue-lure are common in the management of fruit flies and this technique is the part of Integrated Pest Management (IPM) in early monitoring of this pest (Afzal and Javed, 2001). The major constraint in using attractants/pheromones, methyl eugenol and Cue lure, is risk of immigration of already protein satiated females (Dhillon *et al.,* 2005; Stonehouse *et al.,* 2007). The cultural/mechanical control, in the form of field sanitation has been tried as a part of IPM in which the infested fruits are collected and then buried into 4-5 inches deep in soil to destroy maggots which is not possible to bury all the infested fruit on large scale due to labor intensive process (Panhwar, 2005). The efficacy of biological agents such as parasites and predators are not considered as successful due to low fecundity of parasitoids as compared to fruit flies and poor searching ability of parasitoids to larval and pupal populations of fruit flies (Sivinski *et al.,* 1996). The farmers largely rely on cover spray for the control of fruit flies and chemical control has been the most important measure against fruit flies in Pakistan. The cover sprays against fruit flies are extensively in practice in Pakistan (Stonehouse *et al.,* 1997). Endrin, Dialordin, Diptrex, Dimecron and Diazinon has been applied on mango orchards as a cover spray in Pakistan (Panhwar, 2005). Pesticides including organophosphates (Ops), pyrethorids, carbamates (CARBs) and of new chemistry are used 5-7 times at 10-15 days interval in guava, 2 times in peach, plum, apricot and persimmon, 2-3 times in mango and at a week interval in melons for controlling fruit flies were used

(Anonymous, 2008). Peach orchards were sprayed by five insecticides *viz.,* fenitrothion, fenthion, methyl parathion, malathion and trichlorfon to check the infestation of *Bactrocera* species and fenitrothion was found to be the highest and trichlorfon the least toxic one (Kashyap and Hameed, 1982). Malathion, carbaryl, spinosad, imadacloprid, thiacloprid, carbaryl, azinphosmethyl and Diptrex have been applied in bait as well as cover sprays. The heavy infestation has led to the use of cover sprays without bait application (Alston, 2002; El-Aw *et al*, 2008).

In susceptibility test against fruit flies it is reported that development of resistance against fruit flies has occurred all over the world causing problems for its control. The tendency of existence of resistance occurred in oriental fruit flies, *Bactrocera dorsalis* (Hendel), to ten insecticides including six organophosphates (Naled, trichlorfon, fenthion, fenitrothion, malathion and formothion), 3 pyrethroids (cyfluthrin, fenvalerate and cypermethrin) and one carbamate (Methomyl) (Hsu *et al*., 2004). Susceptibility level of insecticides in two strains of *B. zonata* from Multan and Faisalabad in Punjab, Pakistan showed that both strains were observed resistant to trichlorfon, lambda-cyhalothrin, bifenthrin and malathion (3-19-fold) while susceptible to spinosad whereas trichlorfon showed maximum resistance level (10-19-fold) followed by bifenthrin (8-11-fold), lambda-cyhalohtrin (4-9-fold) and malathion (3-6-fold) (Ahmad *et al.*, 2010).

Keeping in the view the occurrence of insecticide resistance in fruit flies, there was a dire need to test the resistance level of insecticides against *B. zonata* infesting mango, guava and vegetables in cotton growing areas like Chichawatani, District Sahiwal of Pakistan. *B. zonata* was selected as research trail insect as a prevalent species of fruit flies in guava orchards in Chichawatani. The overall objective of this study was to check the level of resistance to different insecticides against fruit fly, *B. zonata* which were commonly used in study area against different pest of other crops nearby guava orchards and *B. zonata* in guava trees.

## MATERIALS AND METHODS

**Collection of specimens of *Bactrocera zonata*:** Full grown specimens of *B. zonata* at larval stage were collected from infested guava fruits from 14 locations of guava orchards areas of tehsil Chichawatni District Sahiwal, Punjab. These sites *i.e*., 105/7R, 111/7R, 113/12L, 6/14L, 5/14L, 11/14L, 96/12L, 69/12L, 67/12L, 168/9L, 31/11L, 174/9L, 15/11L, 184/9L were selected as 15-20 Km apart from each other during the year 2009. The collected specimens with infested fruits were kept in marked plastic jars having sand till emergence of their adults.

**Rearing of the *B. zonata*:** The fruit fly, *B. zonata* was reared in the insect rearing laboratory of Agricultural Entomology Department, University of Agriculture, Faisalabad, Pakistan at controlled temperature (26±2$^{o}$C) and relative humidity (60±5%) with a 12:12 (L: D) photoperiod. Healthy fruits of guava were offered to the adult flies inside the cages for their egg lying inside the fruits. The infested fruits were placed in a plastic jar with provided sterilized sand until pupation occurred. The pupae were isolated from the sand and transferred into separate adult rearing cages of 30×30×30cm size. The sides of cages were provided with iron wire covered with mesh cloth. The adult flies were fed artificial adult food composed of sugar mixed with protein hydrolysate (3:1 w/w) and provided water in the form of wet cotton.

**Susceptible strain:** Susceptible strain of *B. zonata* was obtained from mass rearing laboratory of fruit flies at Nuclear Institute of Agriculture (NIA), Tandojam where it was maintained for many generations since 1992. Culture of susceptible strain was established at laboratory under standard rearing conditions as mentioned above.

**Insecticides used under study:** The technical grade of six insecticides *i.e*., trichlorfon (98%) Jiangsu Anpon, China, malathion (95%), lambda-cyhalothrin (98%) Jiangsu Huangma Agrochemicals, China, bifenthrin (95%), methomyl (93%) Agro-Care Chemical, China and spinosad (95%) Shenzhen Crop Star Chemical, China were used in different concentration prepared in acetone (98%) Riedel -de Haën, Germany for present study.

**Bioassay of insecticides to determine the resistance level:** To determine the insecticides resistance level against *B. zonata* adult populations against insecticides topical assay was carried out (Anonymous 1979). Adult flies of 3-5 days old were treated with different concentration of the insecticide in acetone after $CO_2$ anaesthetized adult flies (10-15 seconds). A batch of 50 adults were exposed per dose treatment with 6 doses includes control (Acetone). In each treatment equal number of male and female was applied with 1 µl drop of insecticide solution on the pronotum of the flies with help of Burkard Micro Applicator. Treated flies were kept in 250 ml paper cups with top covered by muslin cloth and flies were fed diet having sugar, protein hydrolysate and water (4:1:5 w/w) soaked in a small piece of cotton. All treated flies were maintained above mentioned laboratory conditions.

**Analysis of data:** Data on mortality of flies was recorded against each insecticide at different concentrations after 24 hours post treatment and analyzed by using Probit analysis (Finney, 1971) by applying the software POLO-PC (LeOra Software, 1987). The values of $LC_{50}$ of field populations were recorded. Resistance factors were computed by dividing $LC_{50}$ values of field strains with $LC_{50}$ value of susceptible strain. Resistance Factor (RFs) was observed and recorded as described by Torres-Vila *et al.*, (2002): susceptibility (RF=1), low resistance (RF= 2-10), moderate resistance (RF= 11-30), high resistance (RF= 31-100) and very high resistance (RF >100).

## RESULTS AND DISCUSSION

**Susceptible baseline values:** $LC_{50}$ values of trichlorfon, bifenthrin, malathion, methomyl, lambda-cyhalothrin and spinosad in the susceptible strain of *B. zonata* were used as described in Nadeem *et al*., 2012 to determine the resistance level in field populations of *B. zonata.*

**Effect of trichlorfon against different populations of *B. zonata*:** *B. zonata* populations collected from different locations showed variation in their resistance factor as per listed in table 1, which ranged from 1.00-fold to 41.13-fold (Susceptible to high resistance). High resistance ratio was observed in populations of 31/11L, 174/9L, 6/14L, 15/11L, 111/7R, 105/7R, 113/12L, 168/9L and 184/9L (41.13-, 40.65-, 39.66-, 38.31-, 34.85-, 33.24-, 32.67-, 31.42- and 30.01-fold respectively) with $LC_{50}$ ranging from 97.90µgmL$^{-1}$ to 70.15µgmL$^{-1}$. Populations collected from 69/12L, 11/14L, 5/14L, 67/12L and 96/12L showed susceptible to trichlorfon. In our study trichlorfon bioassay against five populations of *B. zonata* showed susceptible trend which contradicts the study conducted by Kashyap and Hameed (1982), who checked susceptibility tests of five insecticides *viz.*, fenitrothion, fenthion, malathion, methyl parathion and trichlorfon on peach fruits against larvae of *B. cucurbitae* and reported that fenitrothion was more susceptible and trichlorfon was the least toxic. In our results nine populations were highly resistant to trichlorfon, which are in line with the results of experiments conducted by Ahmad *et al*. (2010) and Jin *et al*. (2010).

**Effect of bifenthrin against different populations of *B. zonata*:** Bifenthrin showed variation in resistance factors (1.00-fold to 14.27-fold) when treated with tested populations of *B. zonata* (Table 1). Moderate resistance ratio was detected in populations of 113/12L (14.27-fold) followed by 105/7R (13.53-fold), 168/9L (12.84-fold), 15/11L (12.01-fold), 31/11L (11.50-fold), 6/14L (11.03-fold), 111/7R (11.03-fold), 184/9L (10.61-fold) and 174/9L (10.52-fold) with $LC_{50}$ ranged from 36.84µgmL$^{-1}$ to 27.16µgmL$^{-1}$. Populations from 96/12L, 67/12L, 11/14L and 69/12L were categorized susceptible to bifenthrin. Ahmad *et al*, (2010) reported that from low to medium resistance level (8-11-fold) against bifenthrin which partially confirm to our results from susceptible to moderate resistance level.

**Effect of malathion against different populations of *B. zonata*:** The effect of malathion to different population of *B. zonata* showed moderate resistance ratio in 31/11L, 174/9L, 6/14L, 15/11L, 111/7R, 105/7R, 113/12L, 168/9L and 184/9L (20.37-, 18.21-, 17.41-, 17.23-, 16.96-, 15.54-, 14.80-,14.49- and 14.31-fold) with $LC_{50}$ ranging from 91.47µgmL$^{-1}$ to 70.73µgmL$^{-1}$, while other populations were remained as susceptible to malathion (Table 1). Effect of malathion on the major tested populations of *B. zonata* showed moderate resistance level in our study, which is partially in agreement to the results reported by Ahmad *et al.* (2010). Hsu and Feng (2000) who conducted bioassays against adults of *B. dorsalis* to determine the toxicity of insecticides *viz*., fenitrothion, malathion, fenthion, naled and trichlorfon, revealed that considerable increase in the level of $LD_{50}$ (1.9-4.3 folds) was observed for all the tested insecticides except trichlorfon which are in the line with our study. Comparable results to our studies by Hsu *et al.* (2002) who compared the resistance against six field population of *B. dorsalis* and *B. cucurbitae* and reported that all tested field strains of *B. cucurbitae* and observed resistance to fenthion, malathion, methomyl and cyfluthrin for 29-fold which are at par to our results as resistance to malathion.

**Effect of methomyl against different populations of *B. zonata*:** Methomyl showed no variation in resistance ratios when assayed with different populations of *B. zonata* (Table 1). All the 14 tested populations were showed almost same behavior to methomyl bioassay in the laboratory and remained susceptible to methomyl. Methomyl showed no variation in resistance factors when assayed with different tested populations of *B. zonata*. There is no comparable study of methomyl against fruit flies in Pakistan however our work is contradictory to results reported by El-Aw *et al.* (2008) who carried the toxicity of insecticides and found methomyl, malathion, spinosad and Actara baits against male and female adults of peach fruit fly, *B. zonata* by feeding bioassay method. Similarly, Hsu *et al.* (2002) also compared the resistance level in their trial against six field population of *B. dorsalis* and *B. cucurbitae* and reported the highest resistance ratio (43-fold) to methomyl against *B. dorsalis* among the tested strains which did not agree to our results.

**Effect of lambda-cyhalothrin against different populations of *B. zonata*:** Population from 113/12L, 105/7R, 168/9L, 15/11L, 31/11L, 6/14L,111/7R,184/9L and 174/9L showed low resistance ratio (9.57-, 9.45-, 9.09-,7.69-,7.55-, 6.53-, 5.89-, 5.34- and 4.06-fold) with $LC_{50}$ 23.17 µgmL$^{-1}$ to 9.84 µgmL$^{-1}$ when treated with lambda-cyhalothrin (Table 1). Other populations belonging to 67/12L, 96/12L, 11/14L, 5/14L and 69/12L were rated as susceptible to lambda-cyhalothrin in tested trails.Our results are in the line with the work reported by Ahmad *et al*. (2010) and partially agreed to Oke, (2008), who conducted the field experiments to test the effectiveness of lambda-cyhalothrin and deltamethrin and reported that lambda-cyhalothrine was better as its

**Table 1: Toxicity of tested insecticides on field populations of *B. zonata* at adult stage.**

| Insecticides | Population | $LC_{50}$ (µgmL$^{-1}$) FL (95%) | Fit of Probit Line | | RR* |
|---|---|---|---|---|---|
| | | | Slope ± SE | $\chi^2$ | |
| Trichlorfon | 105/7R | 79.12 (64.04-96.74) | 2.04±0.23 | 0.58 | 33.24 |
| | 111/7R | 82.96 (67.78-100.26) | 2.12±0.26 | 0.48 | 34.85 |
| | 113/12L | 77.76 (64.72-92.32) | 2.40±0.28 | 2.03 | 32.67 |
| | 6/14L | 94.41 (62.27-128.90) | 2.49±0.29 | 3.96 | 39.66 |
| | 5/14L | 2.43 (1.48-3.58) | 2.58±0.28 | 5.61 | 1.02 |
| | 11/14L | 2.47 (1.66-3.42) | 2.61±0.28 | 4.17 | 1.03 |
| | 96/12L | 2.38 (1.69-3.16) | 2.68±0.29 | 3.32 | 1.00 |
| | 69/12L | 2.59 (2.18-3.04) | 2.79±0.29 | 2.60 | 1.08 |
| | 67/12L | 2.41 (1.99-2.86) | 2.56±0.28 | 1.47 | 1.01 |
| | 168/9L | 74.79 (55.66-97.43) | 2.74±0.31 | 3.11 | 31.42 |
| | 31/11L | 97.90 (81.56-114.98) | 2.59±0.29 | 1.57 | 41.13 |
| | 174/9L | 96.77 (77.51-116.76) | 2.12±0.27 | 0.23 | 40.65 |
| | 15/11L | 91.18 (73.67-109.12) | 2.27±0.28 | 2.99 | 38.31 |
| | 184/9L | 70.15 (57.07-84.21) | 2.22±0.27 | 1.57 | 30.01 |
| Bifenthrin | 105/7R | 34.92 (27.47-43.37) | 1.85±0.23 | 0.88 | 13.53 |
| | 111/7R | 28.47 (22.32-35.07) | 1.98±0.24 | 1.73 | 11.03 |
| | 113/12L | 36.84 (29.23-45.58) | 1.89±0.23 | 1.12 | 14.27 |
| | 6/14L | 32.20 (25.28-39.58) | 1.89±0.23 | 1.73 | 11.03 |
| | 5/14L | 2.59 (1.93-3.35) | 2.85±0.30 | 3.01 | 1.00 |
| | 11/14L | 2.71 (2.23-3.23) | 2.39±0.26 | 2.56 | 1.05 |
| | 96/12L | 2.90 (2.32-3.54) | 2.32±3.54 | 2.01 | 1.12 |
| | 69/12L | 2.56 (1.71-3.55) | 2.28±0.26 | 3.53 | 0.99 |
| | 67/12L | 2.85 (2.30-3.45) | 2.13±0.24 | 0.10 | 1.10 |
| | 168/9L | 33.14 (21.01-48.08) | 2.02±0.24 | 3.67 | 12.84 |
| | 31/11L | 29.67 (23.55-36.30) | 2.05±0.24 | 1.50 | 11.50 |
| | 174/9L | 27.16 (21.61-33.52) | 1.92±0.23 | 0.75 | 10.25 |
| | 15/11L | 31.00 (20.24-43.58) | 1.99±0.24 | 3.07 | 12.01 |
| | 184/9L | 27.38 (21.59-34.06) | 1.83±0.22 | 1.55 | 10.61 |
| Malathion | 105/7R | 76.81 (60.46-93.62) | 2.15±0.26 | 2.84 | 15.54 |
| | 111/7R | 83.81 (65.34-104.59) | 1.01±0.33 | 1.01 | 16.96 |
| | 113/12L | 73.16 (56.36-91.61) | 1.78±0.22 | 1.07 | 14.80 |
| | 6/14L | 86.02 (66.34-107.30) | 1.83±0.23 | 0.09 | 17.41 |
| | 5/14L | 4.97 (3.95-6.08) | 2.07±0.24 | 0.20 | 1.00 |
| | 11/14L | 5.74 (4.65-6.98) | 2.14±0.24 | 0.42 | 1.16 |
| | 96/12L | 4.95 (3.79-6.21) | 1.77±0.23 | 0.52 | 1.00 |
| | 69/12L | 5.14 (4.04-6.33) | 1.95±0.23 | 1.02 | 1.04 |
| | 11/14L | 5.74 (4.65-6.98) | 2.14±0.24 | 0.42 | 1.16 |
| | 96/12L | 4.95 (3.79-6.21) | 1.77±0.23 | 0.52 | 1.00 |
| | 69/12L | 5.14 (4.04-6.33) | 1.95±0.23 | 1.02 | 1.04 |
| | 67/12L | 5.13 (3.94-6.43) | 1.77±0.22 | 0.09 | 1.03 |
| | 168/9L | 71.60 (42.85-105.13) | 2.07±0.25 | 1.05 | 14.49 |
| | 31/11L | 91.47 (73.46-112.05) | 2.01±0.23 | 0.43 | 20.37 |
| | 174/9L | 89.96 (70.17-112.61) | 1.76±0.22 | 0.02 | 18.21 |
| | 15/11L | 85.13 (68.25-104.42) | 1.99±0.23 | 2.41 | 17.23 |
| | 184/9L | 70.73 (54.38-86.71) | 2.09±0.28 | 0.76 | 14.31 |
| Methomyl | 105/7R | 6.19 (4.95-7.52) | 2.21±0.35 | 0.12 | 1.59 |
| | 111/7R | 7.38 (6.13-8.75) | 2.43±0.29 | 1.62 | 1.90 |
| | 113/12L | 6.59 (5.40-7.85) | 2.38±0.29 | 0.92 | 1.69 |
| | 6/14L | 6.88 (5.56-8.28) | 2.18±0.27 | 0.76 | 1.77 |
| | 5/14L | 6.40 (4.45-8.51) | 2.56±0.31 | 3.33 | 1.64 |
| | 11/14L | 3.94 (3.33-4.54) | 2.96±0.36 | 1.78 | 1.01 |
| | 96/12L | 3.99 (2.93-5.05) | 3.00±0.36 | 3.21 | 1.02 |

| | | | | | |
|---|---|---|---|---|---|
| | 69/12L | 3.98 (3.35-4.60) | 2.88±0.35 | 1.68 | 1.02 |
| | 67/12L | 4.47 (3.20-5.82) | 2.68±0.33 | 3.40 | 1.15 |
| | 168/9L | 7.23 (5.81-8.77) | 2.06±0.26 | 0.63 | 1.86 |
| | 31/11L | 7.28 (5.93-8.76) | 2.19±0.27 | 0.92 | 1.87 |
| | 174/9L | 5.98 (4.86-7.12) | 2.42±0.30 | 2.48 | 1.54 |
| | 15/11L | 6.75 (5.62-7.95) | 2.57±0.30 | 2.66 | 1.73 |
| | 184/9L | 7.48 (6.05-9.05) | 2.10±0.26 | 0.51 | 1.92 |
| Lambda-cyhalothrin | 105/7R | 22.89 (12.60-33.91) | 2.48±0.29 | 6.16 | 9.45 |
| | 111/7R | 14.27 (9.44-19.38) | 2.41±0.29 | 3.72 | 5.89 |
| | 113/12L | 23.17 (18.55-28.39) | 2.01±0.23 | 1.31 | 9.57 |
| | 6/14L | 15.82 (9.20-23.55) | 2.40±0.29 | 5.86 | 6.53 |
| | 5/14L | 2.45 (1.95-2.99) | 2.06±0.25 | 0.36 | 1.01 |
| | 11/14L | 2.51 (1.95-3.11) | 1.86±0.23 | 0.28 | 1.03 |
| | 96/12L | 2.57 (2.07-3.10) | 2.18±0.25 | 0.76 | 1.06 |
| | 69/12L | 2.43 (1.94-2.96) | 2.12±0.25 | 0.61 | 1.00 |
| | 67/12L | 2.63 (2.13-3.16) | 2.25±0.25 | 0.50 | 1.08 |
| | 168/9L | 22.02 (17.48-27.08) | 1.97±0.23 | 1.10 | 9.09 |
| | 31/11L | 18.29 (11.29-26.22) | 2.26±0.28 | 4.56 | 7.55 |
| | 174/9L | 9.84 (7.95-11.90) | 2.22±0.26 | 2.94 | 4.06 |
| | 15/11L | 18.63 (14.54-23.00) | 1.96±0.23 | 1.94 | 7.69 |
| | 184/9L | 12.94 (10.46-15.83) | 2.03±0.23 | 2.14 | 5.34 |
| Spinosad | 105/7R | 20.45 (16.06-25.26) | 1.93±0.23 | 2.75 | 7.95 |
| | 111/7R | 23.32 (18.84-28.24) | 2.19±0.25 | 1.26 | 9.09 |
| | 113/12L | 25.69 (20.56-31.47) | 2.01±0.24 | 1.14 | 9.95 |
| | 6/14L | 16.81(13.38-20.65) | 1.98±0.23 | 0.18 | 6.51 |
| | 5/14L | 4.39 (2.92-5.92) | 2.90±0.31 | 4.56 | 1.18 |
| | 11/14L | 4.44 (3.70-5.20) | 2.70±0.30 | 2.95 | 1.20 |
| | 96/12L | 4.91 (4.15-5.70) | 2.83±0.31 | 1.70 | 1.33 |
| | 69/12L | 4.54 (3.76-5.33) | 2.61±0.30 | 1.00 | 1.23 |
| | 67/12L | 4.67 (3.81-5.55) | 2.35±0.28 | 0.99 | 1.26 |
| | 168/9L | 16.46 (13.08-20.25) | 1.97±0.23 | 1.08 | 4.46 |
| | 31/11L | 22.68 (18.03-27.91) | 1.95±0.23 | 1.39 | 8.79 |
| | 174/9L | 31.94 (18.14-29.39) | 1.73±0.23 | 1.89 | 9.06 |
| | 15/11L | 24.35 (19.44-29.81) | 2.02±0.24 | 2.61 | 9.43 |
| | 184/9L | 21.87 (17.54-26.69) | 2.07±0.24 | 0.75 | 8.47 |

$LC_{50}$ (Lethal concentration of field population); FL (Fiducial limits); ±SE (Standard Error); RR*Resistance ratio ($LC_{50}$ of field population/$LC_{50}$ of susceptible strain).

application reduced more number of melon fruit fly pupae emerged than those of the deltamethrin.

**Effect of spinosad against different populations of *B. zonata*:** Effect of spinosad to the 14 different populations of *B. zonata* showed variation in their resistance factors (Table 1). Resistance ratio among 14 tested populations ranged between 1.20- fold to 9.95- fold from susceptible to low resistance towards spinosad. Low resistance ratio was observed in 113/12L (9.95-fold) followed by 15/11L (9.43-fold), 111/7R (9.09-fold) , 174/9L (9.06-fold), 31/11L (8.79-fold), 184/9L (8.47-fold), 105/7R (7.95-fold), 6/14L (6.51-fold) and 168/9L (4.46-fold) with $LC_{50}$ ranging from 25.69µgmL$^{-1}$ to 16.46µgmL$^{-1}$. Populations from 96/12L, 67/12L, 69/12L, 11/14L and 5/14L were observed as susceptible to spinosad. Our result supported the work reported by Steven and McQuate (2000), who worked on the susceptibility of malathion, spinosad and phloxine B on wild population of *Ceratatis capitata* in Hawaii and got comparable results of test treatments where malathion was most effective than other tested insecticides. Work of Ahmad *et al.* (2010) is partially in agreement to our findings that our five populations among fourteen were susceptible to spinosad.

**Conclusions:** Findings from above study conclude that the most of field populations of *B. zonata* has developed resistance towards trichlorfon, malathion (Organophosphates), bifenthrin, lambda-cyhalothrin (Pyrethorids) and spinosad (Microbial), whereas, methomyl (Carbamate) proved susceptible to all tested populations on *B. zonata*. Hence, methomyl is recommended to control fruit fly in field while, the insecticides showing resistance against *B. zonata* populations need to adopt new techniques to overcome resistance.

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