Comparative Toxicity of Certain Pesticides to Peach Fruit Fly, *Bactrocera zonata* Saunders (Diptera: Tephritidae) under Laboratory Conditions

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Abstract

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Peach fruit fly, *Bactrocera zonata* (Saunders) (Diptera: Tephritidae), has been a serious pest in the last decade attacking a wide range of fruits in Egypt. The toxicity of Malathion, Diazinon, Methoxyfenozide, and Lufenuron to adult males and females of *Bactrocera zonata* was studied under laboratory conditions. Diazinon was the most toxic among the tested compounds followed by Malathion, Lufenuron and Methoxyfenozide to *Bactrocera zonata* at 24 h post treatment, the respective LC_{50} values were 0.20 ppm, 0.48 ppm, 8.97 ppm, and 9.73 ppm for males and 0.26 ppm, 0.91 ppm, 11.26 ppm, and 14.12 ppm for females. At 48 h post treatment Diazinon was the most toxic followed by Malathion, Methoxyfenozide and Lufenuron to *Bactrocera zonata*, LC_{50} values were 0.09ppm, 0.34 ppm, 1.60 ppm, and 1.88 ppm for males and 0.14 ppm, 0.44 ppm, 1.68 ppm and 2.17 ppm for females. At 72 h post treatment Diazinon was the most toxic followed by Malathion, Lufenuron and Methoxyfenozide to *Bactrocera zonata,* LC_{50} values were 0.02 ppm, 0.13 ppm, 0.22 ppm and 0.51 ppm for males and 0.07 ppm, 0.16ppm, 0.55 ppm and 0.62 ppm for females. It is observed that LC_{50} values for treated adult females increased more than in the treated adult males at 24 h, 48 h, and 72 h post treatment. It means that the adult males were more susceptible to the tested insecticides than the adult females.

Keywords: Malathion; Methoxyfenozide; Lufenuron; Diazinon; Tephritidae; peach fruit fly; *Bactrocera zonata*

Tephritid fruit flies are among the major pests of fleshy fruits which affect their production throughout the world and represent the most economically important group of polyphagous dipterous pests (Robison & Hooper 1989). The fruit flies are one of the most important insect pest groups of horticultural production and export throughout the world. Four hundred species belonging to the genus *Bactrocera* are widely distributed in tropical regions of Asia, South Pacific and Australia, but very few species of this genus were recorded in Africa (Drew & Hancock 1994). Recently in 1993, the peach fruit fly, *Bactrocera zonata* (Saunders), (Diptera: Tephritidae), was recognized in Egypt causing the most fruit damage, attacking a range of fruits including mango, guava, apricot, peach, apple and fig, although this insect species was recorded in Egypt as early as in 1924 (Efflatoun 1924). In India, *Bactrocera zonata* (Saunders) is active throughout the year except the cold winter months of January and February (Grewal 1981). The peach fruit fly, *Bactrocera zonata* (Saunders), is native to South and South East Asia, where it attacks a wide variety of soft fruits. Female flies lay their eggs in the fruits while the maggots devour the pulp. Subsequently, secondary infections with bacterial and fungal diseases are frequent and infested fruits drop down (White & Elson-Harris 1994). Also, it is considered as one of the most destructive fruit pests in temperate, tropical and subtropical countries due to the losses caused by fruit larvae as they feed and live in the fruits of host plants (Joomaya & Price 2000; Hashem *et al*. 2001). The infestation of fruits ranged between 10% and up to 20% in the north-western Himalayan region (Gupta & Bhalla Verma 1990) and reached up to 89.5% of peach fruits in Pakistan (Grewal & Kapoor 1987).

The present study aims to evaluate the efficiency of certain insecticides belonging to different groups in the control of *Bactrocera zonata* (Saunders).

MATERIAL AND METHODS

Laboratory and mass rearing technique

The insects were obtained from infested mango fruits from the farm of El-Qasasin Agricultural Research Station, Ismalia governorate, Egypt, and reared in the laboratory according to the rearing method described by Youssef (2004). According to this method, the infested fruits were kept under laboratory conditions (24 ± 3°C and 50:70% RH). Plastic containers were furnished with sterilized sand and the infested fruits were placed inside the containers where eggs were hatching to 1st instars, then to 2nd and 3rd instars of larvae until pupation. Pupae were collected daily and transferred to adult rearing cages. The sides of the adult cages were coated with wire screen except one side which had a sleeve opening (for daily examination) and the cage floor was made of wooden sheet. The newly emerged flies were provided with a source of drink water and the food was sugar mixed with buminal (3:1), the adult cages were supplied with artificial plastic fruits that had many small pores (as an ovipositor site) except 3 cm at the bottom and one wide pore at the top which was covered with a suitable lid; these plastic fruits were filled with water to the mentioned 3 cm at the bottom to receive the eggs. The deposited eggs were collected every 24 h and placed on an artificial diet containing wheat bran (1000 g), brewer's yeast (250 g), sugar (300 g), sodium benzoate (2 g), HCl (2 ml) and water (500 ml). The diet was kept in plastic containers and stored in a refrigerator.

Laboratory assay of some selected insecticides against the adult stage of *Bactrocera zonata*

The experiment was planned to evaluate the toxicity of various insecticides belonging to different chemical groups.

Insecticides. Malathion (Malathin® 57% EC), Diazinon (Bassudin® 60% EC), Methoxyfenozide (Runner® 24% SC), and Lufenuron (Match® 5% EC) were applied to the adult stage of *Bactrocera zonata* under laboratory conditions (24 ± 3°C and 50:70% RH).

Procedure. Toxicity experiments were conducted in small glass jars; each jar received ten adult male and female flies of PFF. They were confined separately without food and the cups were coated with muslin. Pieces of cotton were immersed in a series of different concentrations (six concentrations) of the tested insecticides. The cotton pieces were placed in small plastic cups. Four replications were used for each concentration and four untreated replications were also set up as a check (control). The jars were examined at 24 h, 48 h, and 72 h post treatment and the dead flies were counted and recorded. The average percentage of adult mortality was calculated for each concentration.

Statistical analysis. The average percentage of adult mortality calculated for each concentration was plotted against each test concentration on a logarithmic probit paper. The concentration killing 50% (LC_{50}) of the tested adults was calculated according to Finney (1971). From this concentration the corresponding toxicity lines (LC-P lines) were estimated and the relative efficiency of LC_{50} values of the tested insecticides was determined according to Sun (1950) and the slope values of tested compounds were also estimated.

RESULTS AND DISCUSSION

Toxicity of some insecticides to the adult stage of *Bactrocera zonata*

The toxicity of the used insecticides Malathion and Diazinon, which belong to the organophosphate group (OP's), Methoxyfenozide and Lufenuron, which belong to the group of insect growth regulators (IGRs) was evaluated by the laboratory bioassay, numbers of dead flies were counted and recorded, slope and toxicity index of both sexes of

Table 1. Toxicity of certain insecticides against adult males and females of *Bactrocera zonata* at 24 h, 48 h and 72 h post treatment under laboratory conditions

Pesticides	Males			Females		
	lethal concentrations and their limits (ppm) at LC_{50}	slope ± SE	toxicity index% at LC_{50}	lethal concentrations and their limits (ppm)at LC_{50}	slope ± SE	toxicity index% at LC_{50}
24 h						
Malathion	0.48 (0.36–0.60)	1.21 ± 0.11	41.67	0.91 (0.67–1.22)	0.90 ± 0.10	28.57
Methoxyfenozide	9.73 (8.12–11.63)	1.57 ± 0.14	2.06	14.12 (11.55–17.54)	1.35 ± 0.13	1.84
Lufenuron	8.97 (7.56–10.56)	1.73 ± 0.14	2.23	11.26 (9.52–13.34)	1.69 ± 0.14	2.31
Diazinon	0.20 (0.15–0.24)	1.51 ± 0.18	100	0.26 (0.20–0.32)	1.39 ± 0.18	100
48 h						
Malathion	0.34 (0.26–0.44)	1.28 ± 0.11	26.47	0.44 (0.32–0.56)	1.13 ± 0.11	31.81
Methoxyfenozide	1.60 (0.93–2.26)	1.46 ± 0.19	5.63	1.68 (0.92–2.46)	1.21 ± 0.16	8.33
Lufenuron	1.88 (1.30–2.47)	1.11 ± 0.13	4.79	2.17 (1.23–3.13)	1.09 ± 0.14	6.45
Diazinon	0.09 (0.05–0.12)	1.28 ± 0.19	100	0.14 (0.09–0.18)	1.27 ± 0.18	100
72 h						
Malathion	0.13 (0.06–0.20)	0.88 ± 0.13	15.38	0.16 (0.08–0.25)	0.82 ± 0.13	43.75
Methoxyfenozide	0.51 (0.06–1.12)	1.11 ± 0.25	3.92	0.62 (0.09–1.34)	0.94 ± 0.22	11.3
Lufenuron	0.22 (0.003–0.77)	0.82 ± 0.23	9.09	0.55 (0.01–2.88)	0.90 ± 0.16	12.73
Diazinon	0.02 (0.006–0.05)	1.14 ± 0.23	100	0.07 (0.03–0.11)	1.21 ± 0.20	100

Bactrocera zonata were calculated at 24h, 48 h, and 72 h post treatment. Obtained data demonstrated that the adult susceptibility to the particular tested insecticides was found to be different based on the calculated LC_{50} values in Table 1 and Figures 1–6.

Diazinon was the most toxic among the tested compounds followed by Malathion, Lufenuron and Methoxyfenozide to males of *Bactrocera zonata* at 24 h post treatment. The respective values of LC_{50} of these compounds were 0.20 ppm, 0.48 ppm, 8.97 ppm, and 9.73 ppm. The toxicity index values show the superior efficiency of Diazinon at LC_{50} (100%) followed by Malathion (41.67%), Lufenuron (2.23%), and Methoxyfenozide (2.06%) (Table 1 and Figure 1A).

As for slope values, the steepest toxicity line of Lufenuron possesses the highest slope value 1.73, while the flattest line of Malathion possesses the lowest slope value 1.21, whereas that of the remaining toxicants lies between the values of the two above-mentioned compounds: Methoxyfenozide 1.57 and Diazinon 1.51.

Table 1 and Figure 1B show that Diazinon was the most toxic among the tested compounds followed by Malathion, Lufenuron and Methoxyfenozide to the females of *Bactrocera zonata* at 24 h post treatment. The respective values of LC_{50} of these compounds were 0.26 ppm, 0.91 ppm, 11.26 ppm, and 14.12 ppm. The toxicity index values show the superior efficiency of Diazinon at LC_{50} (100%) fol-

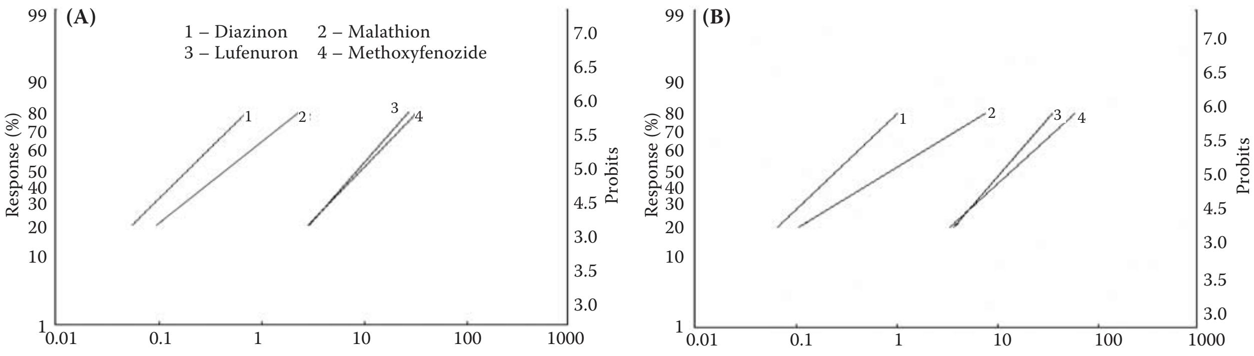

Figure 1. Comparative toxicity lines of certain insecticides to the adult males (A) and female (B) of *Bactrocera zonata* at 24 h post treatment

lowed by Malathion (28.57%), Lufenuron (2.31%), and Methoxyfenozide (1.84%).

As for slope values, the steepest toxicity line of Lufenuron possesses the highest slope value 1.69, while the flattest line of Malathion possesses the lowest slope value 0.90, whereas that of the remaining toxicants lies between the values of the two above-mentioned compounds: Diazinon 1.39 and Methoxyfenozide 1.35.

Diazinon was the most toxic among the tested compounds followed by Malathion, Methoxyfenozide and Lufenuron to the males of *Bactrocera zonata* at 48 h post treatment. The respective values of LC_{50} of these compounds were 0.09 ppm, 0.34 ppm, 1.60 ppm, and 1.88 ppm. The toxicity index values show the superior efficiency of Diazinon at LC_{50} (100%) followed by Malathion (26.47%), Methoxyfenozide (5.63%), and Lufenuron (4.79%) (Table 1 and Figure 2A).

As for slope values, the steepest toxicity line of Methoxyfenozide possesses the highest slope value 1.46, while the flattest line of Lufenuron possesses the lowest slope value 1.11, whereas Diazinon and Malathion slope values lie between them with the same value 1.28.

Diazinon was the most toxic among the tested compounds followed by Malathion, Methoxyfenozide and Lufenuron to the females of *Bactrocera zonata* at 48 h post treatment. The respective values of LC_{50} of these compounds were 0.14 ppm, 0.44 ppm, 1.68 ppm, and 2.17 ppm. The toxicity index values show the superior efficiency of Diazinon at LC_{50} (100%) followed by Malathion (31.81%), Methoxyfenozide (8.33%), and Lufenuron (6.45%) (Table 1 and Figure 2B).

As for slope values, the steepest toxicity line of Diazinon possesses the highest slope value 1.27, while the flattest line of Lufenuron possesses the lowest slope value 1.09, whereas that of the remaining toxicants lies between the values of the two above-mentioned compounds: 1.21 and 1.13 for Methoxyfenozide and Malathion, respectively.

Diazinon was the most toxic among the tested compounds followed by Malathion, Lufenuron and Methoxyfenozide to the males of *Bactrocera zonata* at 72 h post treatment. The respective values of LC_{50} of these compounds were 0.02 ppm, 0.13 ppm, 0.22 ppm, and 0.51 ppm. The toxicity index values show the superior efficiency of Diazinon at LC_{50} (100%) followed by Malathion (15.38%), Lufenuron

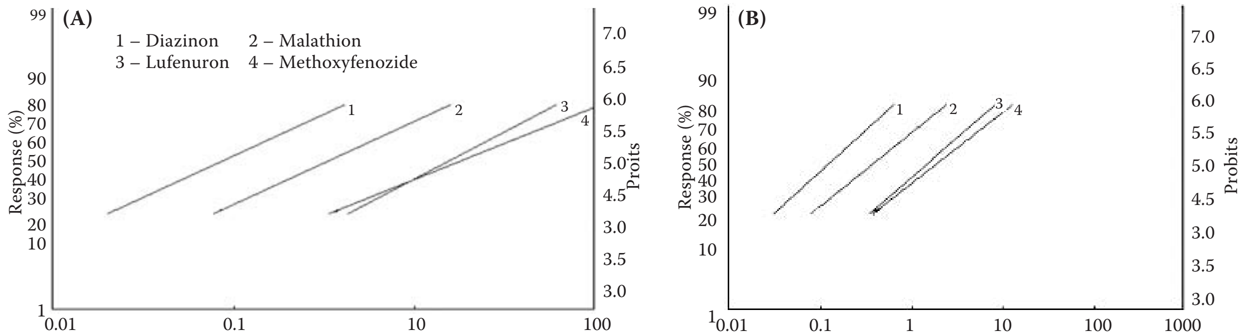

Figure 2. Comparative toxicity lines of certain insecticides to the adult males (A) and female (B) of *Bactrocera zonata* at 48 h post treatment

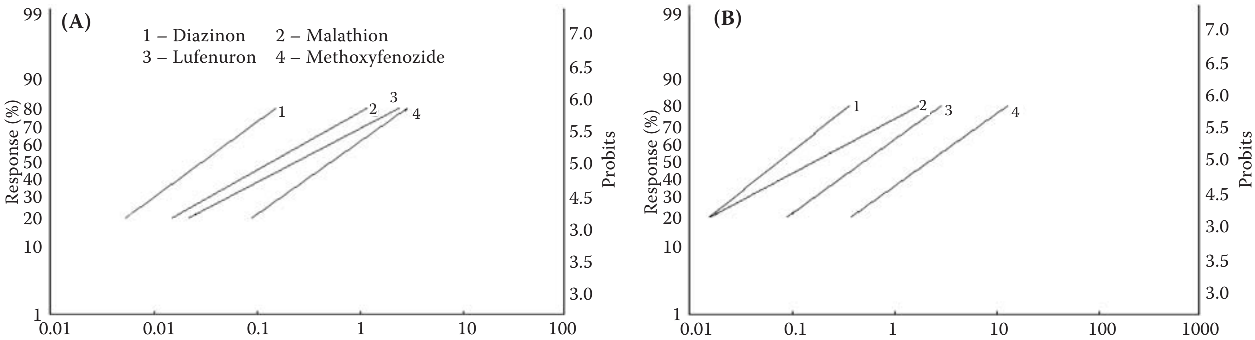

Figure 3. Comparative toxicity lines of certain insecticides to the adult males (A) and female (B) of *Bactrocera zonata* at 72 h post treatment

(9.09%) and Methoxyfenozide (3.92%) (Table 1 and Figure 3A).

As for slope values, the steepest toxicity line of Diazinon possesses the highest slope value 1.14, while the flattest line of Lufenuron possesses the lowest slope value 0.82, whereas that of the remaining toxicants lies between the values of the two above-mentioned compounds: Methoxyfenozide 1.11 and Malathion 0.88.

Diazinon was the most toxic among the tested compounds followed by Malathion, Lufenuron and Methoxyfenozide to the females of *Bactrocera zonata* at 72 h post treatment. The respective values of LC_{50} of these compounds were 0.07 ppm, 0.16 ppm, 0.55 ppm, and 0.62 ppm. The toxicity index values show the superior efficiency of Diazinon at LC_{50} (100%) followed by Malathion (43.75%), Lufenuron (12.73%), and Methoxyfenozide (11.30%) (Table 1 and Figure 3B).

As for slope values, the steepest toxicity line of Diazinon possesses the highest slope value 1.21, while the flattest line of Malathion possesses the lowest slope value 0.82, whereas that of the remaining toxicants lies between the values of the two above-mentioned compounds: Methoxyfenozide 0.94 and Lufenuron 0.90.

From the obtained results in Table 1 it is clear that LC_{50} values for the treated adult females increased more than in the treated adult males at 24 h, 48 h and 72 h post treatment. It means that the adult males were more susceptible to the tested insecticides than the adult females. However, the present findings are consistent with the results of Stark *et al.* (2004) that the males of *Ceratitis capitata* were significantly more susceptible than the adult females. It is also observed from the previous results that the slopes differed between both *Bactrocera zonata* sexes and between 24 h, 48 h, and 72 h post treatment within each sex. The slope values also differed from one tested insecticide to another.

Generally, it can be concluded that Diazinon was the most effective insecticide against adult males and females of *Bactrocera zonata* (Saunders) followed by Malathion, Methoxyfenozide and Lufenuron. So, the females of *Bactrocera zonata* (Saunders) are less sensitive to Malathion, Methoxyfenozide, and Lufenuron insecticides than the males. Diazinon is considered as organophosphorus (OP) insecticide, its mode of action is cholinesterase (ChE) inhibitor.

The synaptic transmission occurs through the synapses in the insect nervous system by neurotransmitters called cholinesterase, which is hydrolyzed by acetylcholinesterase (AChE), which contains two active sites (esteratic site which contains OH group and anionic site which contains negative charge). At the beginning of hydrolysis of ChE by AChE it was binding with the two active sites giving acetic acid and choline.

When the OP insecticide (Diazinon) attacked, it was binding with AChE at the esteratic site only forming a complex called phosphorylated enzyme, then the spontaneous recovery for this phosphorylated enzyme stopped. The inhibition of Diazinon for AChE leads to the accumulation of ChE in the nerve ends, which leads to continuous nerve conduction causing paralysis and then death of the insects.

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