International Journal of Entomology Research
www.entomologyjournals.com
ISSN: 2455-4758
Received: 03-08-2024, Accepted: 02-09-2024, Published: 17-09-2024
Volume 9, Issue 9, 2024, Page No. 78-84

Potency, persistance and resistance development of a pyrethriod compound against two species of fruit flies (Diptera: Tephritidae)

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Abstract
In this study, the efficiency of alpha-cypermethrin (Super-alpha 10% EC) against *B. zonata* and *C. capitata* adults was evaluated. Results indicated that mortality percentages increased with the increment of concentrations. Mortality percentages ranged between 34.5 - 92.35 in case of *B. zonata* adults and 42.55 - 94.8 in case of *C. capitata*. *Ceratitis capitata* adults were more susceptible to the tested insecticide than *B. zonata* ones. Degradation rate of alpha-cypermethrin (Super-alpha 10%EC) in two types of soil (sand and sandy-clay) was trio-interval bioassayed against the full grown larvae of the two species of fruit flies. The full grown larvae of *C. capitata* highly affected with all used concentrations of the tested toxicant in sand than in sandy-clay soil. All tested concentrations showed high significantly effectiveness in sand throughout two weeks of treatment, especially with 2000 and 3000 ppm which significantly recorded high % mortality in sandy soil for long periods that reduced from 97.77 to 48.87 and from 100 to 62.20 for 0- to 15-day intervals, respectively. Whereas, in case of sandy clay soil all concentrations showed very low efficiency against *C. capitata* mature larvae throughout all trio-inspected intervals (0-21 days) with low mortality percentages. Also, mortality percentages in case of *Bactrocera zonata* pre-pupae gradually reduced with time. The mortality percentage for 3000 ppm (in sand) recorded 97.8 at zero time that reduced to 76% after 12 days of treatment. But, the activity for 2000 ppm was 88.33% mortality at zero time which decreased to 62.2% after 9 days of application. The two highest tested concentrations stayed effective till 15 days after treatment. It was found that highly and significantly initial mortality of the two fruit flies in sandy and sandy clay soil at all used concentrations. Significantly and gradual decrement in toxicity of alphacypermethrin by time in the two types of soil at all concentrations was observed. Efficiency of alpha-cypermethrin against the two fruit flies disappeared after about 21 days. Generally, alpha-cypermethrin was more toxic to pre-pupae of both *B. zonata* and *C. capitata* in sand than in sandy clay soil. Results indicated that mortality percentages on adult progeny of both *B. zonata* and *C. capitata* of successive generations, differently and gradually decreased with the progress of generation at all used concentrations for five subsequent generations. Data indicated that adults of *C. capitata* were more susceptible than those of *B. zonata*. The resistance of *B. zonata* to alpha-cypermethrin (Super-alpha 10% EC) was more than that recorded in case of *C. capitata*.

Keywords: *Callosobruchus*, pulse beetle, botanicals, contact toxicity, adult mortality

Introduction

The tephritid fruit flies such as the Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann) and the peach fruit fly, *Bactrocera zonata* (Saunders) are very deleterious insect pests attacking numerous species of horticultural plants. The most species of tephritid fruit flies cause a huge damage in different types of fruit orchards (White & Elson-Harris, 1992 and Hashem *et al*., 2001) [21, 9]. The tephritid fruit flies have a very important economic effect on fruits appear in both qualitative and quantitative yield losses. The world wide spread of these pests is due to its ability for adapting with various climatic changes, the wide range of hosts, highest fertility and the resistance to the continuously-used insecticides. Adult females and larval stages are the destructive stages of these pests.

The management of these pests took place by several controlling methods such as sterile male technique, three components lure female traps catches, the use of ammonium compounds and conventional insecticidal application. Insecticide is a common effective control method. Disadvantage of this method is the environmental pollution, insecticide-residues in fruits and pest insecticidal-resistant strains. A variety of pesticides from various insecticides classes as pyrethroids, spinosad, organophosphates and carbamates used to control these pests (Schouest and Miller, 1988) [18]. Frequent use of insecticides created resistance development in insect strain. To avoid the chemical pollution, it was necessary to find out more safe alternative methods for controlling these pests. These alternative methods in integrated pest management programs include the use of different methods to minimize its damage with minimum risk to the environment and human health. Pyrethroid insecticides characterized by rapid degradation in environment (Haider *et al*., 2011 and Abou-Elfotouh, 2021) [8, 3].

This study aimed to investigate the efficiency of alphacybermethrin (Super-alpha 10% EC) on the Mediterranean fruit fly *Ceratitis capitata* and the peach fruit fly *Bactrocera zonata* as well as persistence of the tested toxicant in both sandy and sandy-clay (50% clay+50% sand W/W) soils as well as to evaluate the developed resistance of the same toxicant throughout several consecutive generations of the two species fruit flies.

Material and methods

Tested insects

Individuals of the two species of fruit flies (*B. zonata* and *C. capitata*) used in this study were obtained from a laboratory strains that were continuously reared in the Horticultural Insects Research Department, Plant Protection Research Institute, Agricultural Research Center, Dokki, Giza under constant conditions (30±1ºC and 70±5 %R. H.) according to Akl (2014).

Pesticide used

Alpha-cypermethrin (Super-alpha 10%EC), which belong to pyrethroid group, was obtained from El-Helb Company for Trading and Agricultural Projects Development.

Surface application

Preliminary screening was conducted to determine susceptibility of males and females of both *Ceratitis capitata* and *Bactrocera zonata*. Different concentrations were prepared to estimate the diagnostic concentration for the tested toxicant (alpha-cypermethrin, Super-alpha 10%EC) based on considerations discussed by (Roush and Miller, 1986) [16]. Two ml. of the insecticidal solution was pipetted into glass Petridishes which rolled for approximately 2 min. to ensure that all surfaces received the insecticidal treatment. Petri-dishes were air-dried (vertically) at room temperature for 2-4 hours. Petri-dishes were placed in small wooden cages (10×10×10 cm) that were provided with sugar and water for flies. Sixty males as well as sixty females of both *C. capitata* and *B. zonata* were used for each concentration in three replicates. Flies mortalities were calculated after 24 hours post-treatment.

Soil treatment

According to the method explained by Sherman (1958) [19], gradual concentrations of aqueous solution of the used toxicant (3000, 2000, 1000, 500, 250 and 125 ppm) were prepared. Each replicate consists of 20 gm of sand or sandy-clay (50% clay+50% sand W/W) soils. Two ml. of each concentration contained the required amount of the formulated insecticide under the test were added. Each concentration repeated 3 times in addition to the control (untreated). In the control test, soil was treated with water only. Each replicate contained 20 full grown larvae of the two fruit fly species, *B. zonata* and *C. capitata*. Pre-pupae (full grown larvae) were transferred to the surface of the treated soil in the jars. Soon they entered the soil to a depth of 2-3 cm. where they pupate till adult emergence. Mortalities of adults were recorded 24hrs after emergence. The total mortality percentages were used in drawing the toxicity lines of the tested toxicant. Mortality percentages were corrected by the use of Abbott's formula (Abbott, 1925) [1]. The persistence of the effectiveness of the tested concentrations of the used toxicants was studied at 0, 3, 6, 9, 12, 15, 18 and 21 days.

Resistance development

Laboratory technique for developed resistance based on preliminary screening susceptibility of males and females adult laboratory strains to the tested insecticide of both fruit flies (*Ceratitis capitata* and *Bactrocera zonata*). Treatment carried out with sub-lethal concentration (LC20) value of each generation by using surface film technique as well as lethal concentrations (LC50) (Abdel-Baset, 2009) [2]. The susceptibility of the successive generations was determined on the basis of LC50 values of each generation to determine resistance for 6 generations under insecticidal pressure.

Statistical analysis

To calculate values of both LC50 and LC90 from LC-p lines, Finney's method was used (Finney, 1952) [7]. Also, results of persistence of the tested insecticide at certain concentrations for the two insect pests in sand and sandy-clay were statistically analyzed according to combined ANOVA using SAS Microsoft programme (SAS, 2006) [17].

Results and discussion

Toxicity against fruit fly adults

Results illustrated in table (1) clarified the efficiency of alphacypermethrin (Super-alpha 10%EC) against *B. zonata* and *C. capitata* adults. The results indicated that mortality percentages increased with the increase of concentrations. Mortality percentages ranged between 34.592.35 in case of *B. zonata* adults and 42.55-94.8 for *C. capitata*. *Ceratitis capitata* adult flies were more susceptible to the tested insecticide than *B. zonata* adult flies. The values of sub-lethal and lethal concentrations of the used insecticide alpha-cypermethrin (Super-alpha 10%EC) differed according to the two species of the tested insects recording LC50 and LC90 values of 226.87, 1656.6 and 170.78, 1283.02 ppm for *B. zonata* and *C. capitata* adult flies, respectively. Respecting to the values of LC50 and LC90, the Mediterranean fruit fly was the most susceptible to the used insecticides. LC-p lines of the two fruit fly species were nearly equal showing values of 1.48 and 1.46 for *B. zonata* and *C. capitata*, respectively. The obtained results are in agreement with those obtained by Abou-Elfotouh (2021) [3] who found that mortality percentages for males and females of *C. capitata*, laboratory strain gradually increased with the increase of Karilot gold 5% EC concentrations. Mortality percentages for the two sexes were nearly similar; the values of LC50, LC90 and LC99, for males were 95.97, 351.03 and 1010.31 ppm, respectively. The respective values for females were 98.78, 376.98 and 1123.14 ppm. The slope values of the Ld-p lines were 2.27 and 2.20 for males and females, respectively. Wang *et al*. (2013) [20] supported the results obtained where they investigated the susceptibility of two populations of B. dorsalis to Abamectin, Deltamethrin and Malathion. Bioassay results demonstrated that the three insecticides were effective against the two populations of the tested species.

Table 1: Toxic Effect of alpha-cypermethrin (Super-alpha 10%EC) at different concentrations against *B. zonata* and *C. capitata* adults

Conc. (ppm)	% Mortality	
	B. zonata	***C. capitata***
1860	92.35	94.8
930	81.85	84.55
465	65.17	74.78
232	50.71	54.55
116	34.5	42.55
	Sub-lethal and lethal concentrations	
LC_{20}	61.48	45.24
LC_{50}	226.87	170.78
LC_{90}	1656.6	1283.02
Slope	1.48	1.46

Persistence of the insecticide

The degradation rate of alpha-cypermethrin (Super-alpha 10%EC) in two types of soil (sand and sand-clay) was trio-interval bio-assayed against the full grown larvae of the two species of fruit flies throughout 21 days (tables, 2 and 3).

Bactrocera zonata

Reduction of the toxic activity of Super-alpha 10%EC at the rates of 125, 250, 500, 1000, 2000 and 3000 ppm against *B. zonata* mature larvae in sandy and sandy-clay soils within 21 days are summarized in table (2). The mortality percentages gradually reduced with the time. The mortality percentage for 3000 ppm (in sand) recorded 97.80 at zero time that reduced to 76% after 12 days of treatment. But, the activity for 2000 ppm was 88.33% mortality at zero time which decreased to 62.2% after 9 days of application. The two highest tested concentrations still effective till 15 days after treatment in sandy soil. The lowest used concentrations (125, 250, 500 and 1000) showed low effectiveness after 15 days recording very low mortality percentages less than 20%.

On the other hand, the same toxicant showed low efficiency in sandy clay soil recording low mortality with the tested concentrations during the tested intervals. The effectiveness of the highest tested concentrations (2000 and 3000 ppm sharply reduced after 6 days of treatment to record 28.87 and 40% mortality, respectively. Mortality percentages of all used concentrations in the two types of soil texture completely collapsed after 21 days of treatment (table, 2).

Table 2: Effectiveness of alpha-cypermethrin (Super-alpha 10% EC) against full grown larvae of the peach fruit fly, *B. zonata* after different intervals of treatment in sandy and sandy clay soils expressed as total mortality percentages

Conc. (ppm)	% Mortality in sandy and sandy clay soils at indicated periods after treatment (Day)															
	Sand								Sandy clay							
	0	3	6	9	12	15	18	21	0	3	6	9	12	15	18	21
125	27.77	20.00	10.00	6.67	4.00	0	0	0	7.80	5.53	3.33	2.23	2.20	1.33	0	0
250	45.00	36.63	16.67	12.23	8.00	4.00	0	0	13.33	13.33	10.00	7.80	6.67	5.33	0	0
500	56.10	41.00	30.33	28.87	21.10	12.00	0	0	31.10	17.80	13.33	7.80	7.80	6.67	0	0
1000	67.77	55.00	46.67	45.57	30.00	16.00	0	0	33.33	24.43	20.00	16.67	13.33	6.67	0	0
2000	88.33	81.10	63.33	62.20	40.00	22.30	5.63	2.00	56.67	48.87	28.87	23.30	22.20	10.67	5.00	0
3000	97.80	85.53	83.33	78.87	76.00	43.33	21.33	7.50	65.57	62.20	40.00	31.13	31.10	13.33	7.33	1.30

Ceratitis capitata

The full grown larvae and pre-pupae of *C. capitata* were highly affected by all concentrations of the used toxicants in sandy soil than sandy-clay soil as shown in table (3). All tested concentrations of Super- alpha 10%EC showed high effectiveness in sand throughout two weeks of treatment, especially with the highest ones of 2000 and 3000 ppm which recorded high potency as % mortality in sandy soil for long periods that decreased from 97.77 to 48.87 and from 100 to 62.20 on 0- to 15-day intervals, respectively. Whereas, in case of sandy-clay soil all concentrations showed very low efficiency against *C. capitata* mature larvae throughout all trio-inspected intervals (0-21 days) with low mortality percentages, except with the highest concentrations of 2000 and 3000 ppm that recorded mortality percentages which decreased from 43.33 to 0.00 and 58.90 to 2.30 during the tested intervals, respectively.

Table 3: Effectiveness of alpha-cypermethrin (Super-alpha 10% EC) against full grown larvae of the Mediterranean fruit fly, *C. capitata* after different intervals treatment in sandy and sandy clay soils expressed as total mortality percentages

Conc. (ppm)	% Mortality in sand and mixed soils at indicated periods after treatment (Day)															
	Sand								Sandy-clay							
	0	3	6	9	12	15	18	21	0	3	6	9	12	15	18	21
125	64.43	38.90	12.33	8.90	6.67	2.23	0	0	4.00	4.00	2.23	1.10	0	0	0	0
250	71.10	47.77	30.67	30.00	26.67	13.33	2.33	0	7.80	6.67	6.67	6.67	5.33	1.33	0	0
500	91.10	77.80	62.23	46.67	34.67	31.10	15.60	3.45	11.10	10.67	9.97	7.70	6.70	2.33	0	0
1000	95.53	93.33	88.90	64.43	53.33	44.40	22.53	8.33	33.33	17.67	17.33	10.00	6.67	2.33	1.30	0
2000	97.77	97.77	91.10	76.00	55.57	48.87	34.21	12.53	43.33	36.00	24.43	21.33	17.77	8.90	3.60	0
3000	100	100	97.80	89.33	79.97	62.2	40.32	19.33	58.90	57.33	44.47	22.23	13.33	11.43	5.33	2.30

Data in tables (2 and 3) were recapitulated in tables (4, 5 and 6) which statistically proved high significantly differences in soil type, the used concentrations and treatment interval as well as the two species of fruit flies. Highly initial mortality of the two fruit flies in sandy and sandy clay soils in case of all used concentrations was recorded. The toxicity of alpha-cypermethrin showed high significantly gradual decrement with time in the two types of soils at all concentrations (table, 4). Efficiency of alpha-cypermethrin against the two fruit flies completely disappeared after about 21 days. Generally, alpha-cypermethrin was significantly more toxic to pre-pupae of both *B. zonata* and *C. capitata* in sand than in sandy-clay soil (table, 5). On other side, individuals of *C. capitata* were significantly at 1% level of probability more susceptible in sandy soil than that of *B. zonata*, but the reverse took place in case of sandy-clay soil (table, 5) . Also, the potency of the used compound as % mortality high significantly increased with the increment of concentrations (table, 6), whereas the reverse took place in case of time where the effectiveness reduced with time. In general, individuals of *C. capitata* were more significantly affected than those of *B. zonata* (F value=36.85, $P<0.0001$).

Table 4: Average of % mortality of *B. zonata* and *C. capitata* pupae at tri-term periods

Species	Average of % mortality after 3-days interval								Grand average	F value	P
	0	3	6	9	12	15	18	21			
B. zonata	49.25 a	40.89 b	30.47 c	27.00 c	21.81 d	11.81 e	3.28 f	0.92 f	23.17B	87.76 **	<0.0001
C. capitata	55.67 a	49.00 b	40.67 c	34.89 c	25.56 d	18.86 e	10.4 4f	3.97 g	29.88A	66.66 **	<0.0001
Grand average	52.46 A	44.94 B	35.57 C	30.94 D	23.68 E	15.33 F	6.86 G	2.44 H	-	129.59 **	<0.0001

Table 5: Average of % mortality of *B. zonata* and *C. capitata* pupae in two types of soil texture

Species	Average of % mortality in two types of soil textures		Grand average	F value	P
	Sand	Sandy clay			
B. zonata	31.22a	15.13b	23.17B	152.64**	<0.0001
C. capitata	47.51a	12.26b	29.88A	491.14**	<0.0001
Grand average	39.37A	13.69B	-	540.22**	<0.0001

Table 6: Average of % mortality of *B. zonata* and *C. capitata* pupae at different concentrations of alpha-cypermethrin

Species	Average of % mortality at different concentrations						Grand average	F value	P
	125	250	500	1000	2000	3000			
B. zonata	5.67f	11.19e	17.08d	23.46c	35.02b	46.63a	23.17B	92.52**	<0.0001
C. capitata	9.06f	15.25e	25.83d	35.42c	42.08b	51.65a	29.88A	69.41**	<0.0001
Grand average	7.38F	13.22E	21.46D	29.44C	38.55B	49.14A	-	134.87**	<0.0001

The behavior of pesticide in soils as potency and persistence was dependent on several complicated and overlapping factors concerning to the physico-chemical properties of compound itself as well abiotic and biotic characteristics of soil such as physical and chemical properties of soil and soil-inhabitant microorganisms. The obtained data are confirmed with those previously recorded by Mosallam (1993) [13] who bio-assayed differently-grouped pesticides against full grown larvae and pupae of *C. capitata* in three types of soil texture (sand, silt and clay) in laboratory experiments and found that the efficiency of the tested compounds differed according to the compound used, the exposed individuals and type of soil texture. The potency of the used pesticides was the highest in sand followed by silt and clay. Mulrooney *et al*. (2006) [4] conducted laboratory and field studies to determine the persistence and efficacy of termiticides (Bifenthrin (0.067%), chlorpyrifos (0.75%) and imidacloprid (0.05%) which were applied to soil beneath a monolithic concrete slab at their minimum labeled rates. Soil samples were taken from three depths (0-2.5, 2.6-7.6 and 7.7-15.2 cm) at six sampling times (0, 3, 6, 9, 12 and 48 mo). Residue analyses were conducted on the 0-2.5 and 2.6-7.5 cm depths, and bioassays were conducted using all three depths. In field studies, significant termiticide degradation occurred between sampling times. At all sampling times, the top 2.5 cm of soil contained more termiticide than the other depths. Termite mortalities in contact bioassays remained high for bifenthrin and chlorpyrifos throughout sampling period; however, mortality of termites exposed to imidacloprid-treated soil dropped after the initial sampling. Percentage of mortality in these bioassays was 15, 43, and 13for bifenthrin, chlorpyrifos, and imidacloprid, respectively. Navarro *et al*. (2007) [15] stated that the effectiveness of pesticide or its impact on the environment depended on physical and chemical properties of the pesticide, site characteristics, such as soil, geology, and vegetation, environmental conditions, crop management systems, and chemical handling practices. The results of Durović *et al*. (2009) [6] indicated that soils with different physico-chemical properties had different effects on the adsorption of most pesticides, especially at higher concentration levels. Kucharski and Sadowski (2009) [12] determined the influence of the soil type and adjuvants on the dynamics of ethofumesate degradation in two types of soil when applied at a rate of 800 g/ha, alone or mixed with adjuvant. The authors found that type of soil influenced the degradation rate of ethofumesate. Significant differences in degradation rate between soils during the first period after treatment (36 days) influenced the DT50 indicator. The addition of oil adjuvant slowed down the degradation of ethofumesate and increased the level of residue in soils. Chauhan *et al*. (2012) [5] determined the leaching behaviour of pyrethroids (bifenthrin and λ– cyhalothrin) in sandy loam soil under laboratory conditions with simulated rainfall of 300 mm. Bifenthrin was applied at 2 and 4 µg while λ - cyhalothrin was applied at 2 and 4 µg on soil columns, respectively. Maximum concentration of bifenthrin and λ - cyhalothrin was recovered from 0-5 cm depth in the soils. Results indicated low mobility of both the insecticides under saturated moisture condition. Ismail *et al*. (2013) [10], in laboratory studies determined the adsorption, desorption and mobility of cypermethrin and deltamethrin in peat and silt-clay soils and indicated that cypermethrin and deltamethrin were more easily adsorbed in peat soil. But, desorption of these insecticides was higher in silt-clay soil than in peat soil. Also, results showed that mobility of these insecticides was greater in peat soil than silt-clay soil. Akel (2014) [4] studied the activity and persistence of five chemical insecticides against *Bactrocera zonata*, and reported that the insecticides still effective in soil for 10 days in highly concentrations and the degradation time ranged between 12 to18 days. Ismail *et al*. (2015) [11] studied persistence and dissipation of deltamethrin in two types of soil (peat and silty clay) under laboratory conditions. The dissipation rate of deltamethrin was faster in silty clay soil than in peat soil at 25°C. When the temperature was increased from 25 to 35°C, the half-life of deltamethrin decreased by 32.53% in peat soil and 22.9% in silty clay soil in the presence of light. But, in the dark, the decrement in the half-life of deltamethrin was 27.9% in peat soil and 22.5% in silty clay soil. In case of increasing soil moisture content from 40 to 60%, the half-life of deltamethrin decreased by 50.7 and 19.75% in peat soil and silty clay soil, respectively. A significant degradation rate of deltamethrin was investigated in non-autoclaved soil compared to that in autoclaved soil where the half-life was reduced by 76.05% in peat soil and 59.21% in silty clay soil. Results showed that the degradation rate of deltamethrin in soil had a direct relationship with the microbial activity in the soil.

Development of resistance in the two fruit flies

Data in tables (7 and 8) showed the effect of alpha-cypermethrin (Super-alpha 10% EC) at sub-lethal and lethal concentrations (LC20, LC50 and LC90) as mortality percentages on adult progeny of both *B. zonata* and *C. capitata* of successive generations. Results indicated that mortality percentages in adults of the two species of fruit flies differently and gradually decreased with the increase of generation at all used concentrations for five subsequent generations. Data indicated that adults of *C. capitata* were more susceptible than that of *B. zonata*. The resistance of *B. zonata* fruit flies to Super-alpha 10% EC was more than that recorded with *C. capitata* flies. Results revealed statistically that, there was a correlation between the response of the different generations and selection pressure with Super-alpha 10% EC. The LC50 values increased by succession of generations irrespective of the tested toxicant. As shown in table (7) and Fig. (1), the LC50 values showed that the highest susceptibility appeared in the 1st generation of *C. capitata*, whereas the highest resistance recorded in the 5th generation at the comparable rate of concentrations. Data compiled in table (8) and illustrated in Fig. (2) indicate that different levels of tolerance and resistance to the toxicity of Super-alpha 10% EC in adults of *B. zonata* were recorded. It is evident that the LC50 values, in ppm, of the treated generations increased comparing to the base line strain.

Table 7: Development of resistance in the adults (males and females) of the Mediterranean fruit fly, *C. capitata* to the toxic action of Superalpha 10% EC

Generations	**LC50** ppm	**slope**	**Resistance ratio (Relative to parents)**
Parent	170.78	1.46	1
G1	196.72	1.46	1.15
G2	307.29	1.30	1.79
G3	364.62	0.709	2.13
G4	800.68	0.655	4.68
G5	2682.8	0.674	15.70

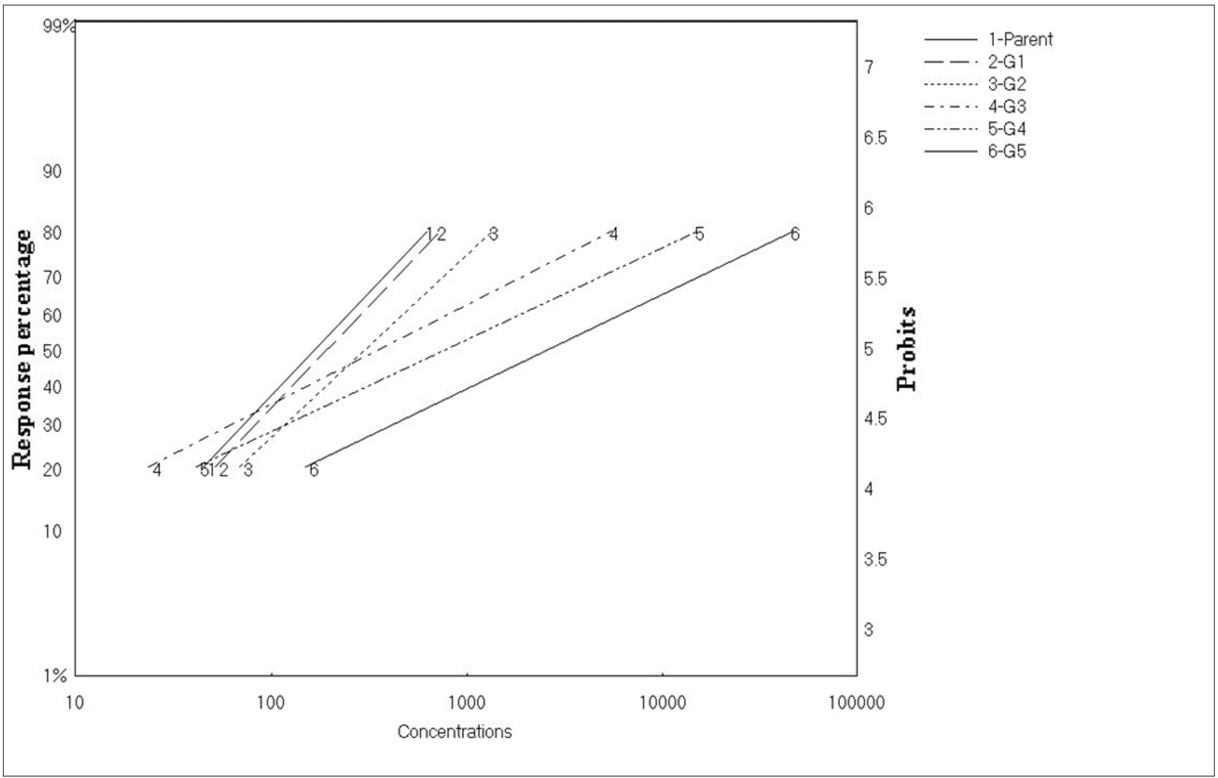

Fig 1: Toxicity regression lines of alpha-cypermethrin (Super-alpha 10% EC) developed resistance for *C. capitata* adult laboratory strain

Table 8: Development of resistance in the adults (males and females) of the peach fruit fly, *Bactrocera zonata* to the toxic action of Super-Alpha 10%EC

Generations	**LC_{50}** ppm	**slope**	**Resistance ratio (Relative to parents)**
Parent	226.87	1.48	1
G1	266.47	1.38	1.17
G2	389.22	1.03	1.71
G3	601.52	1.03	2.65
G4	1001.65	0.712	4.41
G5	3284.8	0.785	14.47

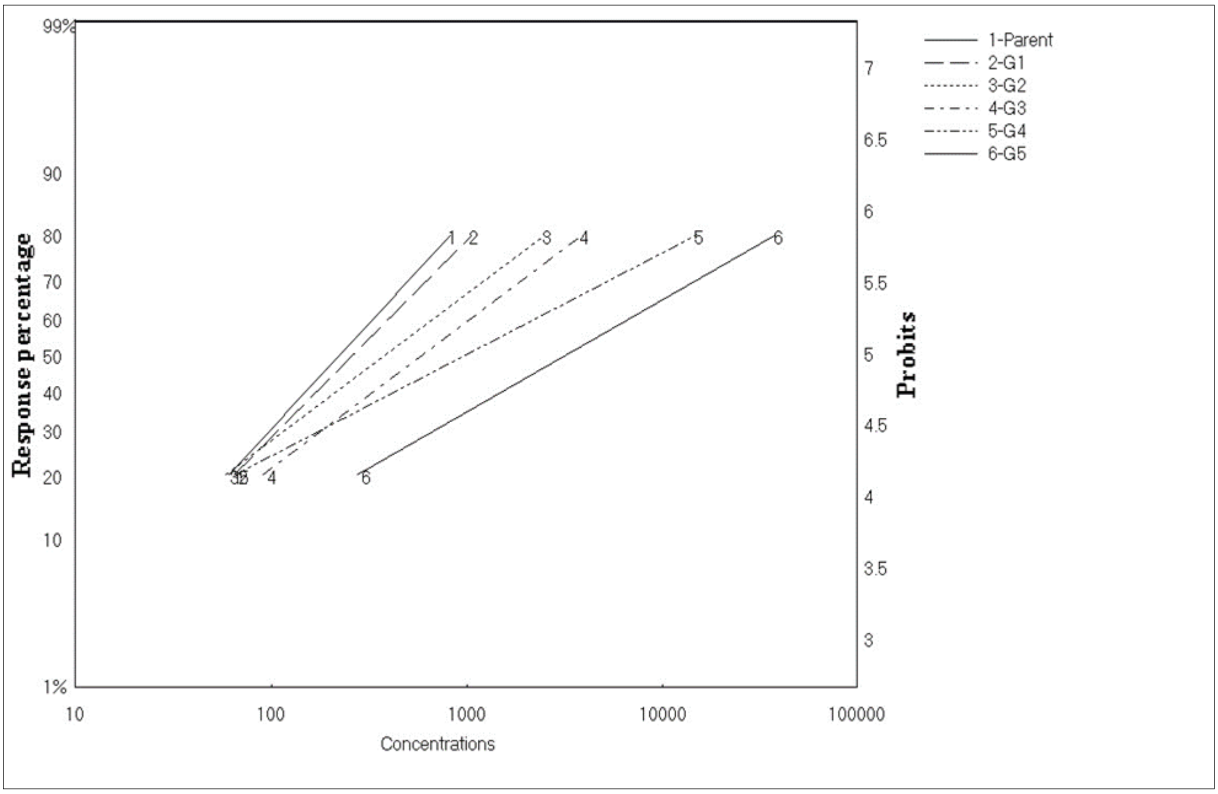

Fig 2: Toxicity regression lines of alpha-cypermethrin (Super-alpha 10%EC) developed resistance for *Bactrocera zonata* adult laboratory strain

Tolerance in the selected adults to the toxicant was noticed in the first four generations, i.e. G_1 - G_4, whereas G_5 exhibited high resistance level in the selected adults. The resistance ratios in case of *C. capitata* in the first four generations were 1.15, 1.79, 2.13 and 4.68 fold, respectively. But, the compared value for the last generation, i.e. G_5 was 15.70 fold. The resistance ratios in the first four generations of *B. zonata* were 1.17, 1.71, 2.65 and 4.41 fold, respectively. Whereas, in case of the last generation (G_5), the resistance ratio highly increased to14.47 fold.

Akel (2014) [4] supported the results obtained in this study stating that the pressure of Malathion against the flies of *B. zonata* showed an increase of 20.05 folds than the laboratory strain after six generations. Results revealed that, the LC_{50} values increased by succession of generations irrespective of the tested toxicant by using LC_{20} of Malathion as compared to the laboratory strain. Tolerance in the selected adults to the toxicant was noticed in the first four generations, i.e. G_1–G_4, whereas G_5 and G_6 exhibited resistance in the selected adults. Also, AbouElfotouh (2021) [3] confirmed the obtained results recording resistance of both males and females of *C. capitata* to lambda-cyhalothrin (Karilot gold 5% EC) that gradually increased via the consequent treatment throughout the consecutive generations. The resistance ratio of the successive generations to the first one ranged between 0.39-0.98 (for males) and 0.35-0.96 (for females). The results agreed with those published by Haider *et al*. (2011) [8] who revealed that the resistance ratio in the field strain of *B. zonata* adults collected from Multan area to Malathion toxicity exhibited 5.54 folds as compared to the laboratory strain. The results are in accordance with the findings of Abdel-Baset (2009) [2] who proved an increase in the slope or a decrease in the LC_{90}/LC_{50} ratio indicate and increase in the steepness of the toxicity line as well as an increase in the toxicity of the toxicant.

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