

EFFICACY OF SOME IGR_s FOR THE CONTROL OF PEACH FRUITFLY, *BACTROCERA ZONATA* (SAUNDERS) (DIPTERA: TEPHRITIDAE)

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Abstract

Peach fruit fly, *Bactrocera zonata* (Saunders) (Diptera: Tephritidae), has been recognized as a serious insect pest during the last decade attacking a wide range of fruits in Egypt. The potential of some insect growth regulators, Pyriproxyfen, Methoxyfenozide and Novaluron to cause fatal hormonal disorders in immature stages, full grown larvae and 1-day old pupae, of *B. zonata* in sandy soil was studied under laboratory conditions. In addition, morphogenetic activity as larval-adult and pupal-adult intermediates of *B. zonata* resulting from IGRs treatment was recorded. Results indicated that, LC₅₀ for full grown larvae were 0.96, 11.40 and 64.0 ppm in case of Pyriproxyfen, Novaluron and Methoxyfenozide, respectively. The LC₅₀ values for 1-day old pupae of *B. zonata* were 4.50 and 3200 ppm for Pyriproxyfen and Novaluron respectively, while Methoxyfenozide has no fatal effect on 1-day old pupae of *B. zonata*. On the other hand, the EC₅₀ values of full grown larvae were 1.31, 16.8 and 550 ppm for Pyriproxyfen, Methoxyfenozide and Novaluron, respectively. The EC₅₀ values for 1-day pupae were 2.80, 1450 and 5000 ppm, for the same compounds, respectively. The obtained results proved that, Pyriproxyfen is a promising candidate for the control of the peach fruit fly.

Key words: *Bactrocera zonata* - IGR – Pyriproxyfen – Novaluron – Methoxyfenozide – controlling agent.

INTRODUCTION

Fruits considered one of the most important crops in the whole world because of its nutritional and economic importance as well as for local utilization or exportation. Pest infestation of fruit trees may seriously affect its quantitative and qualitative productivity because of infestation with scale insects, mealy bugs, mites, wood borers and fruit flies. The peach fruit fly, *Bactrocera zonata* (Saund.) is considered one of the most important economic pests for several kinds of fruits in temperate, tropical and subtropical countries (Younes *et. al.*, 2009). It attacks a wide species of soft fruits, e.g. peach, apricot, guava, citrus and mango (White and Elson-Harris, 1992 and Allwood *et. al.*, 1999). Recently, in 1993 the peach fruit fly *B. zonata* was recognized in Egypt causing severe damage for several hosts.

The control measures for fruit flies adopted mainly on contact conventional insecticides which cause destructive side effects on the environment, human health, wild life and biological control agents. So, utilization of environmental-friendly compounds with minimal mammalian toxicity such as insect growth regulators (IGRs) might help to overcome problems of conventional insecticides such as resistance, residues and resurgence. IGRs interfere with insect enzymes and hormones which play important roles throughout the entire life cycle of insects such as molting, metamorphosis, yolk synthesis, dieresis, and mobilization of energy for flight (Staal, 1975).

Insect Moulting and metamorphosis are mainly controlled by two hormones, the steroid ecdysone and the sesquiterpenoid juvenile hormone (JH) (Riddiford, 1994). Ecdysone induces and coordinates molting, but the character of the molt is determined by JH. In the presence of JH, there is no change in form but in the absence of JH, the ecdysone-induced Broad (BR) transcription factors which appear at the onset of metamorphosis and have been shown to play a complex role in activation and/or suppression of genes involved in the larval-pupal transformation (Karim *et al.*, 1993, von Kalm *et al.*, 1994, Hodgetts *et al.*, 1995, Crossgrove *et al.*, 1996, Mugat *et al.*, 2000, Renault *et al.*, 2001). In pupal- adult transformation, ecdysone in the absence of JH must switch off BR so that the adult-specific program of differentiation can occur (Zhou and Riddiford, 2002).

Thus, the present work was directed to evaluate certain IGR_s with different modes of action (Pyriproxyfen, juvenile hormones analoge, Methoxyfenozone, an ecdysone agonist, and Novaluron, chitin synthesis inhibitor) as agents that might lead to fatal hormonal disorders in immature stages (prepupae and pupae) of the peach fruit fly, *B. zonata*, in sandy soil under laboratory conditions. Malformations resulted due to treatment with the tested compounds will also be studied.

MATERIALS AND METHODS

Rearing Technique

Full grown larvae and pupae of *B. zonata* used in this study were obtained from the laboratory of Plant Protection Research Institute, Dokki, Giza, reared under laboratory conditions of 25±3 °C and 60±5% R.H.

Larvae were reared on an artificial diet consisted of 500 ml water, 3 gm sodium benzoate, 3 gm citric acid, 84.50 gm sugar, 84.50 gm brewers yeast and 330 gm wheat bran. These ingredients were carefully mixed in large plastic container. Then eggs were scattered on the surface of the diet which was placed in plastic trays

of 20x 10x 8cm and tightly covered with muslin. After that, these trays were placed in a wooden cage with sand at the bottom to allow the jumping larvae to pupate (Shehata *et. al.*, 2006).

Adults of *B. zonata* were reared in a cage (100x 30x 30 cm) with wooden frames and covered from each side with metal screen. Flies were fed on sugar and fortified protein hydrolysate at ratio of 3:1, respectively. Also, water was added in a plastic bottle. The cage was supplied with plastic fruits that had many small pores (as an oviposition receptacle). These plastic fruits were filled with 3 ml water to receive and prevent drying of the eggs.

Insecticides Used

Pyriproxyfen (Admiral 10% SC, Sumitomo®), Methoxyfenozide (Runner 20% SC, Agro consult import®) and Novaluron (Depron 10% SC, Isagro SPA- Italy®).

Procedures

Three pesticides were tested against certain immature stages of *B. zonata* in sandy soil that was sieved by 1 mm sieve. One hundred gm of the sieved sandy soil were put in each plastic cup. Fifteen milliliters of each concentration of each compound diluted with tap water were added. Fifty full grown larvae (the 3rd larval instar) or 1-day old pupae were confined in each cup which containing the treated soil, then covered with muslin and tightly secured with rubber bands and left under laboratory conditions till adult emergence. Seven concentrations were used for each tested compound. Three replicates for each concentration were used. Experiments using soil and water only were also carried out as untreated check. All individuals failed to completely emerged considered dead. Also, the malformed individuals were graded and counted.

Statistical Analysis

Abbott's formula was used for comparing and correcting mortalities in the treatments (Abbott, 1925). Probit analysis was used to calculate LC₅₀, LC₉₀ values and the slope of regression lines for the tested toxicants (Finney, 1971). Sun's equation was used to calculate the toxicity index (Sun, 1950). Also, the emerged adults were inspected for detecting the pseudo-juvenilizing action of the tested compounds during larval-pupal and pupal-adult transformations, the graded scoring system was used to yield EC₅₀ values for the tested compounds (Redfern *et. al.*, 1970).

RESULTS AND DISCUSSION

A-Sub Lethal Effect of The Tested IGRs on Full Grown Larvae and 1-Day Old Pupae

The toxicity of three IGR compounds belonging to different chemical groups and mode of actions was tested against the full grown larvae and pupae (1-day old)

of *B. zonata* using sandy soil treatment at different concentrations (in ppm) for each compound.

1-Sub Lethal Effect on Full grown larvae

Data in Table (1) and Fig.(1) show the lethal effect of the three tested compounds against full grown larvae of *B. zonata*. It is clear that Pyriproxyfen had the greatest fatal effect at both LC₅₀ and LC₉₀ levels followed by Novaluron and Methoxyfenozoide, respectively. This was represented by the LC₅₀ values (0.96, 11.40 and 64.00 ppm) and LC₉₀ values (7.00, 140.00 and 5000ppm), for the three tested compounds, respectively. The toxicity index at LC₅₀, for the tested compounds compared to Pyriproxyfen (the standard toxicant = 100) were 8.40 and 1.50 for Novaluron and Methoxyfenozoide, while at LC₉₀, it was 5.00 and 0.14, for the two compounds compared with pyriproxfen, respectively. The above mentioned results reveal that Pyriproxyfen was the most effective compound against full grown larvae of the peach fruit fly when applied as soil treatment. In this respect Saul *et. al.* (1983) reported similar results, where they stated that *Ceratitis capitata* (Wied) adult emergence was completely inhibited when larvae were allowed to pupate on filter paper treated with methoprene, a juvenile hormone analogue ,and that soil treatment with methoprene in the field was effective in controlling this pest on peach. Mosallam (1993) also found that Pyriproxyfen was the most effective (LC₅₀ = 0.034ppm) among Chlorfluazuron, Fenamiphos, Fenobucarb, Fenvalerate, Imidacloprid, Oxamyl, and Pirimiphos-methyl against the full grown larvae of *Ceratitis capitata* in case of sandy soil treatment. The LC₅₀s for the tested compounds were 27.5, 0.042, 6.8, 50., 33., 2.9, and 0.036ppm, respectively.

Table 1. Sub lethal effect of tested IGR compounds against the 3rd instar larvae of *B. zonata* in sandy soil under laboratory conditions.

Compound	LC ₅₀ (ppm)	LC ₉₀ (ppm)	Slope	Toxicity index at	
				LC ₅₀	LC ₉₀
Pyriproxyfen	0.96	7.00	1.54	100	100
Novaluron	11.40	140.0	1.20	8.40	5.00
Methoxyfenozoide	64.00	5000	1.43	1.50	0.14

These results might be explained by the fact that BR proteins are first induced in the epidermis when ecdysone acts in the absence of JH to cause pupal commitment at the onset of metamorphosis, then persist during the prepupal period (Zhou *et. al.*, 1998 , Zhou and Riddiford, 2001). Application of JH analog at this time prevents the appearance of BR and the larval- adult transformation (Zhou and Riddiford, 2002).

2- Effect of tested IGRs against (1-day old) pupae of *B. zonata*

The fatal effect of the tested IGRs against 1-day old pupae of *B. zonata* in treated sandy soil is given in Table (2) and Fig. (2). With respect to LC₅₀ values, Pyriproxyfen was the most potent compound (4.50 ppm), while Methoxyfenozide was the least one recording LC₅₀ more than 3000 ppm against 1-day old pupae of *B. zonata*. According to LC₉₀ values, Pyriproxyfen also was the most effective pesticide (122.00 ppm) followed by Novaluron (6200 ppm). Regarding to the toxicity index, at LC₅₀ and LC₉₀ (Table, 2) it's clear that Novaluron was about 0.14 and 1.96% as potent as Pyriproxyfen, respectively. The 3rd compound (methoxyfenozide) had no lethal effect on pupae of peach fruit fly at high concentrations.

Table 2. Sub lethal effect of tested IGRs on 1-day old pupa of *B. zonata* in sandy soil under laboratory conditions.

Compound	LC50 (ppm)	LC90 (ppm)	Slope	Toxicity index at	
				LC50	LC90
Pyriproxyfen	4.5	122	0.95	100	100
Novaluron	3200	6200	0.95	0.14	1.96

These results are in agreement with the findings of (Saul and Seiferp, 1990) who found that toxicity was highest in early pupal stages of *Ceratitis capitata* when treated with the insect growth regulator, methoprene. Mosallam (1993) stated that Pyriproxyfen was the most efficient compound when he tested the efficiency of Chlorfluazuron, Fenamiphos, Fenobucarb, Fenvalerate, Imidacloprid, Oxamyl, and Pirimiphos-methyl against 1- old day pupae of *Ceratitis capitata* recording LC₅₀ and LC₉₀ values of 0.137 and 1.900 ppm.

B- Morphogenetic Activity of Pyriproxyfen, Novaluron and Methoxyfenozide on Full Grown Larvae and 1-Day Old Pupae of *B.zonata*.

Sandy soil was treated with the tested IGRs at different concentrations. Full grown larvae or 1- day old pupae were introduced to the above mentioned treated soils. The malformed individuals were recorded and scored according to the graduated scoring system (Tables, 3 & 4 and Plates A- N).

Data presented in Table 5 and Figs. 3&4 show that Pyriproxyfen exhibited the highest effect on full grown larvae followed descendingly by Novaluron and Methoxyfenozide. The EC₅₀ values of the tested compounds in treated sandy soil were 1.31, 16.80 and 550 ppm, respectively. On the other hand, EC₅₀ values of IGRs tested compounds against 1-day old pupae were 2.80, 1450 and >5000 ppm, respectively.

Table 3. Scoring of larval-adult transformations of *B. zonata* after sandy soil application of the tested IGRs to full grown larvae.

Scores	Characteristics	Pyriproxyfen	Novaluron	Methoxyfenozide
0	Adults seemed to be normal	+	+	+
1	Adults with wings slightly curled	+	-	-
2	Adults wingless	+	+	+
3	Adults severely curled	+	-	-
4	Adults attached with puparium	+	+	+
5	Partial emergence(head and thorax)	+	+	+
6	Partial emergence with head only	+	+	+
7	Posterierly partial emergence (End only)	+	+	+
8	dead pupa	+	+	+
9	Larval pupal intermediate	+	+	-
10	Dead larvae	+	+	+

Table 4. Scoring of pupal-adult transformations of *B. zonata* after treatment with Pyriproxyfen, Novaluron and Methoxyfenozide to 1-day old pupae.

Scores	Characteristics	Pyriproxyfen	Novaluron	Methoxyfenozide
0	Adults seemed to be normal	+	+	+
1	Adults with wings slightly curled	-	-	+
2	Adults wingless	+	-	+
3	Adults severely curled	+	-	-
4	Adults attached with puparium	+	+	+
5	Partial emergence(head and thorax)	+	+	+
6	Partial emergence with head only	+	+	+
7	Posterierly partial emergence (End only)	+	+	+
8	dead pupa	+	+	+

Table 5. EC₅₀s values of Pyriproxyfen, Novaluron and Methoxyfenozoide against full grown larvae and 1-day old pupa of *B. zonata*.

Compound	EC ₅₀	
	Full grown larvae	Pupae
Pyriproxyfen	1.31	2.80
Novaluron	16.80	1450
Methoxyfenozoide	550	>5000

These results are agree with those obtained by Mosallam. (1993) studied the morphogenetic activity of Pyriproxyfen against *Ceratitis capitata* when applied as soil treatment and found that Pyriproxyfen had a pseudo-juvenilizing action. Also, Khalil *et. al.* (2010). stated that Pyriproxyfen induced high percentage of abnormalities in the adult flies of housefly *Musca domestica* (small size body and curved legs, crumbled wings and curved abdomen). Larval-pupal and pupal-adult intermediates were recorded.

JH was reported to disrupt metamorphosis of the nervous and muscular systems of *Drosophila melanogaster* when applied during the pre-pupal period (Restifo and Wilson, 1998).

Also the other authors stated that JH analogs prevent normal adult development of the abdominal integument when given at pupation (Riddiford, 1993 and Zhou and Riddiford, 2002). In addition, Zhou and Riddiford, 2002 stated that JH mimic causes re-expression of mRNAs for BR and a pupal cuticle protein Edg78E and suppression of mRNA for the adult cuticle protein Acp65A in the *Drosophila* abdomen during adult development.

In conclusion, the obtained results indicate that Pyriproxyfen achieved the highest activity against immature stages of peach fruit fly followed by Novaluron and Methoxyfenozoide. Thus, it's recommended the application of Pyriproxyfen as a promising candidate in soil treatment to control full grown larvae, pupae, and emerging adults of *B. zonata* to prevent further spread.

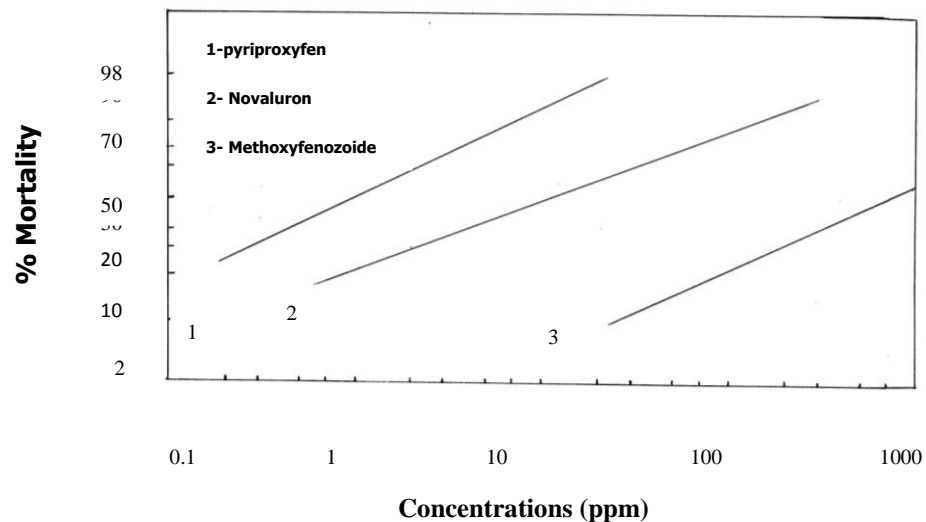


Fig. 1. Ld-p lines of tested igrs applied in sandy soil against the full grown larvae of *B.zonata*.

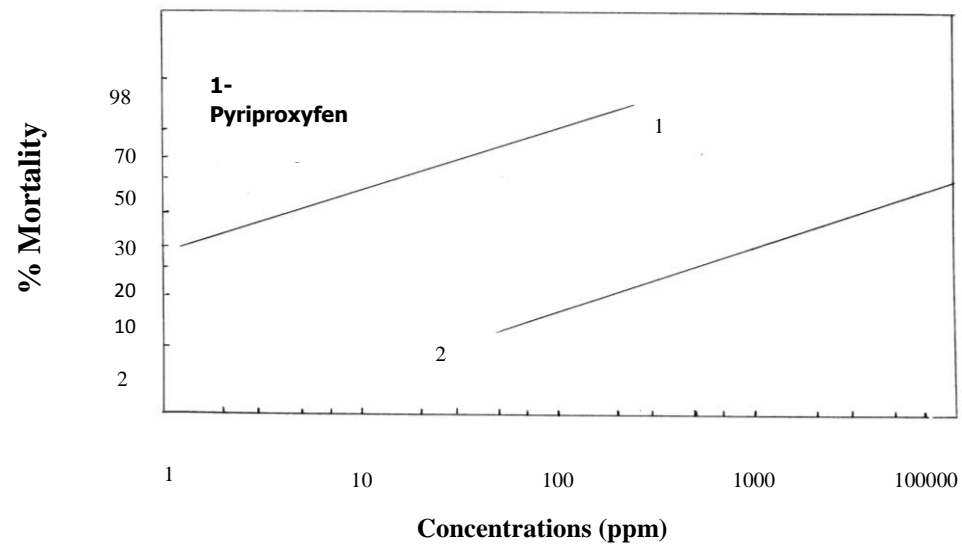


Fig. 2. Ld-p lines of tested igrs applied in sandy soil against the 1-day- old pupae of *B.zonata*.

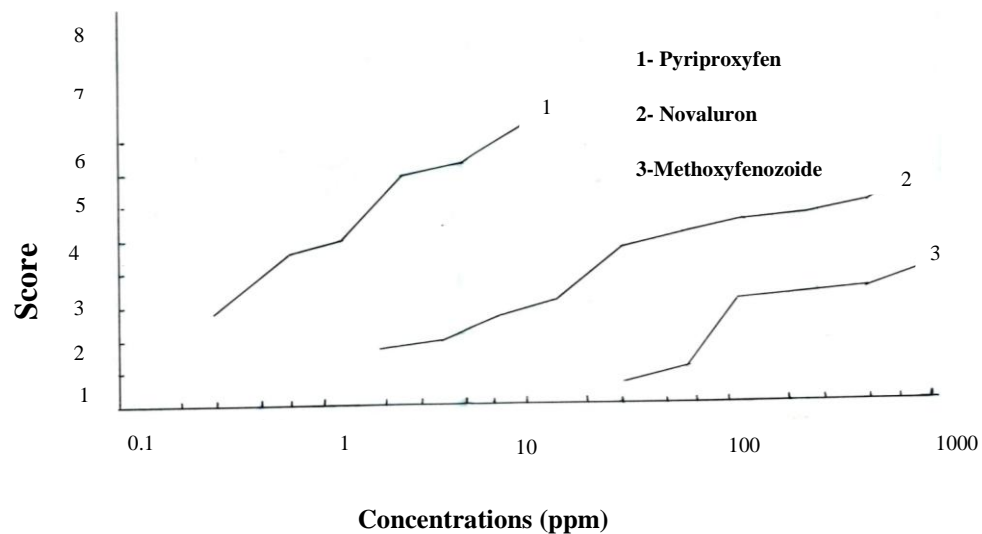


Fig. 3. Morphogenetic action of tested igrs applied in sandy soil against full grown larvae of *B.zonata*.

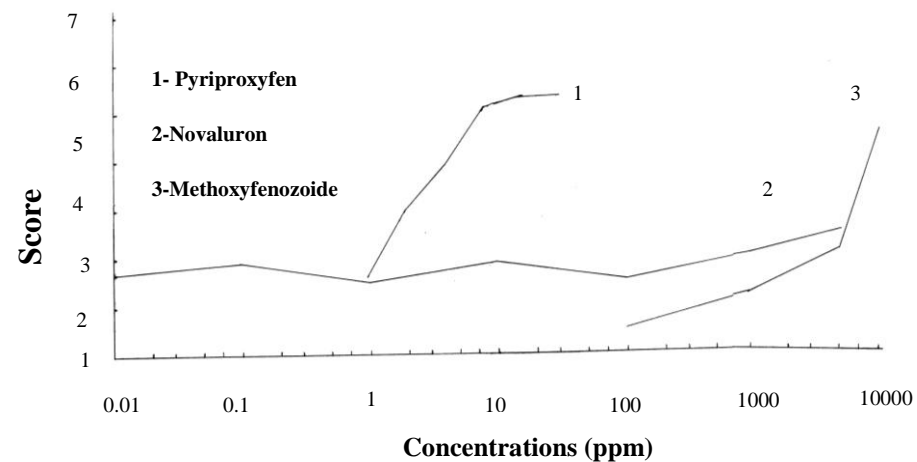


Fig. 4. Morphogenetic action of used igrs in treated sandy soil against 1-day-old pupae of *B.zonata*

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كفلة بعض منظمات النمو الحشرية لمكافحة ذبابة ثمار الخوخ باكتروسييرا زوناتا- ديبترا- تفرتيدي

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تعتبر ذبابة الخوخ من أكثر الآفات اضراراً بمحاصيل الفاكهة في كثير من بلدان العالم منها جمهورية مصر العربية حيث تصيب العديد من العوائل من أشجار الفاكهة. وقد اختبرت فعالية بعض منظمات النمو الحشرية.

(Novaluron ، Pyriproxyfen, Methoxyfenozide) ضد العمر اليرقي الأخير وعذارى عمر اليوم الواحد في التربة الرملية وذلك بإضافة تركيزات مختلفة من المركبات المختبرة ووضع الأعمار المختبرة بها وذلك تحت ظروف المعمل. وقد تم تسجيل التركيز النصفى المميت لكل من الأطوار المختبرة كما سجلت التشوهات المورفولوجية الموجودة في الحشرات الناتجة من المعاملة

وقد أثبتت الدراسة أن مركب البيروبروكسفين كان أكثر المركبات فعالية حيث كانت قيم التركيز المميت للنصف لها 0.96 جزء في المليون للعمر اليرقي الأخير و4.50 جزء في المليون لعذارى عمر اليوم الواحد.

كما أثبتت الدراسة أيضاً أن جميع المركبات المختبرة لها فعالية علي التغيرات المورفولوجية ليرقات العمر الثالث وعذارى عمر اليوم الواحد لذبابة الخوخ وكانت أكثرهم فعالية هو مركب البيروبروكسفين حيث كانت قيم التركيز المؤثر لليرقات والعذارى هو 1.31 و2.8 جزء في المليون علي الترتيب.

وتوصي الدراسة بإمكانية إضافة مركب البيروبروكسفين كمركب واعد في

برامج مكافحة ذبابة الخوخ.