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Ovicidal efficacy of some common insecticides against the pink bollworm, *Pectinophora gossypiella* (Saunders)

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Ovicidal activity of five insecticides belong to different groups (clothianidin, fipronil, imidacloprid, pyriproxyfen and etofenprox) was evaluated under laboratory conditions against the pink bollworm, *Pectinophora gossypiella* eggs at different ages (one, two and four days old). The obtained results showed that the percentages of hatchability were decreased greatly by fipronil and pyriproxyfen in all applications than other tested insecticides. The percentages of hatchability in both fipronil and pyriproxyfen were 11.7 and 12.0%, 19.7 and 14.0%, 17.9 and 11.3% with one, two and four days old, respectively. The lowest percentage of hatchability was occurred by clothianidin (70.6, 78.0 and 79 %, respectively). The efficacy of these insecticides on some biological aspects also was studied. The obtained results showed all biological aspects (Eggs incubation period, larval duration, pupal period, adult longevity, fecundity and hatchability) were affected by fipronil and pyriproxyfen compared with other treatments. The results also showed that although fipronil was not belong to the developmental insecticide, it has a great effect on biological aspects.

Keywords: The pink bollworm, ovicide efficacy, clothianidin, fipronil, imidacloprid, pyriproxyfen and etofenprox

INTRODUCTION

The pink bollworm, *Pectinophora gossypiella* (Saunders) is the most destructive insects on cotton in Egypt (El-Aswad and Aly 2007). Many and many insecticides from all insecticides group were used against these insect (Sabry, 2013). This insect was acquired resistance to many insecticides groups (Sabry and Abdel-Aziz, 2013). It was known that this insect laid the egg under the bracteoles at the base of the boll, particularly on bolls up to 14 days old, so the newly hatched larvae can penetrate flowers or bolls within 20–30min (Hutchison et al., 1988). Hence, control of eggs hatching was the most effective control against pink bollworm infestation.

Clothianidin is a new systemic insecticide used against many insect pests. In the USA, clothianidin was used on 146 agricultural crops, and between 2009 and 2011 was treated to about 46 million acres (18.6 million ha) of corn, *Zea mays* (Brassard, 2012)

Fipronil is very effective when used at low field application rates against insects that are resistant to pyrethroids, organophosphates and carbamate insecticides (Bobe et al., 1997). This insecticide features of a selectivity toward the target insects by binding with the GABA-regulated chloride channels of insects than the mammalian GABA receptors (Hainzl and Casida, 1996)

Imidacloprid is a potent systemic insecticide against sucking insects and bollworm (Karabhantanal et al., 2007). Some researcher used the imidacloprid as a seed dressing (7g / Kg seed) to protect the cotton seedling from the sucking insects and bollworm (Simon-Delso et al., 2015). This phenomenon may be protecting the non-target insects such as the honey bee and natural enemies.

Pyriproxyfen is a developmental insecticide used against the immature insects stages. Harburguer et al., (2014) found that pyriproxyfen was effective on fertility and fecundity of *Aedes aegypti* females. Oouchi (2005) recorded that pyriproxyfen has an embryotoxic against the tomato leaf miner eggs.

Etofenprox is a pyrethroid ether insecticide and has a same mode of action of pyrethroid ester group. This insects was effective against many pests such as sucking pests, plant hopper, leafhopper, aphid and thrips tomato crop, fruit trees, cotton, and rice (Cao et al., 2010)

The aim of this work to assessment some insecticides as ovicide against different ages of pink bollworm eggs, and also clear of the effect of these insecticides on some biological aspects such as egg incubation, larval duration, pupal period, adult longevity, number of laid eggs per female and hatchability.

MATERIALS AND METHODS

Tested insects

The pink bollworm eggs were obtained from the bollworms department, Plant Protection Research Institute, Agriculture Research centre, Giza, Egypt. Different ages were used; one day old, two days old and four days old.

Tested insecticides

1- Clothianidin (Trade name is Supertox 48% SC) produced by Jiangsu Flag Chemicals Indus., China. This insecticide belongs to the neonicotinoids insecticide group. Clothianidin acts on the central nervous system of insects as an agonist of acetylcholine, the neurotransmitter that stimulates nAChR, targeting the same receptor site (AChR) and activating post-synaptic acetylcholine receptors but not inhibiting AChE.

2- Fipronil (Trade name is Orbit 20% SC) produced by Sharda worldwide India. This insecticide belongs to phenylpyrazole group. This insecticide acts by disrupting the insect central nervous system through blocking of the GABA-gated chloride channels and glutamate-gated chloride (GluCl) channels.

3- Imidacloprid (Trade name is Commando 35% SC) produced by Vapco Company Jordan. This insecticide also belongs to neonicotinoids group. This insecticide acts on the central nervous system of insects, with much lower toxicity to mammals. The chemical works by interfering with the transmission of stimuli in the insect nervous system. Specifically, it causes a blockage of the nicotinergic neuronal pathway. By blocking nicotinic acetylcholine receptors, imidacloprid prevents acetylcholine from transmitting impulses between nerves, resulting in the insect's paralysis and eventual death.

4- Pyriproxyfen (Trade name is Admiral 10% SC) produced by Sumitomo Chemical, Japan. This product belongs to juvenoids group. It prevents larvae from developing into adulthood and thus rendering them unable to reproduce (Szabo2016).

5- Etofenprox (Trade name is Primo 10% SC) produced by Shanxi Lvhai Agrochemicals, China. This insecticide belongs to pyrethroid ether group. This insecticide acts on the membrane of nerve cells blocking the closure of the ion gates of the sodium channel during re-polarization. This strongly disrupts the transmission of nervous impulses, causing spontaneous depolarization of the membranes or repetitive discharges.

Bioassay

Ovicide effect of the tested insecticides against pink bollworm

Stock solution of recommended field rate for all tested insecticides was prepared. All treatments have three replicates. Three different eggs ages were treated; one day old, two days old and four days old. Deeping test was used for all applications. Other three replicated were treated with water only as a control. All treatment eggs were put in incubation (26± 1 C° and 70%± 5 RH). All treated eggs were inspected after two, three, four and five days of treatments. The percentages of hatchability were calculated in each treatment.

Effect of the tested insecticides on some biological aspects

The newly hatched larvae which survived from all treatments were used in biological aspects test. The incubation period for eggs was calculated. The larval duration for survived larvae was calculated by the rearing of larvae on semi artificial diet described by (Rashad and Amar, 1985). This diet consists of dray kidney beans (860 g), Agar Agar (64 g), dray active yeast (128 g), ascorbic acid (10 g), sorbic acid (5 g) and formaldehyde (15 ml). The larvae were fed on semi artificial put in glass tube (3 x 7 cm) covered by cotton piece. The pupal stage for all treatment also was counted. The obtained adults were put in glass cages covered by muslin and fed on sugar solution. The adult longevity, number of laid eggs per female and hatchability were determined.

Statistical analysis

Data were analyzed by analysis of variance (one ways classification ANOVA) followed by a least significant difference, L.S.D at 5% (Costat Statistical Software, 1990).

RESULTSAND DISCUSSION

Ovicidal effect of the tested insecticides against one day old eggs

Data in Table (1) show that the percentages of hatchability were 70.6, 11.7, 54.2, 12.0, 44.1 and 89.7% for clothianidin, fipronil, imidachloprid, pyriproxyfen, etofenprox and control, respectively. This result shows that fipronil and pyriproxyfen have the most effective insecticides as ovicide against the pink bollworm eggs. Clothianidin is the least effective as an ovicide.

Ovicidal effect of the tested insecticides against two days old eggs

When the two days old eggs were treated, both fipronil and pyriproxyfen treatments have most Ovicidal effects and no significant differences among other treatments (Table 1). The results show that no significant difference between control and clothianidin, imidacloprid and etofenprox.

Ovicidal effect of the tested insecticides against four days old eggs

Ovicidal efficacy when the four days old eggs treated was increased with the pyriproxyfen. The percentages of hatchability are decreased to 11.3%. The statistical analysis shows that the pyriproxyfen has the most Ovicidal effect followed by fipronil (17.9%), etofenprox (44.4%), imidachloprid (52.8%) and clothianidin (79.9%). These results were agreed with Sun et al. (2017). The author found that pyriproxyfen has an excellent ovicidal effect against *Helicoverpa armigera* eggs at a concentration of 600 g/ml. Tom´e et al., (2014) found that pyriproxyfen has an embryotoxic and ovicide effects against the tomato leaf miner.

Mahmoudvand et al., (2011) found that fipronil has an ovicidal effect against diamondback moth, *Plutella xylostella* eggs at concentration of 1000 mg/l. Aghabaglou et al., (2013) found that imidachloprid has a moderate ovicidal effect against *Cryptolaemus montrouzieri* eggs. Peter and David (1996) found that etofenprox decreases the percent of hatchability for *Spodoptera litura*to 62.5%.

The latent effect of the tested insecticides on one day old eggs

The newly hatched larvae which survived from the one day old eggs treatment were tested in the effect of tested insecticides on some biological aspects (Table 2). The obtained data show that there is no effect of the tested insecticides on eggs incubation period. The statistical analysis shows that there is no significant difference. Data also both fipronil and pyriproxyfen treatments have significant effects on the larval duration. The larval duration increases to 25.3 and 26.7 days in fipronil and pyriproxyfen, respectively, compared with 19.3 days in control. The pupal period and adult longevity also are affected by pyriproxyfen treatment. The pupal period and adult longevity are increased to 16.3 and 21.7 days, respectively, compared with 10.7 and 15.3 days in control. On the other hand, the percentages of laid eggs per female and hatchability are deceased in fipronil and pyriproxyfen treatments compared with other tested insecticides and control.

The number of laid eggs per female is decreased to 156.0 and 143.3, respectively, compared with 197 egg/ female in control. The corresponding results with hatchability are 61.3 and 56.0%, respectively, compared with 82.0% in control.

The latent effect of the tested insecticides on two days old eggs

Data in Table (3) show that the incubation period in pyriproxyfen treatment is increased to 8.0 days compared with 6.0 day in control. There are no significant differences between other treatments and control except clothianidin. The incubation period is decreased in clothianidin treatment compared with control. The incubation period is 5.3 days compared with 6.3 days in control. The larval duration is decreased in both clothianidin (18.3) and imidacloprid (19.0) compared with control (19.7 days). On the other hand, the maximum larval duration is found in pyriproxyfen treatment (24.3 days)

Table 1. Percentages of the pink bollworm eggs hatchability treated by the tested insecticides during different ages

Insecticides	Percentages of hatchability		
	One –day old	Two -days old	Four – days old
Clothianidin	70.6±3.4[b]	78.0 ± 5.6[a]	79.9±2.7[b]
Fipronil	11.7±2.9[e]	19.7± 1.5[b]	17.9±2.1[e]
Imidacloprid	54.2±3.6[c]	77.0 ± 3.0[a]	52.8±17[c]
Pyriproxyfen	12.0±2.6[e]	14.0± 3.6[b]	11.3±1.7[f]
Etofenprox	44.1±6.1[d]	77.0 ± 6.0[a]	44.4±3.1[d]
Control	89.7±0.6[a]	86.3± 3.2[a]	89.0±1.7[a]
F- values	230.9***	188.65***	458.4***
LSD	6.36	7.32	4.50

*Means under each variety sharing the same letter in a column are not significantly different at P<0.05

Table 2. Effect of the tested insecticides on some biological aspects of the pink bollworm, *P. gossypiella* (one day old eggs treated)

Insecticides	Eggs incubation period	Larval duration	Pupal period	Adult longevity	No. laid eggs/female	Hatchability
Clothianidin	5.7± 0.6[a]	21.0 ± 1.0[b]	10.3± 0.6[c]	15.3 ± 0.6[c]	194.0±7.5[a]	80.7±3.8[a]
Fipronil	7.3± 1.2[a]	25.3 ± 0.6[a]	15.3 ± 0.6[b]	20.3 ± 0.6[b]	156.0±8.9[b]	61.3±3.5[b]
Imidacloprid	6.0 ± 1.0[a]	20.7 ± 1.5[b]	10.3 ± 0.6[c]	15.7 ± 0.6[c]	188.7±10.5[a]	81.3±6.8[a]
Pyriproxyfen	7.3 ± 0.6[a]	26.7 ± 0.6[a]	16.3 ± 0.6[a]	21.7 ± 0.6[a]	143.3±4.1[b]	56.0±6.2[b]
Etofenprox	6.0 ± 0.0[a]	21.3 ± 0.6[b]	11.0 ± 0.0[c]	15.7 ± 0.6[c]	185.7±7.6[a]	78.7±2.1[a]
Control	6.3 ± 0.6[a]	19.3 ± 1.2[b]	10.7 ± 0.6[c]	15.3 ± 0.6[c]	197.0±13.1[a]	82.0±3.0[a]
F- values	2.8[ns]	26.9***	81.1***	74.4***	18.1***	19.1***
LSD	1.3	1.7	0.9	1.1	16.1	8.1

*Means under each variety sharing the same letter in a column are not significantly different at P<0.05

Table 3. Effect of the tested insecticides on some biological aspects of the pink bollworm, *P. gossypiella* (two days old eggs treated)

Insecticides	Eggs incubation period	Larval duration	Pupal period	Adult longevity	No. laid eggs/female	Hatchability %
Clothianidin	5.3± 0.6[c]	18.3± 1.5[c]	11.3±0.6[b]	15.7 ± 1.5[b]	181.3±11.1[a]	74.0±2.6[a]
Fipronil	7.3 ± 0.6[ab]	22.3 ± 1.5[ab]	15.0 ± 1.0[a]	21.0 ± 0.0[a]	137.0± 15.9[b]	61.3±5.6[b]
Imidacloprid	5.7 ± 0.6[bc]	19.0 ± 1.0[c]	11.7 ± 1.5[b]	15.7 ± 1.5[b]	182.3 ± 16.4[a]	74.7±1.5[a]
Pyriproxyfen	8.3 ± 0.6[a]	24.3 ± 1.2[a]	16.7 ± 1.2[a]	21.7 ± 1.5[a]	134.7 ± 8.1[b]	58.0±3.0[b]
Etofenprox	6.3 ± 1.2[bc]	20.7 ± 1.1[bc]	12.0 ± 1.7[b]	15.7 ± 0.6[b]	186.3 ± 11.6[a]	73.3±4.1[a]
Control	6.3 ± 0.6[bc]	19.7 ± 1.5[bc]	11.0 ± 1.0[b]	16.0 ± 0.0[b]	200.7 ± 17.7[a]	79.0±2.6[a]
F- values	7.4**	8.6**	11.8***	16.2***	11.9***	13.3***
LSD	1.3	2.4	2.2	2.2	24.7	7.7

*Means under each variety sharing the same letter in a column are not significantly different at P<0.05

Table 4. Effect of the tested insecticides on some biological aspects of the pink bollworm, *P. gossypiella* (four days old eggs treated)

Insecticides	Eggs Incubation period	Larval duration	Pupal period	Adult longevity	No. laid eggs/female	Hatchability %
Clothianidin	5.7± 0.6^{b}	18.7± 1.2^{b}	11.3±1.2^{b}	15.0 ± 0.0^{b}	188.7±10.5^{a}	79.7± 2.1^{a}
Fipronil	7.0 ± 1.0^{ab}	23.7 ± 1.2^{a}	15.0 ± 1.0^{a}	21.0 ± 1.7^{a}	145.7± 9.5^{b}	59.7± 4.1^{b}
Imidacloprid	5.7 ± 0.6^{b}	19.0 ± 1.0^{b}	11.7 ± 0.6^{b}	15.7 ± 0.6^{b}	188.3 ±10.1^{a}	79.0± 2.0^{a}
Pyriproxyfen	8.0 ± 1.0^{a}	24.7 ± 1.2^{a}	16.3 ± 1.2^{a}	22.3 ± 0.6^{a}	138.7 ± 18.1^{b}	48.7±3.5^{c}
Etofenprox	6.0 ± 0.0^{b}	20.3 ± 2.1^{b}	11.0 ± 0.0^{b}	15.7 ± 0.6^{b}	183.0 ± 5.3^{a}	78.7±2.1^{a}
Control	6.0 ± 0.0^{b}	19.3 ± 1.5^{b}	11.7 ± 0.6^{b}	15.7 ± 0.6^{b}	195.3 ± 6.7^{a}	79.7 ±1.2^{a}
F- values	5.8***	10.2***	21.0***	43.1***	15.4***	75.9***
LSD	1.2	2.5	1.5	1.5	19.3	4.7

*Means under each variety sharing the same letter in a column are not significantly different at P<0.05

The obtained data show also, the pupal period is increased in both fipronil (15.0) and pyriproxyfen (16.7days) compared with control (11.0 days). Statistical analysis shows that no significant difference among other treatments. The same results are found in adult longevity, number of laid eggs per female and hatchability. Both fipronil and pyriproxyfen have distinct effect of adult longevity, number of laid eggs per female and hatchability. The adult longevity is increased to 21.0 and 21.7 days, respectively, compared with 16.0 days in control. The number of laid eggs per female is decreased to 137.0 and 134.7, respectively, compared with 200.7 eggs/ female in control. Hatchability is decreased to 61.3 and 58.0, respectively, compared with 79.0% in control.

The latent effect of the tested insecticides on four days old eggs

When four days old eggs treated by the tested insecticides the eggs incubation period are affected only by pyriproxyfen. The incubation period increases to 8.0 days in pyriproxyfen treatment compared with 6.0 days in control. No significant differences among all other treatments are observed. The larval duration increases to 23.7 and 24.7 days in both fipronil and pyriproxyfen treatments, respectively, compared with 19.3 days in control (Table 4). The same results are found in pupal period. The pupal period is affected in both fipronil and pyriproxyfen treatments compared other treatments. The pupal periods are increased to 15.0 and 16.3 days in fipronil and pyriproxyfen treatments, respectively, compared with 11.7 days in control. This result is found also in adult longevity. The numbers of eggs per female are decreased in both fipronil and pyriproxyfen treatments to 145.7 and 138.7 eggs/female, respectively, compared with 195.3 eggs /female in control. The percentage of hatchability is decreased in pyriproxyfen treatment to 48.7% compared with 79.9% in control. These results were agreed with Basley and Goulson (2017). The authors found that there were no latent effects for clothianidin on earthworm, *Lumbricus terrestris*. On the other hand, Xianxian et al., (2014) found that clothianidin was prolonged both the larval and pupal periods. Ghorbani et al., (2016) found that the adult longevity and progeny production of *Trichogramma brassicae* were affected by fipronil in comparison to the control. Fipronil also was decreased the fecundity of brown plant hopper, *Nilaparvata lugens* (Ling et al., 2006).

Effect of imidacloprid on one day old of third instars of *Harmonia axyridis* also studied by Vincent et al., (2000). The authors found that the larval duration not affected by imidacloprid treatment. The number of eggs laid per female were decreased in *Aedes albopictus* treated by pyriproxyfen (Ohba et al., 2013). The hatchability also decreased significantly. DeLorenzo and De Leon (2010) found that etofenprox caused increasing of eggs incubation in grass shrimp, *Palaemonetes pugio*.

CONCLUSION

Finally, these results cleared that both fipronil and pyriproxyfen have good effects on all biological aspects of the pink bollworm. The efficacy of these insecticides were clearly with one and four day old than two day old. This may be due to the chorion of eggs were delicate after laid and before hatching, so these insecticides can be penetrated the eggs easily. Clothianidin was the lowest effective against the pink bollworm. Although fipronil was known as disrupting the insect central nervous system through blocking of the GABA-gated chloride channels and glutamate-gated chloride (GluCl) channels, the results showed that it has a good effective on developmental processes in these insects. This work recommended that the use of fipronil and pyriproxyfen have very good results against the pink bollworm.

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CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

Al-kazafy H. Sabry, put the scientific idea, participate in laboratory experiment, statistical analysis and write the paper. Mostafa A. Shalaby, participate in laboratory experiment, statistical analysis and write the paper. Ayman M. Adly, rearing insects and participate in laboratory experiment, Atef Abdel-Rahman, participate in laboratory experiment and biological aspects.

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