Effect of Magnetic Field on the Toxicity of Triflumuron and Teflubenzuron Pesticides with Special Reference to Some Biological and Histological Parameters of Cotton Bollworm, *Earias insulana*

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Abstract

El-Shennawy, R.M. 2024. Effect of Magnetic Field on The Toxicity of Triflumuron and Teflubenzuron Pesticides with Special Reference to Some Biological and Histological Parameters of Cotton Bollworm, *Earias insulana*. Arab Journal of Plant Protection, 42(3): 387-395. https://doi.org/10.22268/AJPP-001249

This study aimed to evaluate the impact of magnetic field (MF) on the toxicity of two experimental insect growth regulators (IGRs) pesticides Triflumuron (Cancoun 40% SC) and Teflubenzuron (Nomolt 15% SC) against the spiny bollworm; *E. insulana* larvae under laboratory-controlled conditions (26±1°C and 75±5 % RH), and their implications on different biological and histological parameters. The results obtained showed an increase in the toxicity of pesticides after exposure to magnetic field strength of 180 mT for one hour. The LC_{50} values were 45.22 and 66.45 ppm for Cancun and Nomult, respectively, as compared to 35.54 and 49.56 ppm, respectively, after exposure to the magnetic field. A high mortality rate and malformation were observed for each of the larvae and pupae after pesticides magnetization, compared to the non-magnetized insecticides, as well as the untreated larvae. The lifespan of both larvae and pupae was significantly prolonged, and thus the total period of immature stages after magnetization was increased. In addition, the treatments caused a decrease in the rates of adult emergence, female fertility, and hatching rate, and with greater efficiency of the magnetized pesticides. Different histological changes were also observed in the epidermis and midgut of the larvae under study, where the treatments caused significant destruction in the epidermal and midgut cells of the treated larvae, with a more pronounced effect of the magnetized insecticide compared to the non-magnetized and the control check.

Keywords: Spiny bollworm, magnetic field, toxicity, triflumuron, teflubenzuron.

Introduction

The spiny bollworm (SBW), *Earias insulana* (Lepidoptera: Nolidae) is one of the most dangerous pests attacking many crops of Malvaceae and a few species of Tiliaceae families. It causes yield loss in cotton bolls up to 50%, in both quality and quantity of cotton bolls (Dhawan, 1998; Amin and Gergis, 2006). Insect growth regulators especially chitin synthesis inhibitors (CSI) have received wide consideration in insect pest control as they interfere with chitin biosynthesis (El-Naggar, 2013). Such compounds tend to be selective and usually less toxic to non-target organisms with less environmental hazards than conventional insecticides (Biddinger & Hull, 1995). The benzoyl-urea group of chitin synthesis inhibitors, such as Triflumuron and/or Teflubenzuron is efficient against the immature stages of lepidopterous insects that undergo complete metamorphosis, with relatively slow but effective action (Sammour *et al.*, 2008). Electromagnetic energy is one of nature's fundamental forces, and it has plenty of important applications in today's world. Certain species including some insects are particularly sensitive to magnetic fields which can be considered a promising physical method in pest control (Hussein *et al.*, 2014). Several studies referred to the impact of EMF exposure on different biological aspects of diverse insects such as: *Rhyzoperta dominica* (F.) (Starick *et al.*, 2005), *Ephestia kuehniella* (Pandir *et al.*, 2013), *Pectinophora gossypiella and Eries insulana* (El-Shennawy *et al.*, 2019). Changes and alterations in insects' biology, behavior, and metabolism as a result of MFs exposure were reported earlier (El-Shennawy *et al.*, 2019; Said *et al.*, 2017). The aim of this work is to study the effect of two IGR compounds before and after magnetic field exposure on treating spiny bollworm 1st instar larvae with a special focus on some biological and histological characteristics of the treated larvae as well as the following stages, compared to the untreated control.

Materials and Methods

Laboratory experiments were applied in the Bollworms Research Department, Plant Protection Institute, Agriculture Research Center, Ministry of Agriculture, Giza, Egypt.

Insect rearing

The first larval instars of spiny bollworm *E. insulana* (SPW) laboratory strain were reared at the Bollworms Research Department, Plant Protection Research Institute, for several generations away from any insecticides' contamination, under constant conditions of 26±1°C and 75±5 % RH, on an artificial diet described by Amer (2015).

Tested Compounds

Triflumuron: Cancoun 40% SC, (120 cm^3/200 L), produced by Chemical Industry Stock Co., Ltd., China, and Teflubenzuron: Nomolt 15% SC, (50 cm^3/100 L), produced by BASF Crop Protection Company, Germany.

https://doi.org/10.22268/AJPP-001256

Adjusting and creating the magnetic flux

A magnetic apparatus consists of two similar rows each of eight magnetic pieces (30 mT/piece) arranged side by side. The two rows were put in parallel (with 2 cm distance in between) in a repulsion position, which allows magnetic power of 180 mT for each compound, tested concentrations were exposed for one hour to the magnetic flux. The strength of this magnetic flux was measured with Tesla Meter apparatus at the Faculty of Engineering, Menofiya University, Egypt.

Toxicological estimations

The toxic effects of Cancoun and Nomolt were evaluated against the newly hatched larvae of *E. insulana* before and after magnetic field exposure.

Pesticides preparation

Serially diluted concentrations were prepared as follows: 200, 100, 50, 25, and 12.5 ppm for Cancoun and 75, 37.5, 18.75, 9.37 and 4 ppm for Nomolt, to estimate LC values. Similar groups of concentrations for each compound were exposed to a magnetic flux of 180 mT for an hour (Magnetized (M) Cancoun and Magnetized (M) Nomolt treatments).

LC values estimation

Tested concentrations were spread uniformly on the upper surface of the freshly prepared artificial diet. Three replicates were used for each concentration. In addition, three other replicates (sprayed only with water) were used as an untreated control. One hour later, newly hatched dry larvae of *E. insulana* (50/replicate) were allowed to feed on the treated diet under constant conditions of 26±1°C and 75±5 % RH. Three days later, the mortality rate for all treated and untreated larvae were estimated and corrected according to Abbott (1925). The LC_{90}, $LC_{50,}$ and LC_{25} values were calculated by Proban software program according to Finny (1971).

Biological studies

At the LC_{50} level, the latent effects of tested compounds in relation to certain biological, morphological, and histological parameters of treated SPW larvae were studied compared to the untreated control. For each compound, glass tubes (2x7cm) containing 2 gm of the diet, were sprayed with 1ml of the LC_{50} using a micropipette. The control tubes were only treated with distilled water. All tubes were left for an hour to dry. Newly hatched larvae of *E. insulana* were transferred individually by camel hairbrush to the prepared tubes, capped with cotton wool, and kept under the same constant conditions. Three replicates (50 larvae/rep.) were prepared for each treatment. All tubes were daily inspected until pupation. The total accumulative mortalities, malformations, durations, and mass of larvae and pupae were recorded. Pupation, as well as emerged adults rate, were also recorded. The newly emerged moths were placed in a glass chimney cage for mating. Three replicates (each of five pairs of moths) were used for each compound as well as a control. The upper and lower surfaces of each cage were covered with muslin cloth held in position with rubber bands for egg laying. Moths were fed on a 10% sucrose solution through a soaked piece of cotton wool and examined daily until death. The daily number of laid eggs was counted and fecundity (eggs number) and hatchability rate were recorded. In addition, female longevity was represented in pre-oviposition, oviposition and post-oviposition periods, in addition, male longevity was determined. The percentage of reduction and change were calculated by:

$$\text{Reduction (\%)} = \frac{\text{Treatment - Control}}{\text{Control}} \times 100$$

Histopathological studies

Histological changes in the treated full-grown larvae of SBW (two treatments) were compared to the untreated control. Preserved samples were fixed in 10% formal saline for twenty-four hrs. Washing was done in tap water then serial dilutions of alcohol (methyl, ethyl, and absolute ethyl) were used for dehydration. Specimens were cleared in xylene and embedded in paraffin at 56 degrees in a hot air oven for twenty-four hrs. Paraffin beeswax tissue blocks were prepared for sectioning at 4 microns thickness by sled microtome. The tissue sections obtained were collected on glass slides, deparaffinized, and stained by hematoxylin and eosin stain for examination through the light electric microscope (Banchroft *et al*, 1996).

Statistical analysis

Analysis of variance (ANOVA) was conducted for all values of biological parameters of *E. insulana* using Costas program software. Significance between means was determined according to Duncan's Multiple Range Test at the 5 % probability level (Duncan, 1955).

Results

Toxicological effects of tested pesticides

Table 1 summarizes the LC_{90}, $LC_{50,}$ and LC_{25} values 72 hours after treatment with cancoun and nomolt compounds against newly hatched larvae of *E. insulana* before and after magnetic field exposure. Results obtained showed that Cancoun was more effective than Nomolt against *E. insulana* neonates. The corresponding $LC_{25,}$ $LC_{50,}$ and LC_{90} values were 7.32, 45.22, 620.96 ppm for Cancoun and 14.60, 66.45, and 827.28 ppm for Nomolt. After MF exposure, the toxicity of both tested compounds was enhanced. The equivalent LC_{25}, LC_{50}, and LC_{90} values were 3.90, 35.54, and 500.07 ppm for M. Cancoun and 9.81, 49.56, and 509.19 ppm for M. Nomolt, respectively (Table 1).

Mortality and malformation rate of immature stages

The data presented in Table 2 indicate that treating *E. insulana* neonates with LC_{50} of cancoun and nomolt produced larval and pupal mortality rates of 77.24 and 76.33%, respectively, but mortality rates were increased considerably to 89.33 and 88.67% for magnetized cancoun and nomolt, respectively, compared to 6.33% mortality for the untreated control.

Cancoun and nomolt treatments showed percentages of deformation rate of 11.67 and 13.67% for larvae and 9.33 and 9.84% for pupae, respectively, compared to 1 and 0% for larvae and pupae of the untreated control, respectively. After magnetic field exposure, these rates increased significantly in both larvae (17 and 13.67%) and pupae (20 and 15.33%) for magnetized cancoun and nomolt treatments, respectively. The larvae were tiny and dwarfed, with a black thorax and constricted abdomen that turned black just before death. In addition, the pupae were stripped, with either partially or entirely lacking cocoons compared to the untreated control (Figures 1, 2 and 3).

Table 1. Toxicity of two tested pesticides against newly hatched larvae of *E. insulana* before and after magnetic field exposure based on LC values.

Treatments	Lethal concentrations (95% confidence limits) (ppm)			Slope ± SE
	LC_{25}	**LC_{50}**	**LC_{90}**	
Cancoun	7.32 (4.072-10.80)	45.22 (33.53-65.184)	620.96 (311.99-1930.6)	0.8529±0.1131
Magnetized cancoun	3.90 (1.583-6.649)	35.54 (27.185-47.64)	500.07 (242.96-1778.3)	0.7803 ±0.1168
Nomolt	14.60 (11.46-19.07)	66.45 (42.14-118.84)	827.28 (404.807-2294.1)	0.938 ±0.0878
Magnetized nomolt	9.81 (7.73-12.50)	49.56 (35.49-77.20)	509.19 (267.74-1260.80)	0.9591 ±0.0877

Table 2. Effects of magnetized and non-magnetized tested compounds on the mortality and malformation rates of *E.* insulana immature stages.

Treatments	Larval stage		Pupal stage	
	% Accumulative mortality	**% Malformation**	**% Accumulative mortality**	**% Malformation**
Cancoun	77.24	11.67	36.88	9.33
Magnetized cancoun	89.33	17	45.37	20
Nomolt	76.33	10.33	43.73b	9.84
Magnetized nomolt	88.67	13.67	51.93	15.33
Control	6.33	1	2	0.0

Figure 1. Normal untreated *Earias insulana* stages, A= normal larva, B= normal cocoon, C= normal adult.

Figure 2. Malformed *Earias insulana* stages treated as neonates by Cancoun pesticide. A= Dwarfed larvae with dark soft, B= Stripper malformed pupae resulted from Cancoun-treated larvae, C= Malformed adults emerged from Cancun treatment.

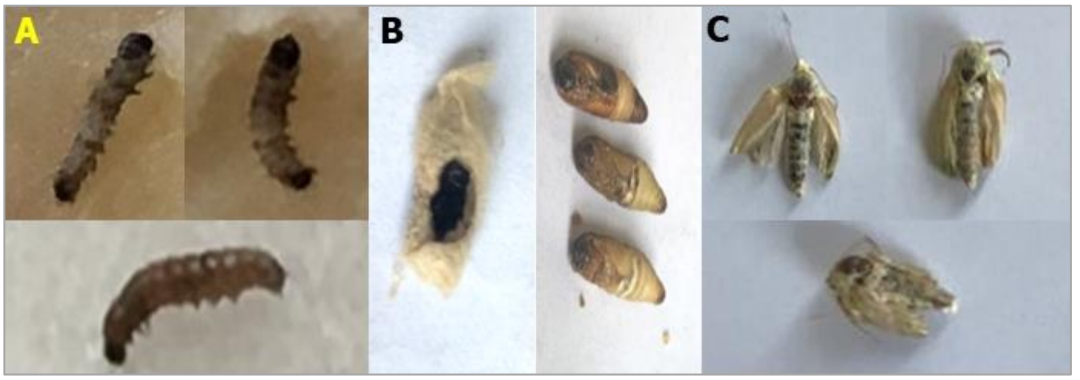

Figure 3. Malformed *Earias insulana* stages treated as neonates by Nomolt pesticide. A= Very small-sized Nomolt-treated larvae, darker to black in color with lean body textures, B= Partially and/or entirely stripped pupae resulted from Nomolt larvae, C= Malformed adults emerged from Nomolt treatment.

Effect of magnetized treatment on duration of immature stages

Results obtained (Table 3) indicated a significant increase in the developmental time needed for larval and pupal stages as a result of treatments in comparison to the untreated control. For Cancoun and Nomolt LC_{50} treatments, the larval period was 18.67 and 21.67 days, respectively.

Larval duration was increased significantly to 20.67 days for magnetized cancoun treatment and insignificantly to 24.33 days for magnetized nomolt treatment, as compared to 15.27 days for the untreated larvae. Additionally, the averages of the pupal period were 9.67 and 11.6 days with cancoun and nomolt treatments, respectively, and was increased to 12.17 and 13.27 days after magnatic field exposure of the preceding compounds, respectively. Subsequently, the duration of total immature stages (larvae and/or pupae) increased to 29 and 33.27days when newly hatched larvae were treated with Cancoun and Nomolt respectively; however, the time significantly increased to 32.83 and 37.60 days respectively, after MF exposure.

Effect of magnetized treatment on weight of immature stages

The average weight of untreated larvae was 0.071g/larva. This average decreased insignificantly to 0.031 g/larva for nomolt treatment and significantly to 0.0106, 0.0107and 0.023 g/larva in magnetized nomolt, magnetized cancoun, and cancoun treatments, respectively. Similarly, the weight of untreated pupae was 0.031g on average. This average was reduced from 0.0247 and 0.0283 g/pupa for cancoun and nomolt to 0.0093 and 0.0087 g/pupa for cancoun and magnetized nomolt, respectively.

Adult emergence and malformation rate

The latent effect of tested compounds was extended to *E. insulana* emerging adults (Table 4). Adults emergence rates of 66.47 and 56.27% were detected as a result of cancoun and nomolt pesticides treatment, and these values were markedly reduced to 54.63 and 48.07%, respectively, following magnetization, compared to 98% for the untreated control. In addition, adult malformation rates of 33.0 and 17.77% were recorded for cancoun and nomolt treatments and increased significantly after magnetization to 43.33 and 31.67%, respectively.

Adults longevity

The pre- and post-oviposition periods for female moths was increased as a result of treatments (Table 4). Compared to 2.67 days for the untreated check, the pre-oviposition periods increased to 4.00, 3.43, 4.33, and 3.67 days for cancoun, magnetized cancoun, nomolt and magnetized nomolt, respectively. In addition, the post-Oviposition periods were significantly increased from 1.73 days in the untreated control to 4.53, 3.57, 4.00, and 4.67 days for the above-mentioned treatments. The Oviposition period, however, was sharply shortened to 3.33, 3.00, 3.33, and 4.00 days for the above-mentioned treatments, compared to 13.5 days for the untreated control. The severe decline in Oviposition reflected a discernible reduction in the total females' longevity, compared to 17.9 days/female and 15.13 days/male for the untreated control. The total female longevity recorded was 11.53, 10.0, 11.67, and 12.27 days whereas the total male longevity was 8.33, 10.60, 10.00, and 8.00 days for the same mentioned treatments, respectively.

Adult reproductive potential

Data displayed in Table (4) established that treating *E. insulana* neonates with tested pesticides affected adults' fecundity. Compared to 216.0 eggs/female for the untreated check, the number of laid eggs was reduced to 26.87, 19.53, 35.0, and 22.67 eggs/female for the cancoun, magnetized cancoun, nomolt, and magnetized nomolt treatments. In addition, the hatchability rate was reduced to 79.85, 71.78, 82.67, and 76.98% for the mentioned treatments compared to 95.94% for the untreated control.

Histopathological studies

The Light microscopic examination of untreated *E. insulana* larva indicated a normal histological structure of cuticular layers with the normal and clearly distinguished epidermis with a typical cellular composition of buds and spines. At the gut region, normal glandular and cellular structures and closely arranged columnar epithelium cells with large central nucleus rest on a basement membrane and are separated from the gut lumen by the peritrophic membrane with no histological modifications (Figure 4).

Treatment of newly hatched larvae of *E. insulana* with LC_{50} concentration of cancoun and nomolt pesticides resulted in different histological alternations of certain tissues. Moreover, exposing the two tested pesticides to magnetic field enhanced their damaging effects, leading to substantially higher cellular apoptosis in the insect tissues. As compared to the untreated control, cancoun-treated larvae had a thinner epidermis that seemed to degenerate in some areas, along with a deformed cuticle that resulted in a rope-like appearance. Degenerative alternations were also observed in the cellular structure. The foregut showed a semi-normal histological structure, whereas the midgut showed necrobiosis in its cells which were evident in the form of spherical basophilic dots in the lumen. The histopathological alternations were obvious in the magnetized cancoun-treated larvae including hypertrophy in the buds and loss of spines, atrophy in the cellular structures and general dwarfism throughout the entire body and necrobiosis throughout the gut epithelium lining (Figures 5, 6, 7 and 8).

Table 3. Effects of magnetized and non-magnetized tested compounds on the developmental time of *E. insulana* immature stages.

	Larval stage			**Pupal stage**			**Total immature stages**	
Treatment	**Duration (days)**	**Weight (g)**	**% Reduction in weight**	**Duration (days)**	**Weight (g)**	**% Reduction in weight**	**Duration (days)**	**Change in duration (days)**
Cancoun	18.67 c	0.023 b	-67.6	9.67 b	0.0247 ab	-20.3	29.0 c	6.13
Magnetized Cancoun	20.67 bc	0.0107 b	-84.9	12.17 a	0.0093 ab	-70	32.83 b	9.96
Nomolt	21.67 ab	0.031 ab	-56.3	11.60 a	0.0283 ab	-8.7	33.27 b	10.4
Magnetized Nomolt	24.33 a	0.0106 b	-85.1	13.27 a	0.0087 b	-71.9	37.60 a	14.73
Control	15.27 d	0.071 a	0.0	7.60 c	0.031 a	0.0	22.87 d	0.0

Means followed by the same letters in the same column are not significantly different at P=0.05.

Table 4. Effects of magnetized and non-magnetized tested compounds on *E. insulana* emerging adults.

			Female longevity					**Reproductive potentials**		
Treatments	**Adult emergence %**	**% Malformation**	**Pre oviposition**	**Oviposition**	**Post oviposition**	**Total longevity**	**Male longevity (days)**	**Total eggs/♀**	**No. eggs daily/♀**	**Hatchability %**
Cancoun	66.47	33.0	4.00 a	3.33b	4.53 a	11.53 bc	8.33 b	26.87b	8.43 bc	79.85
Nomolt	56.27	17.77	4.33 a	3.33 b	4.00 a	11.67 b	10.00 b	35.00 b	10.93 b	82.67
Magnetized cancoun	54.63	43.33	3.43 ab	3.00 b	3.57 a	10.0 c	10.6 b	19.53 b	6.70 c	71.78
Magnetized nomolt	48.07	31.67	3.6 7 ab	4.00 b	4.67a	12.27 b c	8.00 b	22.67 b	6.22 c	76.98
Control	98.00	0	2.67 b	13.5 a	1.73b	17.9 a	15.13 a	216 a	15.89a	95.94

Means followed by the same letters in the same column are not significantly different at P=0.05.

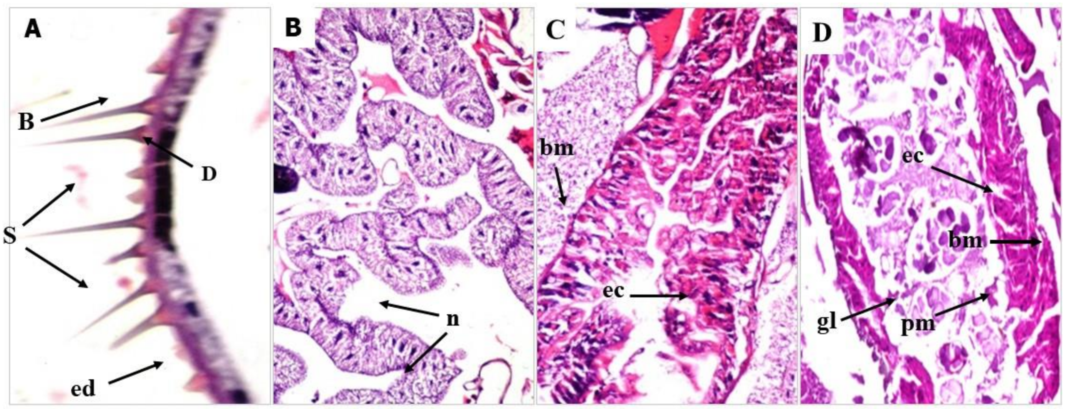

Figure 4. Light microscopic examination of normal untreated *E. insulana* larva (x16) showing: A= Cuticle of *E.insulana* control larva showing normal dermis (D), and epidermis (ed), with outer buds (B), and spines (S) of normal structure, B= Glandular structure of *E.insulana* untreated larva showing the normal histological structure of regularly arranged cells with obvious nuclei (n), C= Normal histological structure of the foregut and mucosal lining epithelium (ec), resting on the basement membrane (bm), in E.insulana control larva, D= Normal histological structure of the midgut of *E.insulana* untreated larva. Showing the epithelial columnar cell (ec), resting on the basement membrane (bm), and separating from the inner gut lumen (gl), by the Peritrophic membrane (pm) which surrounds the food mass.

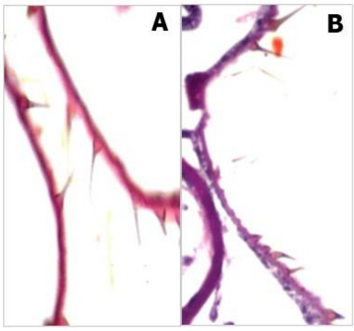

Figure 5. Light microscopic examination showing the cuticle layer of *E. insulana* larva treated as a neonate with LC_{50} of A= Cancoun, showed a reduction in cuticular thickness with a loss in spines and buds, B= magnetized Cancoun treatment showing necrosis and blurred cuticle layers with loss of spines with hypertrophy in the buds in most regions.

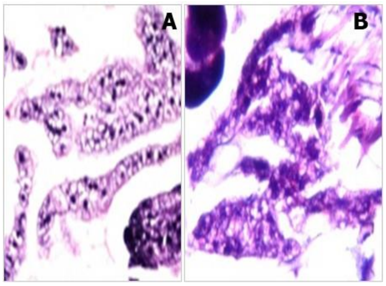

Figure 6. Light microscopic examination shows the glandular structure of A= Cancoun-treated *E.insulana* larva showing cellular degenerative changes with some vacuolization, B= magnetized Cancoun-treated larvae showing atrophy in the cellular structure causing loss of the compact disappearance and vacuolization.

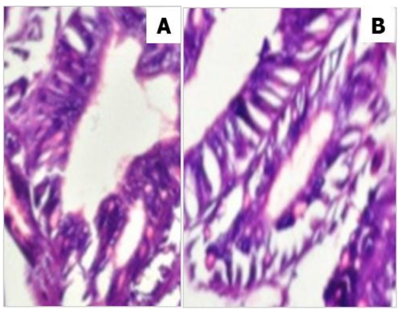

Figure 7. Histological structure of the foregut of *E. insulana* treated larva with A= Cancoun showing compressed epithelial cells with diffused goblet cells and large vacuoles in between, diffuse goblet cell formation, B= magnetized Cancoun treatment showing massive degeneration in the epithelial cell layer with fading of cells boundaries in most regions.

On the other hand, the cuticle layers of *E. insulana* larvae, however, showed compression and lacked buds and spines after being subjected to nomolt treatment. A malformed cellular structure associated with degeneration was observed. The gut's lining epithelium was shown to have widespread diffuse goblet cellular proliferation. Similar results were seen after treatment with magnetized nomolt including more visibly shrivelled cuticle layers with missing spines and buds, degenerative alterations of the glandular structures, and necrobiosis in the lining epithelial cells of the foregut and midgut (Figures 9, 10, 11 and 12).

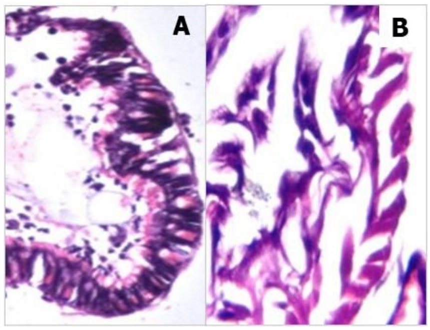

Figure 8. Histological structure of the midgut of *E.insulana* treated larva with A= Cancoun showing disorganization and vacuolization of the columnar cells moreover to the necrotic epithelium, B= magnetized Cancoun treatment showing completely deteriorated peritrophic membrane, also the destruction of the epithelial cells and the boundaries of epithelial cells were extensively damaged leading to disruption and fusion in the lining epithelium.

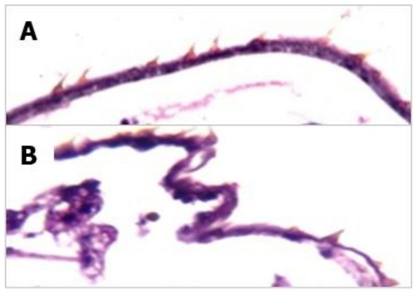

Figure 9. Light microscopic examination of the cuticle of *E. insulana* larva treated as a neonate with LC_{50} of (A) Nomolt compound showing thin dermal and epidermal layers with reduced spines and buds, (B) Magnetized nomolt, showing compression of the cuticle layers with folded and defused dermal and epidermal layers and loss of spines and buds.

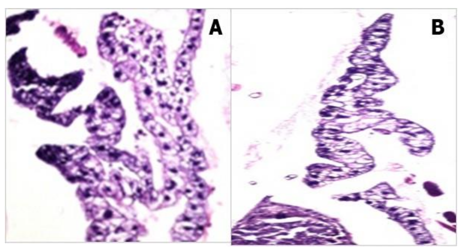

Figure 10. Light microscopic examination shows the glandular structure of (A) Nomolt-treated *E. insulana* larva showing compacted cells with some vacuolization, (B) Magnetized nomolt-treated larvae showing degeneration of the elongated epithelium with general atrophy, an increase in vacuolization and disappearance of nuclei for most cells.

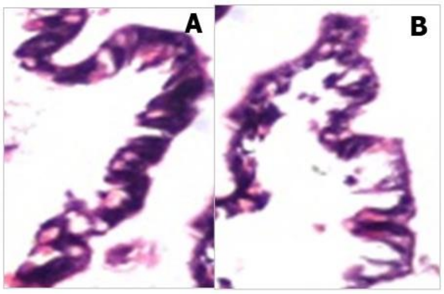

Figure 11. Histological structure of the foregut of *E. insulana* treated larva with (A) Nomolt showing diffuse goblet cell formation, (B) Magnetized nomolt showing collapsed epithelial cells with necrobiosis and exfoliation of lining epithelium.

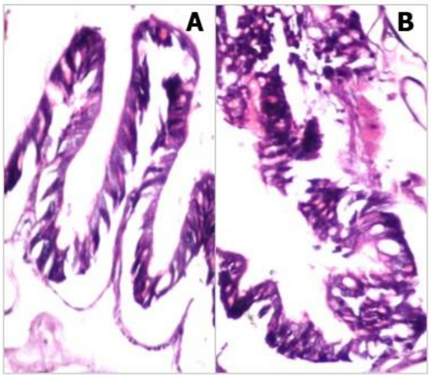

Figure 12. Histological structure of the midgut of nomolt-treated *E. insulana* larva showing necrobiosis of lining epithelium with complete detachment from the peritrophic membrane (A), and magnetized nomolt-treated larvae (B) showing destruction, fusion, and vacuolization of the epithelial cell with completely faded peritrophic membrane.

Discussion

Results obtained confirmed the toxic effect of both cancoun and nomolt pesticides against the 1st instar larvae of *E. insulana*, before and after magnetization. Quiun *et al*. (1997) indicated that the covalent bonds between water molecules are broken as a result of magnetization leading to the absorption of more energy forming single and more active particles, which was confirmed by other workers (Esmaeilnezhad *et al.*, 2017; Ghorbani *et al.*, 2018; Zhou *et al*. 2000).

Results of this study are almost in agreement with those reported earlier (Horowitz *et al*. 1992; Meisner *et al.*, 1986). Similarly, Kandil *et al*. (2022b), reported that based on LC_{50} values, exposing diflubenzuron and lufenuron to magnetic flux doubled their effects against newly hatched larvae of *E. insulana* compared to using the non-exposed products. Moreover, the activity of *Beauvaria bassiana* (Balsamo) prepared in magnetized water against *E. insulana* larvae increased compared to that prepared in non-magnetized regular water (Kandil *et al*., 2022a).

Based on results obtained in this study, treating newly hatched larvae of *E. insulana* with LC_{50} of both cancoun and nomolt pesticides, produced higher larval and pupal mortality rates and malformation after magnetization. Our results are in agreement with the findings of other workers (El-Bassouiny *et al*., 2022; Kandil *et al*., 2018; Ramirez *et al*., 1983; Rehimi & Mokhtar, 2001; Said *et al*., 2017).
Different histopathological alternations at the level of integument and gut were obtained by treating newly hatched larvae of *E. insulana* with cancoun and nomolt pesticides before and after magnetization. Histological findings from the present study are in agreement with the findings of Unsal & Gorer (2018) who demonstrated disruption in the lamellar structure of the endocuticle, over-condensation epidermal cytoplasm, and an increase in cytoplasmic granules along with cytoplasmic loss and cellular vacuoles for triflumuron-treated larvae. Also, they stated that triflumuron treatment caused a decrease in the cuticle thickness by intervening with normal cuticle formation and inhibiting pro-cuticle formation by inhibiting cuticular secretion. On the other hand, a high percentage of histopathological alternations in the midgut epithelial cells had been observed in triflumuron-treated *Agrotis ipsilon* larvae (Abdel-Hakim *et al*., 2016) and *Spodoptera littoralis* larvae (Abdel-Salam *et al*., 2018).

It can be concluded from this study that both cancoun and nomolt pesticides can effectively control neonates of *E. insulana* through their significant effects on different biological parameters. The exposure of these two pesticides to magnetic flux proved to enhance their efficiency on mortality rate, developmental rate, and reproductive potential. Moreover, using cancoun and nomolt pesticides proved to have different histological modifications of insect integument, fore- and mid-guts. Moreover, exposure to magnetic flux increased their damaging effect, leading to substantially higher cellular apoptosis of insect tissues. However, more detailed studies are essential for recommending the use of magnetized insecticides as part of the pest control strategy.

الملخص

الشناوي، رانيا محمود. 2024. تأثير المجال المغناطيسي على سمية المبيدين تريفلومورون وتيفلوبنزورون بالإشارة إلى بعض المعايير البيولوجية والنسيجية لدودة اللوز الشوكية (*Earias insulana*). مجلة وقاية النبات العربية، 42(3): 387-395.
https://doi.org/10.22268/AJPP-001249

هدف هذا العمل إلى دراسة تأثير المجال المغناطيسي على سمية اثنتين من منظمات النمو الحشرية هما: تريفلومورون (كانكون 40% SC) وتيفلوبنزورون (نومولت 15% SC) ضدّ يرقات دودة اللوز الشوكية (*E. insulana*) تحت الظروف المختبرية (26±1°س و 75±5% رطوبة نسبية)، مع الإشارة الخاصة لبعض المعايير البيولوجية والنسيجية المختلفة. أظهرت النتائج زيادة سمية مبيدات الآفات بعد تعريضها للمجال المغناطيسي بقوة 180 mT لمدة ساعة. كانت قيم التركيز

المميت النصفي هي 45.22 و 66.45 جزء في المليون بالنسبة لكانكون ونومولت، على التوالي، بينما انخفضت إلى 35.54 و 49.56 جزء في المليون، على التوالي بعد التعرض للمجال المغناطيسي. كما تمّ رصد نسبة عالية لموت وتشوه كلٍّ من اليرقات والعذارى بعد مغنطة المبيدات مقارنةً بتلك غير الممغنطة وكذلك باليرقات غير المعاملة. كما استطالت أعمار كل من اليرقات والعذارى بشكل ملحوظ، وبالتالي إجمالي مدّة الأطوار غير الناضجة، بعد المغنطة. كما أحدثت المعاملات انخفاضاً في نسب انبثاق الفراشات، وخصوبة الإناث، ونسبة الفقس وبكفاءة أكبر في معاملة المبيدات الممغنطة. وعلاوةً على ذلك، تم رصد تغيرات نسيجية مختلفة في مستويات البشرة والمعي الوسطي لليرقات المدروسة، حيث سببت المعاملات تدميراً ملحوظاً في خلايا البشرة وأنسجة المعي الوسطي لليرقات المعاملة، مع تأثير أكثر وضوحاً للمبيد الحشري الممغنط مقارنة بغير الممغنط والشاهد غير المعامل.

كلمات مفتاحية: دودة لوز القطن الشوكية، المجال المغناطيسي، سمية، تريفلومورون، تيفلوبنزورون.

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Received: May 18, 2023; Accepted: August 16, 2023

تاريخ الاستلام: 2023/5/18؛ تاريخ الموافقة على النشر: 2023/8/16