# Effect of four insecticides on certain biological aspects of cotton leaf worm, *Spodoptera littoralis* (Boisd.) (Lepidoptera: Noctuidae) under laboratory conditions

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**ABSTRACT**:

The effect of four insecticides including emamectin benzoate (Surrender 5 % SG), chlorantraniliprole (Coragen 20 % SC), novaluron (Roxy 10 % EC) and methomyl (Goldben 90 % SP) against 4th instar larvae of laboratory and field strains of *Spodoptera littoralis*, and the effect of their $LC_{50}$ values on certain biological aspects were studied under laboratory conditions. The 4th instar larvae were fed for 24 hrs on castor bean leaves (*Ricinus communis* L.) treated with different concentrations of the tested compounds. The obtained results indicated that emamectin benzoate was the most potent among the tested insecticides on 4th instar larvae of *S. littoralis*. The $LC_{50}$ values of laboratory strain were 0.025, 4.09, 4.21 and 6.67 ppm for emamectin benzoate, chlorantraniliprole, novaluron and methomyl, respectively, while the $LC_{50}$ values of field strain were 1.12 ppm, 6.88 ppm, 13.35 ppm and 102.63 ppm for emamectin benzoate, novaluron, chlorantraniliprole, and methomyl, respectively. The cumulative effect changed between the strains and compounds; therefore, larval and pupal durations and pupae and moth's malformations and sterility % were increased, however pupation percentage, adult emergence %, fecundity, hatchability and longevity were decreased. Novaluron had the highest effect on the tested biological aspects compared with control in laboratory strain. Additionally, chlorantraniliprole and novaluron had the greatest effect on fecundity of field strain. However, emamectin benzoate had the highest effect on both adult longevity and pupal duration of field strain, while novaluron decreased the larval duration. Finally novaluron was most effective than other compounds for controlling *S. littoralis* insect.

**Keywords:** Cotton leafworm**;** novaluron; emamectin benzoate; methomyl; chlorantraniliprole; biological aspects**.**

## INTRODUCTION

The cotton leaf worm, *Spodoptera littoralis* (Boisd.) (Lepidoptera: Noctuidae) is a destructive productive and highly polyphagous insect in Egypt that causes different destructive actions not only for cotton plants (*Gossypium hirsutum* L.), but also for most field crops like peanut (*Arachis hypogaea* L.), soybean (*Glycine max* L.) and vegetables such as pepper (*Capsicum* L.), eggplant (*Solanum melongena* L.), tomato (*Solanum lycopersicum* L.), potato (*Solanum tuberosum* L.), lettuce, (*Lactuca sativa* L.), bean (*Phaseolus vulgaris* L.), strawberry (*Fragaria ananassa* L.) as well as some ornamental crops. It is carefully thought believed to be a major pest of great money-based importance in many countries in Africa, Asia and Europe since it attacks a large number of host plants (Pineda *et al.,* 2007; Rami *et al.,* 2011; Megahed *et al.,* 2013; Zidan *et al .,* 2013; Ali *et al.*, 2015; Abd-Allah *et al.,* 2021).

This pest makes considerable damage by eating leaves, flowers buds, fruiting points and occasionally, as well as on the bolls. (Metayi *et al*., 2015; Khalifa *et al.,* 2015).

The intensive use of insecticides like pyrethroids, carbamates and organophosphorus in developing countries has led to some problems like insect resistance to different groups of insecticides, environmental pollution, destruction of natural enemy population and the health risks connected with pesticides residues (El-Zemaity *et al.,* 2003; Hussein and El desouky 2019; Saleh *et al.,* 2021; Moustafa *et al.,* 2023).

It is necessary to make something else complete or perfect our reliance on producing insecticides with less danger, safe and breaks down naturally substitutes. Some insecticides with different modes of action, emamectin benzoate, chlorantraniliprole, novaluron and methomyl were chosen for this study.

Emamectin benzoate is a new semi-synthetic output for natural product abamectin is one of most important Avermactin family. Avermactins includes emamectin benzoate had been showed to be more impact against wide range of arthropod pests (Putter *et al*., 1981). This compound is a second generation avermectin analog with exceptional activity on lepidopterans (Teran-vargas *et al.,* 1994). Emamectin benzoate acts as a chloride channel

activator, which reduce the excitability of neurons. Grafaton-cardwell *et al.,* (2005) added that shortly after exposure, the insect larvae were stop feeding and became irreversibly paralyzed and die during 3 to 4 days. This compound is used against several species of lepidopteran insect pests. Emamectin benzoate is a member of the avermectin group acts as a gamma amino butyric acid (GABA) -gated chloride channels. Also is highly efficacy against the cotton leafworm *S. littoralis* larvae (Mokbel *et al.,* 2014).

Chlorantraniliprole is a new insecticides belonging to a newer class of selective insecticides. This effectively controlling lepidopterious insects. An anthranilic diamide bind to receptors in insect muscles insecticide (ryanodine) causing uncontrolled release of calcium from internal steers in the sarcoplasmic reticulum leading to feeding cessation, paralysis and death of the insect it can control many insects which belong to Lepidoptera, Diptera, Coleoptera, and Hemiptera, and had been shown to be potent against insects which developed resistance to conventional classes of insecticides (Lahm *et al.,* 2005; Cordova *et al.,* 2006; Bentley *et al.,* 2010).

Novaluron used to control insects (particularly Lepidoptera) on cotton, potatoes, vegetables, fruits, tea and other crops. Novaluron is relatively new penzophenylurea CSI on survival and development and adult performance of *S. littoralis.* Methomyl is a systemic insecticides and acaricides with contact stomach action, used to control a broad spectrum of insects (particularly Lepidoptera, Hemiptera, Homoptera, Diptera and Coleoptera) and spider mites (Ghoneim *et al.,* 2015; Hamadah *et al.,* 2015).

So, this study aimed to investigate the efficacy of three compounds i.e. emamectin benzoate, chlorantraniliprole and novaluron in relative to a traditional insecticide methomyl (carbamate insecticide) against 4$^{th}$ instar larvae of laboratory and field strains of *S. littoralis*, in addition to the cumulative effects of $LC_{50}$ values of tested compounds on certain biological parameters of this insect under laboratory conditions.

## MATERIALS AND METHODS

**Laboratory strain rearing**:

The cotton leafworm, *S. littoralis,* were obtained from Department of Plant Protection Research, Faculty of Agriculture, Assiut University, Egypt. This strain was reared for more than 25 years without any exposure to chemicals. Insects were reared in laboratories of Department of Plant Protection, faculty of Agriculture, Cairo, Al-Azhar university, Egypt under controlled conditions at 25 ± 2° C and 65 ± 10 % relative humidity with 12:12 L:D photoperiod. The 4$^{th}$ instar larvae (average of weight was 23 ± 2 mg larva) were used in the bioassay according to the method of (Eldefrawi *et al.,* 1964). Larval jars were supplied with fresh Castor bean leaves, *Ricinus communis* L., as a source of food which was provided daily. The adults were kept separately and mated on the third day of emergence in clean jars (2 L.), fed on 10 % sugar solution, and fresh green leaves of Tafla, *Nerium oleander* L., were provided for egg laying.

**Field strain rearing:**

The egg masses were collected from corn fields and adjacent fields at Sa Al-Hager Village, Gharbia Governorate, Egypt during 2021 growing season and reared for one generation under the same conditions and left to hatching and reared as described above.

**Tested insecticides:**

Four insecticides were used in this study i.e. emamectin benzoate (Surrender 5% SG), chlorantraniliprole (Coragen 20% SC), novaluron (Roxy 10% EC) and methomyl (Goldben 90% SP). Some important information for the tested insecticides are mentioned in Table (1).

**Determination of $LC_{50}$ values of the tested insecticides on 4$^{th}$ instar larvae of *S. littoralis*:**

The $LC_{50}$ values of insecticides on laboratory and field strains were determined using the leaf dipping technique according to Finney, (1971). Fresh and clean castor bean leaves were dipped for 15 seconds in six different concentrations of the tested insecticides, then left to dry for 1 hour under room temperature and then offered to 4$^{th}$ instar larvae in clean jar (2L.), each jar contained 10 larvae. Four replicates for laboratory strain and three replicates for field strain were used for each concentration of each treatment. Leaves dipped in water served as control. The $LC_{50}$ value that obtained by regression lines were statistically estimated and the goodness of fit of the regression lines to the observed data was calculated after 3 days.

**Determination of biological parameters:**

Clean castor bean leaves were dipped for 15 seconds in the $LC_{50}$ concentration from the

tested insecticides, and then left to air dry. Leaves dipped in water served as control. Ten 4th instar larvae of *S. littoralis* were put in glass jar (500 ml) and provided with treated castor bean leaves. After 24 hrs the survived larvae were transferred to clean jars and provided with untreated leaves until pupation. Percentage of pupation and moth emergence were based on the number of normal pupae or moths obtained.

For mating experiments, the emerged moths either from treated or untreated larvae (control) were sexed and put in glass jar and provided with leaves of *N. oleander* L. that served as an oviposition site and provided with a piece of cotton dipped in 10 % sugar solution for feeding and changed daily till egg-mass depositions throughout their longevity. The eggs were calculated and put in a clean jar with untreated castor bean leaves till hatching. Newly hatched larvae were recorded to calculate the hatchability percentage. Percentage of sterility was calculated according to the equation of Toppozada *et al.,* (1966) as follows:

Sterility % =1- {$a \times b$ / $A \times B$} × 100

Where:

***a***: is the No. of eggs laid/female in treatment.

***b***: the % of hatch in treatment.

***A***: the No. of eggs laid/female in control.

***B***: is the % of hatch in control.

Percentages of mortality, pupation and emergence of moths were corrected when needed according to Abbott's formula (Abbott 1925). The following formula has been used:

% pupation = [Number of pupae/Total number of larvae] × 100

% deformed pupation= [Number of deformed pupae/Total number of pupae] × 100

% emergence = [Number of moths/Total number of larvae] × 100

% deformed moths = [Number of deformed moths/Total number of moths] × 100

**Data analysis:**

Mortality data was corrected using Abbott's Formula (Abbott 1925). The $LC_{50}$ values were expressed as ppm with fiducial limits (FL) and slope which calculated using probit analysis (Finny 1971). Data were subjected to analysis of variance ANOVA and significant differences among the treatments were portioned by Duncan's (1955) Multiple range test LSD test at probability levels of $P$ = 0.05 according to using Costat program (1988).

## RESULTS AND DISCUSSION

**Toxicity study:**

Data presented in Table (2) showed the toxicity of emamectin benzoate, chlorantraniliprole, novaluron and methomyl against 4th instar larvae of both strains of *S. littoralis* under laboratory conditions after 72 hrs post treatment. The data indicated a positive correlation between larval mortality and concentrations of tested insecticides. The probit analysis show that $LC_{50}$ values of laboratory strain for emamectin benzoate, chlorantraniliprole, novaluron and methomyl after 72 hrs were 0.025 ppm, 4.09 ppm, 4.21 ppm and 6.67 ppm, respectively. While $LC_{50}$ values of the same tested insecticides against field strain after 72 hrs were 1.12 ppm, 13.35 ppm, 6.88 ppm and 102.63 ppm, respectively. Emamectin benzoate was the most toxic against 4th instar larvae of both laboratory and field strains than chlorantraniliprole, novaluron and methomyl evidenced by the toxicity index.

The above results are somewhat similar to those obtained by khalifa *et al.,* (2015), who suggested that emamectin benzoate has the most potent against *S. littoralis*, 4th instar larvae followed by chlorantraniliprole then amidacloprid and Agree (*Bacillus thuringiensis*), respectively. In addition, the obtained results were supported by Metayi *et al.,* (2015). Who cleared that the emamectin benzoate was more toxic than novaluron and diflubenzuron. The results of the slope values showed that, the insect population was relatively heterogeneous to the susceptibility to tested insecticides for both laboratory and field strains by leaf-dip method (except emamectin benzoate in laboratory strain the slope was 0.39), all slope values were more than 1.0 for most tested insecticides.

Regarding the efficiency of tested insecticides on the larval, pupal and adult durations, data presented in Table (3) showed that all treatments caused high significant effects on different periods comparing with those in the control for laboratory strain. On the other hand in filed strain had no significant effects on larval and pupal durations comparing with those in the control. The larval duration in the treatments of laboratory strain ranged from 15.00 days for novaluron to 23.00 days for chlorantraniliprole, comparing with

19.25 days in the control. On the other hand, the larval duration in the treatments of field strain ranged from 19.33 days for novaluron to 22.33 days chlorantraniliprole, comparing with 19.67 days in the control. The pupal duration was 0.00 days for novaluron due to no larvae alive followed by 12.00 of methomyl while it was 11.75 days at the control in laboratory strain. The pupal duration ranged from 11.00 days of emamectin benzoate and 13.00 of chlorantraniliprole while it was 11.66 days at the control in filed strain. The highest decrease of adult male longevity of laboratory strain was 0.00 days of novaluron followed by 9.00 days of chlorantraniliprole followed by 11.75 of emamectin benzoate and increased to 12.75 days in methomyl while it was 12.25 days in control.

Also the highest decrease of adult female longevity was 0.00 days of novaluron followed by 11.50 days of chlorantraniliprole followed by 12.50 of emamectin benzoate and it was 14.50 days in methomyl while it was 18.25 days in control. In field strain the highest decrease of adult male longevity was 8.00, 9.00 days of emamectin benzoate and novaluron, respectively but methomyl increased to 14.67 comparing with 11.67 in the control. While there is no significant range in adult longevity females comparing with control.

The obtained results have been supported by Deecher *et al.*, (1990) who reported that in most diptera larvae, sublethal doses from avermectin had been decreased pupation and adult emergence. Ishaaya *et al.*, (2003) using of novaluron and diflubenzuron may lead to mortality by obstruct the molting process through stopping the formation of chitin and decreased egg hatching which treated with (BPUs). Alyokhin and Choban, (2010) showed that novaluron and diflubenzuron had strong effect on most growth and metamorphosis parameters that tested on 2nd instar larvae of *S. littoralis* which treated with two sublethal concentrations. Abdel Rahman *et al*., (2007) showed that, when they used lufenuron (BPUs) on the 3rd instar larvae of *S. littoralis,* the results showed an antifeedent action within 2 days.

Data presented in Table (4) showed that novaluron had the strongest effect on adult longevity in laboratory strain which reduced to 0.00 days comparing to 16.50 days in the control. While in field strain emamectin benzoate and novaluron had the strongest effect comparing with control. On the other hand, novaluron reduced life cycle from 31.00 to 15.00 days of laboratory strain, but it was stable in field strain comparing to control. Also it is observed novaluron decreased the life span in laboratory strain from 47.50 to 15.00 days while in field strain novaluron and emamectin benzoate decreased the life span to 41.66 and 42.00 days, respectively, comparing with 43.67 days in the control.

Data presented in Table (5) showed that the pupation % ranged from 0.00 % of novaluron and 75.00 % of methomyl while it was 100 % at the control in laboratory strain. The pupation % ranged from 53.00 % of novaluron and 20.00 % of methomyl while it was 90 % at the control in filed strain. The highest effect on pupae % malformations in laboratory strain was 29.41 % to emamectin benzoate comparing to 0.00 % in the control, but in field strain were 18.75 % to novaluron compared to 0.00 % in the control. The highest effect on moths % malformations in laboratory strain was 21.42 % to methomyl comparing to 2.70 % in the control, but in field strain was 30.67 % to novaluron comparing to 7.69 % in the control. Also decrease the adult emergence % when compared with control, it ranged from 70.00 to 0.00 and 43.33 to 16.67 % of the laboratory and field strains, respectively treated with the tested compounds comparing with 92.50 and 86.87 % of control. Also, the data pointed that the treatment of 4th instar larvae of both laboratory and field strains with tested insecticides had the strongest effect on the adult sex ratio at $LC_{50}$ values. These compounds caused males increase and females reduced it ranged from 55.56 : 53.50 and 61.53 : 60.00 % males, as compared with control of the laboratory and field strains, respectively which ranged from 46.16 : 44.25 % males.

The obtained results have been supported by wanner *et al.,* (2000) who reported that mature larvae may die before pre pupae or at the stage between larvae and pupae. The decreased number of larvae which in turned to pupation or adult emergence could be a result of pilling up of toxic compounds in the insects body. Pineda *et al*., (2007), Sammour *et al.*, (2008) and El-Sheikh *et al.,* (2009) cleared that the Benzphenyl ureas (BPUs) decreased the pupation, adult emergence, fecundity, hatchability and increased sterility rates comparing to untreated control. Also, malformations in larvae, pupal and adult emergence were obviously recorded comparing to control.

These results are in accordance with the results of Fahmy, (2014) reported that it can be probably due to the hormone mimic in mode of action of methoxyfenozid. Also these results agreed with Hussein and Eldesouky, (2019)

reported that, the sublethal concentrations from chlorfluazuron and chlorantraniliprole significantly increased larvae and pupal durations, while reducing occurred in pupation percentage; longevity of adults; emergence of adults and fecundity of females.

Data in Table (6) showed the cumulative action of the 4th instar larvae of laboratory strain of *S. littoralis* with chlorantraniliprole and novaluron highly reduced the adult fecundity, hatchability percentage and fertility and raised the sterility compared with control. All treatments of filed strain significantly decreased the adult fecundity, hatchability % and fertility. Chlorantraniliprole decreased the adult fecundity to average of 40.00 eggs/female compared to 611.67 eggs/female of control. Novaluron and chlorantraniliprole significantly decreased the fertility and hatchability percentage, and increased the sterility compared to control. Finally the data presented in Table (6) indicated that emamectin benzoate and chlorantraniliprole had a highly effect on the sterility increased to 83.63 and 97.30 %. These results agreed with Khaled and Farag, (2015) who pointed that the reduction in fecundity may be due to the direct entrances with hormone system or less of appetite due to toxic accumulation, which effect on the hermonic system and directly impact on the fecundity of the insect. Also, Acheuk *et al.,* (2011) reported that chitin becomes weak and the exoskeleton so muscle attachment in the early stages, made it incapable of surviving the strong pressure remanded for successful hatching, this way decreased hatching off eggs deposit treated females.

## CONCLUSION

Thus, it is concluded that, emamctin benzoate is the most effective insecticides against 4th instar larvae of S. *littoralis*, laboratory and field strain. Although novaluron is not the most toxic insecticide on 4th instar larvae of S. *littoralis*, but it had the strongest effect on the biological aspects of the insect.

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**Table 1:** list of the tested insecticides**:**

| Trade names | Common names | (IUPAC)* Chemical names | Group | ** Rate of application fed.$^{-1}$ (200L. water) | Source |
|---|---|---|---|---|---|
| Surrender 5 % SG | Emamectin Benzoate | 4"*R*)-5-*O*-demethyl-4"-deoxy-4"-(methylamino)avermectin A1a + (4"*R*)-5-*O*-demethyl-25-de(1-methylpropyl)-4"-deoxy-4"-(methylamino)-25-(1-methylethyl) avermectin A1a (9:1). | Avermectin | 80 gm. | EuroChem Co. |
| Coragen 20 % SC | chlorantraniliprole | 3-Bromo-*N*-[4-chloro-2-methyl- 6 (methylcarbamoyl)phenyl]-1-(3-chloropyridin-2-yl)-1*H*-pyrazole-5-carboxamide. | Anthranilic diamides | 60 cm$^3$ | FMC Swi. Inter. sarl Co. |
| Roxy 10 % EC | Novaluron | 1-[3-chloro-4-(1,1,2-trifluoro-2-trifluoro-methoxyethoxy)phenyl]- 3-(2,6-difluorobenzoyl) urea. | IGRs | 120 cm$^3$ | MyTrade Co. |
| Goldben 90 % SP | Methomyl | *S*-methyl *N*-(methylcarbamoyloxy) thioacetimidate. | Carbamate | 300 gm | StarChem Co. |

*(IUPAC) names according to International Union of Pure and Applied Chemistry Anonymous, (2011).
** Rates of application according to the Agriculture Pesticide Committee (APC), Ministry of Agriculture and Land Reclamation (MALR) 1n 2018 season.

**Table 2**: The $LC_{50}$ values of tested insecticides on laboratory and field strains of 4$^{th}$ instar larvae of *Spodoptera littoralis* (after 72 hrs of exposure) under laboratory conditions.

| Treatments | Laboratory susceptible strain | | | | Field resistance strain | | | |
|---|---|---|---|---|---|---|---|---|
| | $LC_{50}$ values (Upper- Lower) | Slope ± SE* | T.I.** | *** R. P. | $LC_{50}$ values (Upper- Lower) | *** Slope ±SE | **** T.I. | ***** R. P. |
| Emamectin Benzoate | 0.025 (0.061 - 0.008) | 0.394 ± 0.078 | 100 | 1.0 | 1.121 (1.539 -0.077) | 1.561± 0.320 | 100 | 1.0 |
| Chlorantraniliprole | 4.090 (5.677 -2.922) | 1.134 ± 0.150 | 0.611 | 163.6 | 13.351 (22.471 -8.513) | 1.118 ± 0.230 | 8.396 | 11.90 |
| Novaluron | 4.212 (6.541 - 1.475) | 1.301 ± 0.180 | 0.593 | 168.48 | 6.889 (13.468 - 9.305) | 1.301 ± 0.400 | 9.690 | 6.14 |
| Methomyl | 6.674 (8.750 - 5.062) | 1.541 ± 0.200 | 0.375 | 266.96 | 102.635 (143.35 - 60.68) | 1.475 ± 0.330 | 1.092 | 91.55 |

* SE = Standard error.
** T.I. = Toxicity index was calculated according to **Sun, (1950)**, ($LC_{50}$ of the most effective compound / $LC_{50}$ of the tested compound) ×100.
*** R.P. = Relative potency was calculated according to **El-Shikh and Aamir, (2011),** ($LC_{50}$ of the tested compound / $LC_{50}$ of the most effective compound).

**Table 3:** Effect of $LC_{50}$ treatments against 4th instar larvae of *S. littoralis* on durations of larvae, pupae and longevity of adults of both laboratory and field strains under laboratory conditions.

| Treatments | Laboratory susceptible strain | | | | | Field resistance strain | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $LC_{50}$ values (ppm) | Larval duration (days) | Pupal duration (days) | Adult Longevity (days) | | $LC_{50}$ values (ppm) | Larval duration (days ) | Pupal duration (days) | Adult Longevity (days) | |
| | | | | Male | Female | | | | Male | Female |
| Emamectin Benzoate | 0.025 | 21.25 b | 13.50 a | 11.25 b | 12.50 c | 1.121 | 21.33 a | 11.00 a | 8.00 c | 11.33 a |
| Chlorantraniliprole | 4.090 | 23.00 a | 13.00 ab | 9.00 c | 11.50 c | 13.351 | 22.33 a | 13.00 a | 11.00 b | 11.67 a |
| Novaluron | 4.212 | 15.00 d | 00.00 e | 00.00 d | 00.00 d | 6.889 | 19.33 a | 12.00 a | 9.00 c | 11.00 a |
| Methomyl | 6.674 | 22.00 ab | 12.00 b | 12.75 a | 14.50 b | 102.635 | 21.67 a | 11.67 a | 14.67 a | 12.00 a |
| Untreated control | ------- | 19. 25 c | 11.75 b | 12.25 ab | 18.25 a | ------- | 19.67 a | 11.66 a | 11.67 b | 13.00 a |
| *L S D at 5% | ------- | 1.532 | 1.333 | 1.662 | 1.544 | ------- | 2.392 | 2.932 | 1.757 | 2.392 |

*L.S.D. = Least significant difference.

**Table 4:** Effect of treatments on adult longevity, life cycle and life span of adults of two strains of *S. littoralis* (resulted from treated larvae against the 4th instar larvae) under laboratory conditions.

| Treatments | Laboratory susceptible strain | | | | Field resistance strain | | | |
|---|---|---|---|---|---|---|---|---|
| | $LC_{50}$ values (ppm) | Adult longevity (days) | *Life cycle (days) | **Life span (days) | $LC_{50}$ values (ppm) | Adult longevity (days) | *Life cycle (days) | **Life span (days) |
| Emamectin Benzoate | 0.025 | 12.00 c | 34.75 ab | 46.75 a | 12.50 | 9.67 d | 32.33 a | 42.00 b |
| Chlorantraniliprole | 4.090 | 10.25 d | 36.00 a | 46.25 a | 11.50 | 11.33 bc | 35.33 a | 46.67 a |
| Novaluron | 4.212 | 00.00 e | 15.00 d | 15.00 b | 00.00 | 10.00 cd | 31.33 a | 41.66 b |
| Methomyl | 6.674 | 13.75 b | 34.00 b | 47.75 a | 14.50 | 13.33 a | 33.33 a | 46.67 a |
| Untreated control | ------- | 16.50 a | 31.00 c | 47.50 a | 18.25 | 12.33 ab | 31.33 a | 43.67 ab |
| L S D at 5% | ------- | 1.481 | 1.952 | 2.438 | ------- | 1.485 | 3.044 | 3.115 |

* Life cycle = larval duration + pupal duration.

** Life span = life cycle + adult longevity.

**Table 5:** Effect of cumulative treatments on % pupation, % deformed pupae, % of adult emergence, adult sex ratio and % of deformed moths against 4th instar larvae of *S. littoralis* of two strains under laboratory conditions.

| Treatments | Laboratory susceptible strain | | | | | | Field resistance strain | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *% Pupation | % of Deformed Pupae | **% of Adult Emergency | Adult sex ratio (%) | | ***% of Deformed Moths | *% Pupation | % of Deformed Pupae | **% of Adult Emergency | Adult sex ratio (%) | | *** % of Deformed Moths |
| | | | | Male | Female | | | | | Male | Female | |
| Emamectin Benzoate | 42.50 | 29.41 | 10.00 | 50.00 | 50.00 | 00.00 | 40.00 | 00.00 | 40.00 | 58.33 | 41.67 | 16.67 |
| Chlorantraniliprole | 32.50 | 23.07 | 22.50 | 55.56 | 44.44 | 16.67 | 26.67 | 12.50 | 20.00 | 50.00 | 50.00 | 16.67 |
| Novaluron | 00.00 | 00.00 | 00.00 | 00.00 | 00.00 | 00.00 | 53.33 | 18.75 | 43.33 | 61.53 | 38.46 | 30.67 |
| Methomyl | 75.00 | 5.00 | 70.00 | 53.50 | 46.50 | 21.42 | 20.00 | 16.67 | 16.67 | 60.00 | 40.00 | 20.00 |
| Untreated control | 100 | 00.00 | 92.50 | 44.25 | 55.75 | 2.70 | 90.00 | 00.00 | 86.87 | 46.16 | 53.84 | 7.69 |

* % pupation =[Number of pupae/Total number of larvae] × 100.

** % of adult emergency =[Number of moths/Total number of larvae] × 100. Mean No. of adults was 8 for each treatment.

*** % deformed moths = [Number of deformed moths/Total number of moths] × 100.

**Table 6:** Cumulative effect of treatments on reproductive parameter of two strain of *S. littoralis* (resulted from $LC_{50}$ treated larvae against the 4th instar larvae) under laboratory conditions.

| Treatments | Laboratory susceptible strain | | | | Field resistance strain | | | |
|---|---|---|---|---|---|---|---|---|
| | *Fecundity | **Fertility | % of Hatchability | ***Sterility % | *Fecundity | **Fertility | % of Hatchability | ***Sterility |
| Emamectin Benzoate | 252.75 c | 164.00 c | 64.88 | 83.63 | 189.33 c | 142.00 c | 75.10 | 70.57 |
| Chlorantraniliprole | 00.00 d | 00.00 d | 00.00 | 00.00 | 40.00 e | 13.00 d | 32.50 | 97.30 |
| Novaluron | 00.00 d | 00.00 d | 00.00 | 00.00 | 112.00 d | 23.00 d | 20.53 | 95.22 |
| Methomyl | 909.50 b | 740.0 b | 81.39 | 24.91 | 343.66 b | 276.00 b | 75.77 | 45.97 |
| Untreated control | 1039.25 a | 978.25 a | 94.87 | 00.00 | 611.67 a | 481.00 a | 78.30 | 00.00 |
| L S D at 5% | 79.082 | 67.214 | -------- | --------- | 49.221 | 34.566 | -------- | -------- |

*Fecundity = no. of laid eggs for female.

** Fertility = no. of hatched eggs.

*** Sterility was calculated according (Toppozada *et al.*, 1966), Sterility % =1- {$a \times b$ / $A \times B$} × 100.

## تأثير أربعة من مبيدات الحشرات علي بعض المقاييس البيولوجية لدودة ورق القطن تحت الظروف المعملية

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**الملخص العربي**

تمت دراسة تأثير أربعة من المبيدات الحشرات و هي الإيمامكتين بنزوات والكلورانترانيليبرول و النوفاليورون والميثوميل ضد العمر اليرقي الرابع لكل من السلالتين المعملية والحقلية لدودة ورق القطن, وكذلك دراسة التأثير التراكمي للتركيز المميت النصفي الـ $LC_{50}$ لهذه المبيدات علي تطور اليرقات تحت الظروف المعملية. تم تغذية اليرقات لمدة 24 ساعة على أوراق الخروع المعاملة بتركيزات مختلفة من مبيدات الحشرات المختبرة. أظهرت الدراسة أن مبيد الإيمامكتين بنزوات كان الأكثر فاعلية بين هذه المبيدات المختبرة على يرقات العمر اليرقي الرابع حيث كانت قيم التركيز المميت النصفي ($LC_{50}$) للسلالة المعملية 0,025 ، 4,09 ، 4,21 و 6.67 جزء في المليون للإيمامكتين ، الكلورانترانيليبرول ، النوفاليورون والميثوميل علي التوالي. بينما كانت قيم التركيز المميت النصفي للسلالة الحقلية 1,12 ، 6,88 ، 13,35 و 102.63 جزء في المليون للإيمامكتين والنوفاليورون والكلورانترانيليبرول والميثوميل على التوالي. بينما اختلف التأثير التراكمي باختلاف السلالة والمبيد المختبَر. وظهرت تأثيرات شديدة علي يرقات كل من السلالتين, حيث زادت معدلات الأعمار اليرقية و طور التعذير و تشوهات العذارى والفراشات وكذلك زادت النسبة المئوية للعقم. بينما انخفضت نسب التعذير، ونسب خروج الافراد البالغة ، والخصوبة ، ومعدلات الفقس ، وطول عمر الفراشات. النوفاليورون كان المبيد الأعلى تأثيرا على العوامل البيولوجية للسلالة المعملية مقارنة بالكنترول، بينما كان لمبيدي الكلورانترانيليبرول والنوفاليورون التأثير الأكبر على خصوبة الأفراد البالغة وأيضا نسب الفقس في السلالة الحقلية. أما الإيمامكتين بنزوات كان الأعلى تأثيرا على طول عمر الافراد البالغة ومدة التعذير ، بينما قلل مبيد النوفاليورون من عمر اليرقات. مبيد النوفاليورون كان المركب الاكثر فاعلية في السيطرة علي دودة ورق القطن.

**الكلمات الاسترشادية:** دودة ورق القطن، النوفالورون، الايمامكتين بنزوات، الميثوميل، الكلورانترانيليبرول والعوامل البيولوجيه.