Biological Performance of Certain Agrochemicals against Black Cutworm, *Agrotis Ipsilon* (Lepidoptera: Noctuidae)

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ABSTRACT: Agrochemicals play the principal critical role in managing the black cutworm, *Agrotis ipsilon* (Hufn.). The study was taken to demonstrate the biological performance of certain pesticides at their LC_{50} values on the biological aspects against 4th instar larvae of the black cutworm under laboratory conditions. The data revealed that profenofos was the most toxic compound, followed by α-cypermethrin and indoxacarb in corresponding to LC_{50} values of 2.15, 2.59, and 3.03 ppm, respectively. The percent survived larvae treated with LC_{50} values of the tested insecticides after 15 days of the experiment ranged from 6.67% to 48.33% for both indoxacarb and oxamyl treatments, respectively, versus to 96.67% in the control treatment. On the other hand, the highest average number of resulted pupae (4.17) was detected in the profenofos treatment, followed by (4.0) at the oxamyl treatment, versus the lowest observed average number (0.50 and 1.17) in both the performed treatments of indoxacarb and lufenuron, respectively. It could be concluded that the lowest number of malformed adults (1.0) was observed for both the evaluated insecticides of oxamyl, indoxacarb, spinetoram, and thiamethoxam compared to the complete absence of malformed emerging adults at all the other tested insecticides. While the treatment of lufenuron gave the highest number of deformed adults (5.0). Furthermore, high-gained number of deposited eggs/untreated female (733.80), followed by the gradually decreased numbers of 667.60, 617.00, and 559.40 eggs in case of the evaluated LC_{50} values of cypermethrin, oxamyl, and profenofos respectively. The lowest number of deposited eggs (278.60 and 402.00 eggs/female) was recorded for both spinetoram and thiamethoxam treatments.

Keywords: *Agrotis ipsilon*, biological parameters, recent agrochemicals.

INTRODUCTION

Agrotis ipsilon is a major burrowing pest that damages agricultural crops (**Falin *et al*., 2021).** Fields with a high risk of cutworm harm are typically identified by the abundant abundance of weeds in and around the fields (**Reay-Jones, 2021)**. Various species of cutworms have the ability to consume a wide variety of plants, such as vegetables, turf, field crops, and countless weeds (**Edde, 2021)**. Countries in the tropics and subtropics, including Chile, Brazil, Egypt, India, Myanmar, Poland, Spain, and the United States, suffer greatly from crop loss due to that insect pest (**Sorensen *et al*. 2016)**.

The black cutworm, *Agrotis ipsilon*, poses a significant danger to a wide range of agricultural products, including almost every type of vegetables and many essential cereals (**Duportets *et al*., 1998).** The larvae are polyphagous, leading to significant harm to agricultural and horticultural crops, particularly during the early stages of growth (**Yangchan *et al*., 2022)**. Larvae often feed on the host plant's leaves as they hatch, and later on, they move on to the stem. They are most active throughout the night and in the absence of proper management, cutworm larvae can cause extensive damage to plants **(Fernandes *et al*. 2013).**

During the earliest stages of development, the black cutworm primarily feeds on leaves. However, as it reaches the 4th instar, it can cause more significant harm by severing young plant stems near the soil surface through its larval feeding (**Levine *et al*., 1983**). During daylight hours, they have the ability to relocate the injured plants below the ground and consume them. **(Joshi *et al*., 2020).** This kind of eating causes excessive crop damage and can even wipe out entire crop stands. (**Calvin *et al*., 1999)**.

Cutworms are one of the most difficult agricultural pests to control and manage due to their unique feeding habits and methods of infesting their host plant (**Walczak, 2002)**. Meanwhile, the excessive and indiscriminate application of pesticides has led to an increase in insecticide resistance, and pesticide residues have built up in food. There are an increasing demand for novel pest control measures to mitigate the risks posed by these pests to humans, the environment, and non-target creatures (**Yangchan *et al*., 2022).**

It is necessary to use new tactics for managing *A. ipsilon* include the implementation or proposal of biorational compounds, biocontrol agents, and insect growth regulators.

Therefore, this study aimed to use different chemical groups with different mode of actions to utilize specified pesticides.

MATERIALS AND METHODS

Source and rearing of the black cutworm, *Agrotis ipsilon* (Hufn.)

The used larvae of *A. ipsilon* (Hufn.) in the present study were collected as newly captured moths using a light trap at the Etay El-Baroud agriculture research station at El-Behira Governorate (Egypt). The field adult moths were transferred to the laboratory in bigger jars, which were supplied with hanging pieces of cotton moistened with 20 % sugar solution in the space of the glass jar until egg laying. The hatched larvae of the black cutworm were reared on castor oil leaves (*Ricinus communis* L.) under the higro-thermic conditions of 25 ± 2 ºC and 65 ± 5% R.H. for many generations without exposure to any pesticides to obtain the sufficient number of susceptible-laboratory strain insects needed for the experiment.

According to the adopted rearing techniques by **Beheedy (1990)** reported that the newly hatched larvae were kept in clean glass jars (1L) and covered with muslin, which were fixed tightly by rubber bands and provided daily with new castor oil leaves until the third larval instar. Then they were transferred to clean, disinfected, and larger glass jars (2L) to limit or prevent the incidence of larval cannibalism. The bottom of each jar was covered with a thick layer of fine sawdust, and the usual rearing technique was performed along the developing stages of the 4th, 5th and 6th larval instars until pupation occurred. The developed pupae were kept in glass jars with paper towels on the bottoms and covered with gauze until adult emergence. The incipient adult moths (males and females in ratio 1:1) were transferred to bigger jars, which were supplied with hanging pieces of cotton moistened with 20% sugar solution in the space of the glass jar.

Strips of dark or white cloth fixed in the muslin cover of each jar were used as hanging sites for egg deposition by the mated female moths. Swaps of moistened cotton with the sugar solution were replaced every two days. The muslin strips on which the eggs had been deposited were collected daily, transferred to new jars, and left to hatch. The neonates were fed on castor oil leaves, and the colony of mass reared larvae was continued as explained above in rearing technique. The needed 4th instar larvae of the black cutworm for the initiated treatments were obtained from the colony.

Agrochemicals used:

The study employed nine individual pesticides, which were categorized into seven different chemical groups, each with unique mechanisms of action. The chemical groups that resembled the tested insecticides were organophosphates (profenofos and chlorpyrifos), oxime carbamate (oxamyl), pyrethroids (cypermethrin and alpha-cypermethrin), oxadiazines (Indoxacarb), spinosyns (spinetoram), benzoylureas (lufenuron), and neonicotinoids (thiamethoxam) as follows:

A. Organophosphates:
- Profenofos (Deliron® 72 % EC)
- Chlorpyrifos (Dursban H® 48 % EC)

B. Carbamates:
- Oxamyl (Fedal® 24 % SL)

C. Pyrethroids:
- Cypermethrin (Sparkil® 25% EC)
- Alpha-Cypermethrin (Super Alpha® 10 % EC)

D. Oxadiazines:
- Indoxacarb (Avaunt® 15% EC)

E. Spinosyns:
- Spinetoram (Radiant® 12 % SC)

F. Benzoylureas:
- Lufenuron (Match® 5% EC)

G. Neonicotinoids:
- Thiamethoxam (Actara® 25 % WG)

TREATMENTS:

The exhibited amounts in Table 1 elucidate the components and rates of carrier material and stimulants in preparing the baits of each of the evaluated chemical compounds or/and their adopted mixtures in the tested baits during the study. The determined LC_{50} and LC_{25} values mentioned next in the evaluation were added to the prepared baits to determine their influences on the biological aspects against the black cutworm.

Table (1): The components of the poisonous baits used in field and lab.

Site of application	Bait components		
	Carrier material of course corn flour	Water	Molasses
Field	25 kg	20 L.	1 L.
Lab	125 g	100 ml	5 ml

Bioassay studies:

Bioassays were performed on the 4th instar larvae to assess the activity of the nine mentioned insecticides. Series concentrations for each insecticide were prepared using commercial formulations. The poison bait technique was used to determine the median lethal concentration (LC_{50}) values of insecticides on *A. ipsilon* larvae. Noticeably, the experimented pesticides were added and mixed with the other used components of the baits. The exposure of the newly hatched 4th instar larvae to the poison bait was performed in plastic pans (10 cm, in diameter), on which the bait was scattered in regular small amounts. Treatments were run in three replicates, each of which contained 10 larvae. The exposure of treated larvae to the bait extended for 24 hours and then the survived larvae were placed in glass jars and fed on fresh castor leaves. The LC_{50} values were determined and mortality corrections were carried out and adjusted using Abbott's formula (Abbott, 1925). The data were analyzed using an adopted computer program based on a standard implementation of the probit analysis recommended by Finney (1971).

Determination of the insecticidal performance on the fitness components

The influence of the LC_{50} values of the above insecticides was determined on the biological parameters of *A. ipsilon* larvae. The exposure of the newly hatched 4th instar larvae to the poison bait treated with LC_{50} values of the evaluated compounds was performed in plastic pans (10 cm, in diameter) for 24 hours, and then the survived larvae were placed in glass jars and fed on fresh castor leaves until pupation period. Treatments were run in six replicates, each of which contained 10 larvae. The number and percentages of derived normal and malformed larvae, pupae, and emerged moths, the number of deposited eggs/female, and hatchability percentages were calculated and recorded.

Statistical analysis:

All data obtained from the experiments were statistically analyzed through CRD using the Analysis of Variances (ANOVA) test to compare the significance of differences between treatments. The least significant differences (L.S.D) were determined according to Duncan (1955).

RESULTS AND DISCUSSION:

The toxicity of the tested insecticides on the 4th instar larvae of a susceptible laboratory strain of the black cutworm, *Agrotis ipsilon,* was carried out using different concentrations to determine their sublethal concentration (LC_{50}) values.

The data presented in Table 2 demonstrated the LC_{50} values, LdP line slopes, and toxicity index for the tested compounds against the 4th instar larvae of the black cutworm, *Agrotis ipsilon,* under laboratory conditions using the poison bait technique after 2 days of treatments for all the compounds except lufenuron, which was after 4 days of treatments. The Toxicity of the nine insecticides against the fourth larval instar of *A. ipsilon* indicated that profenofos was the most toxic compound (LC_{50} = 2.15 ppm), followed by α-cypermethrin (LC_{50} = 2.59 ppm) and Indoxacarb (LC_{50} = 3.03 ppm), while oxamyl showed the lowest toxic effect (LC_{50} = 3736.19 ppm). The results of the slope values showed that the insect population was relatively heterogeneous in their susceptibility towards tested insecticides by using the poison bait method (the slope values were more than 1.0 for most tested insecticides). The corresponding toxicity index values of these compounds based on the LC_{50} of profenofos were 100, 83.01, 70.96, 57.03, 43.70, 21.61, 6.78, 0.54, and 0.058%, respectively.

Table (2): Toxicity of the tested insecticides against the 4th instar larvae of the black cutworm, *Agrotis ipsilon*

Treatments	LC_{50} Fiducial limits	Slope ± SE	*Toxicity index at LC_{50}	χ^2	R^2
Profenofos	**2.15 (1.48-3.16)**	**1.16 ± 0.17**	**100**	**1.45**	**0.99**
Chlorpyrifos	**4.92 (3.17-7.62)**	**0.99 ± 0.16**	**43.70**	**0.34**	**1.00**
Oxamyl	**3736.19 (2937.30-4625.87)**	**2.27 ± 0.3**	**0.058**	**6.03**	**0.97**
Cypermethrin	**9.95 (7.68-12.89)**	**1.82 ± 0.21**	**21.61**	**3.18**	**0.98**
α-Cypermethrin	**2.59 (1.93-3.50)**	**1.56 ± 0.19**	**83.01**	**1.05**	**0.99**

Indoxacarb	**3.03 (2.28-3.96)**	**1.73 ± 0.20**	**70.96**	**2.51**	**0.98**
Spinetoram	**31.73 (23.16-42.71)**	**1.50 ± 0.19**	**6.78**	**8.61**	**0.94**
Lufenuron	**3.77 (2.80-5.06)**	**1.55 ± 0.19**	**57.03**	**6.46**	**0.94**
Thiamethoxam	**398.21 (288.88-548.72)**	**1.42 ± 0.18**	**0.54**	**2.17**	**0.99**

*** Toxicity index (Sun, 1950) = (LC_{50} of the efficient compound/LC_{50} of the other compound) x 100.**

References to the estimated toxicity index, profenofos, α-cypermethrin, and indoxacarb were the most efficient insecticides, achieving 100, 83.01, and 70.96%, respectively. The moderately efficient ones were lufenuron and chlorpyrifos, resulting in 57.03 and 43.70%, respectively. Meanwhile, the lowest insecticides were cypermethrin, spinetoram, thiamethoxam, and oxamyl, giving toxicity indexes of 21.61, 6.78, 0.54, and 0.054%, respectively. The above results demonstrated that specific insecticides, either conventional or recent ones, were more efficient against *A. ipsilon* than thiamethoxam (neonicotinoids), which were specific against sucking insects, or oxamyl and spinetpram.

Korrat *et al.* (2012) reported that profenofos was more toxic than spinosad against cotton leaf worm larvae, with an LC_{50} value of 10.9 ppm and 19.9 ppm, respectively. **Saeed *et al.* (2012)** found emamectin benzoate had the most significant impact against field populations of *S. exigua* larvae, with an LC_{50} value of 0.005 mg/l. Lufenuron followed closely behind, with an LC_{50} value of 0.65 mg/l. **Mahmoud *et al.* (2016)** showed an improvement in the effectiveness of EPNs when combined with azadirachtin, compared to neonictinoid insecticides.

Massoud *et al.* (2016) found indoxacarb was the most effective insecticide for maize yield loss caused by *Agrotis ipsilon*. **Kumar (2017)** found spraying chlorpyrifos twice was the best way to eliminate *A. ipsilon* on potato crops. **Khan and Naveed (2020)** found that lambda cyhalothirn and thiamethoxam had the least effectiveness for the second and third instars of *S. litura* larvae, which is confirming previous results. **Saad *et al.* (2022)** found that conventional insecticides, (thiamethoxam + chlorantraniliprole), Avaunt (indoxacarb), and Coragen (chlorantraniliprole) are more effective than bioinsecticides Proclaim, Dipel, and Achook against *Tuta absoluta* on tomatoes. **Shaurub *et al.* (2023)** investigated the effects of imidacloprid and spinosad against *S. littoralis*, finding spinosad to be more toxic ones.

Residual effect of tested insecticides on the larvae of the black cutworm:

The demonstrated results in Table 3, and 4 show the revealed residual effect of feeding larvae on the prepared baits treated with the median lethal concentration (LC_{50}) values of 2.15, 4.92, 3736.19, 9.95, 2.59, 3.03, 31.73, 3.77, and 398.21 ppm for the tested compounds of profenofos, chlorpyrifos, oxamyl, cypermethrin, α-cypermethrin, indoxacarb, spinetoram, lufenuron and thiamethoxam, respectively, on the fitness component of the 4th instar larvae of the black cutworm, *Agrotis ipsilon*.

The data presented in these tables showed that all nine insecticides tested caused considerable mortality rates in the 4th instar larvae of the black cutworm throughout the period of the experiment, and the cumulative mortality rates increased as time elapsed. The percent of survived larvae treated with LC_{50} values of the tested insecticides after 15 days of the experiment (i.e., residual effects) ranged from 6.67% to 48.33% for both indoxacarb and oxamyl treatments, respectively, compared with 96.67% in the check untreated treatment, larval mortality was stopped after 3 days after treatments for both profenofos, chlorpyrifos, oxamyl, α-cypermethrin, and spinetoram compounds, versus 5 days in the case of cypermethrin and thiamethoxam treatments; while indoxacarb and lufenuron treatments, larval mortality was continuous until 9 and 15 days after treatment, respectively.

The highest comparative average number of alive larvae (9.67) was observed in the untreated check treatment, followed by the tested LC_{50} of oxamyl (4.83). The lowest numbers of (0.67) and (1.67) larvae were recorded for the tested insecticides of both Indoxacarb and Lufenuron, respectively, compared with (9.67 larvae) in the untreated check.

From the tabulated data in the 4 Table, it is clear that there is no significance between the treated larvae with the lufenuron as an IGR and the untreated larvae throughout the first two days after treatment, and the mean value of alive larvae was recorded at (9.83) and (9.67) for treatment versus the same mean value of (9.83) in the untreated check. However, the survived larvae decreased along the interval days after treatment and were recorded (1.67) at 15 days post-treatment compared to (9.67) for the check untreated treatment. Moreover, although there is no significance difference between the larvae treated with indoxacarb and most other insecticides during the first 72 hours after treatment, the survived larvae declined rapidly and recorded the lowest average number of alive larvae (0.67) at 9 days after treatment.

Saeed *et al*. (2012), who found that the LT_{50} figures indicated that lufenuron took longer to eliminate 50% of the population of the 2nd instar larvae of *S. exigua* compared to all other insecticides tested in a laboratory experiment. On the other hand, cypermethrin required the shortest amount of time. On the other hand, **Saad *et al*. (2022)** recorded that the half-life values for various insecticides against *Tuta absoluta* under field conditions ranged from 2.3 to 4.53 days, while the bio-insecticides had a half-life of one day. In a controlled laboratory environment, **Rimpy and Verma (2018)** assessed the long-term toxicity of seven insecticides on *Agrotis ipsilon* and *A. segetum* 3rd instar larvae. The findings indicated that all of the chosen insecticides caused death in third-instar larvae of both species for a period of up to 15 days after spraying. However, cypermethrin resulted in mortality for up to 10 and 7 days after spraying, respectively.

Table (3): Mean number of the survived larvae/replicate (10 larvae) resulted from the treatment of the black cutworm

Treatment	Mean number of survived larvae throughout bioassay intervals (days)							
	1	**2**	**3**	**5**	**7**	**9**	**12**	**15**
Profenofos	6.50 c ±0.76	5.17 cd ±0.87	4.17 c ±0.95	4.17bcd ±0.95	4.17 bc ±0.95	4.17 bc ±0.95	4.17 bc ±0.95	4.17 bc ±0.95
Chlorpyrifos	7.67 c ±0.67	5.00 cd ±0.45	3.50 c ±0.56	3.50 be ±0.56	3.50 bc ±0.56	3.50 bc ±0.56	3.50bcd ±0.56	3.50 bc ±0.56
Oxamyl	8.17abc ±0.54	6.17 bc ±0.65	4.83 c ±0.79	4.83 b ±0.79	4.83 b ±0.79	4.83 b ±0.79	4.83 b ±0.79	4.83 b ±0.79
Cypermethrin	9.50 ab ±0.22	7.17 b ±0.70	4.00 c ±0.45	3.17cde ±0.48	3.17 c ±0.48	3.17 c ±0.48	3.17 cd ±0.48	3.17 cd ±0.48
α - Cypermethrin	7.33 c ±0.49	4.83 cd ±0.31	3.83 c ±0.31	3.83 be ±0.31	3.83 bc ±0.31	3.83 bc ±0.31	3.83bcd ±0.31	3.83 bc ±0.31
Indoxacarb	7.67 c ±0.80	4.33 d ±0.42	3.67 c ±0.21	2.33 e ±0.42	1.50 d ±0.62	0.67 d ±0.33	0.67 e ±0.33	0.67 e ±0.33
Spinetoram	7.83 bc ±0.79	4.50 d ±0.67	3.67 c ±0.67	3.67 be ±0.67	3.67 bc ±0.67	3.67 bc ±0.67	3.67bcd ±0.67	3.67 bc ±0.67
Lufenuron	9.83 a ±0.17	9.67 a ±0.21	7.67 b ±0.67	4.50 bc ±0.56	3.83 bc ±0.60	3.00 c ±0.58	2.50 d ±0.34	1.67 de ±0.49
Thiamethoxam	7.50 c ±1.02	4.33 d ±0.61	3.67 c ±0.56	2.83 de ±0.31	2.83 cd ±0.31	2.83 c ±0.31	2.83 cd ±0.31	2.83 cd ±0.31
Check untreated	9.83 a ±0.17	9.83 a ±0.17	9.67 a ±0.21	9.67 a ±0.21	9.67 a ±0.21	9.67 a ±0.21	9.67 a ±0.21	9.67 a ±0.21
LSD 5%	1.77	1.55	1.73	1.59	1.63	1.60	1.56	1.58

**** Mean ± S.E. from 6 replicate; each replicate contained 10 larvae**

Table (4): The percentages of survived treated larvae of *A. ipsilon* throughout the bioassay intervals

Treatment	Percent of survived larvae throughout bioassay intervals (days)							
	1	2	3	5	7	9	12	15
Profenofos	65.00	51.67	41.67	41.67	41.67	41.67	41.67	41.67
Chlorpyrifos	76.67	50.00	35.00	35.00	35.00	35.00	35.00	35.00
Oxamyl	81.67	61.67	48.33	48.33	48.33	48.33	48.33	48.33
Cypermethrin	95.00	71.67	40.00	31.67	31.67	31.67	31.67	31.67
α - Cypermethrin	73.33	48.33	38.33	38.33	38.33	38.33	38.33	38.33
Indoxacarb	76.67	43.33	36.67	23.33	15.00	6.67	6.67	6.67
Spinetoram	78.33	45.00	36.67	36.67	36.67	36.67	36.67	36.67
Lufenuron	98.33	96.67	76.67	45.00	38.33	30.00	25.00	16.67
Thiamethoxam	75.00	43.33	36.67	28.33	28.33	28.33	28.33	28.33
Check untreated	98.33	98.33	96.67	96.67	96.67	96.67	96.67	96.67

Influence of the tested insecticides on the fitness components of the developmental stages of the black cutworm, *Agrotis ipsilon*

A. Developed larvae

All the evaluated insecticides were highly efficient, and the number of alive larvae ranged between 4 and 29 out of 60 larvae, compared with the untreated check (58 larvae). The higher mean value of alive larvae was detected at the oxamyl treatment (4.83), followed by the mean numbers (4.17, 3.83, and 3.67) for the LC_{50} values of profenofos, α-cypermethrin, and spinetoram, respectively. While the lowest mean value (0.67) was recorded at the LC_{50} treatment of indoxacarb. (Table 5**).**

Consequently, indoxacarb treatment gave the highest percentage of larval mortality (93.33%), followed by 75.0% at the LC_{50} value of lufenuron treatment. While the lowest percentage of 51.67% was detected in the oxamyl treatment, compared with 3.33% in the untreated check. In addition, the malformed larvae percentage of 8.33% was detected at the LC_{50} value of lufenuron treatment alone, while all the other tested insecticides had no effect on the number of malformed larvae.

B. Developed pupae

The latent effect of unprofitable biological performance of both the tested LC_{50} values of the nine insecticides on the resulted survived pupae, from the black cutworm larvae treatment; was apparent and exhibited in Table (6) and the alive, dead and malformed pupae were calculated and recorded.

Table (5): The effect of tested compounds on the fitness components of the larvae of the black cutworm, *Agrotis ipsilon*

Treatment	Developed larvae					
	Alive		Dead		Malformed	
	A	B	No.	%	No.	%
Profenofos	25.0 (41.67%)	4.17 bc ± 0.95	35.0	58.33	0.0	0.0
Chlorpyrifos	21.0 (35.0%)	3.50 bc ± 0.56	39.0	65.0	0.0	0.0
Oxamyl	29.0 (48.33%)	4.83 b ± 0.79	31.0	51.67	0.0	0.0
Cypermethrin	19.0 (31.67%)	3.17 cd ± 0.48	41.0	68.33	0.0	0.0
α-Cypermethrin	23.0 (38.33%)	3.83 bc ± 0.31	37.0	61.67	0.0	0.0
Indoxacarb	4.0 (6.67%)	0.67 e ± 0.33	56.0	93.33	0.0	0.0
Spinetoram	22.0 (36.67%)	3.67 bc ± 0.67	38.0	63.33	0.0	0.0
Lufenuron	10.0 (16.67%)	1.67 de ± 0.49	45.0	75.0	5.0	8.33
Thiamethoxam	17.0 (28.33%)	2.83 cd ± 0.31	43.0	71.67	0.0	0.0
Check untreated	58.0 (96.67%)	9.67 a ± 0.21	2.0	3.33	0.0	0.0
L.S.D.	-	1.58	-	-	-	-

A = number (percentage).
B = Mean ± S.E. from 6 replicate; each replicate contained 10 larvae.

In all running treatments, the average numbers of resulted pupae were ratherly reduced and ranged between (0.5) and (4.17) pupae, versus, a highest calculated mean number of (9.67) pupae in the untreated control. The highest average number of resulted pupae (4.17) was detected in profenofos treatment, followed by (4.0) at the oxamyl treatment, versus the lowest observed average number of (0.50 & 1.17) in both performed treatments of indoxacarb and lufenuron, respectively.

It is obvious that the highest percent of dead pupae (25.0%) was recorded at the tested LC_{50} value of indoxacarb insecticide, followed by 20.0% at lufenuron treatment, compared to the complete absence of dead pupae in all the LC_{50} values of profenofos, cypermethrin, α-cypermethrin, and thiamethoxam treatments. Also, the only malformed pupa (1.0 pupa) was detected at both α-cypermethrin and lufenuron treatments, but in all the other insecticides and the untreated check, the malformed pupae were completely absent.

Table (6): The effect of tested compounds on the fitness components of the pupae of the black cutworm, *Agrotis ipsilon*

Treatments	**Developed pupae**					
	Alive		**Dead**		**Malformed**	
	A	**B**	**No.**	**%**	**No.**	**%**
Profenofos	25.0 (100.0%)	4.17 b ±0.95	0.0	0.0	0.0	0.0
Chlorpyrifos	19.0 (90.48%)	3.17 b ±0.65	2.0	9.52	0.0	0.0
Oxamyl	24.0 (82.76%)	4.00 b ±1.18	5.0	17.24	0.0	0.0
Cypermethrin	19.0 (100.0%)	3.17 b ±0.48	0.0	0.0	0.0	0.0
α-Cypermethrin	22.0 (95.65%)	3.67 b ±0.42	0.0	0.0	1.0	4.35
Indoxacarb	3.0 (75.0%)	0.50 d ±0.34	1.0	25.0	0.0	0.0
Spinetoram	20.0 (90.91%)	3.33 b ±0.88	2.0	9.09	0.0	0.0
Lufenuron	7.0 (70.0%)	1.17 cd ±0.60	2.0	20.0	1.0	10.0
Thiamethoxam	17.0 (100.0%)	2.83 bc ±0.31	0.0	0.0	0.0	0.0
Check untreated	58.0 (100.0%)	9.67 a ±0.21	0.0	0.0	0.0	0.0
L.S.D.	-	1.90	-	-	-	-

A = number (percentage).
B = Mean ± S.E. 6 replicate; each resulted from treated larvae.

C.Developed adults

The delayed effect of biological parameters for the evaluated compounds on the resulted alive adult-moths of the black cutworm, *A. ipsilon*, from the survived pupae post larval treatment was apparent and exhibited in Table 7. The alive and malformed adult-moths were calculated, and the number of deposited eggs per female, hatchability, and sterility were also noticed and recorded.

The presented data in Table 7 show the numbers of resulted adults were significantly reduced and ranged from 2 to 25 adults, versus the highest recorded number of 58 adults in the untreated check. It was also found that the highest average number of emerged adult-moths (4.17) was revealed at the tested LC_{50} value of profenofos insecticide, followed by (3.83) at oxamyl treatment, while the same average numbers (3.17) were noticed for all the LC_{50} values of chlorpyrifos, cypermethrin, and spinetoram insecticides, versus the lowest detected mean number of alive adults (0.33) for both the evaluated LC_{50} values of indoxacarb and lufenuron compounds. In addition, the lowest number of malformed adults (1.0) was observed for both the evaluated insecticides of oxamyl, indoxacarb, spinetoram, and thiamethoxam, compared to the complete absence of malformed adults at all the other tested insecticides, except for the treatment of lufenuron, which recorded the highest number of deformed adults (5.0).

Table (7): The effect of tested compounds on the fitness components of the adults of the black cutworm, *Agrotis ipsilon*

Treatments	Developed adults						
	Alive		Malformed		No. of Deposited eggs/female	Hatch** %	Ster. %
	A	B	No.	%			
Profenofos	25.0 (100.0)	4.17 b ± 0.95	0.0	0.0	559.40 cd	89.85	10.15
Chlorpyrifos	19.0 (100.0)	3.17 b ± 0.65	0.0	0.0	509.80 d	90.78	9.22
Oxamyl	23.0 (95.83)	3.83 b ± 1.22	1.0	4.17	617.00 bc	94.68	5.32
Cypermethrin	19.0 (100.0)	3.17 b ± 0.48	0.0	0.0	667.60 ab	92.78	7.22
α-Cypermethrin	22.0 (100.0)	3.67 b ± 0.42	0.0	0.0	526.20 d	90.31	9.69
Indoxacarb	2.0 (66.67)	0.33 c ± 0.33	1.0	33.33	Nil	Nil	Nil
Spinetoram	19.0 (95.0)	3.17 b ± 0.95	1.0	5.00	402.00 e	86.82	13.18
Lufenuron	2.0 (28.57)	0.33 c ± 0.33	5.0	71.43	Nil	Nil	Nil
Thiamethoxam	16.0 (94.12)	2.67 b ± 0.42	1.0	5.88	278.60 f	89.09	10.91
Check untreated	58.0 (100.0)	9.67 a ± 0.21	0.0	0.0	733.80 a	96.13	0.0
L.S.D.	-	**1.92**	-	-	**77.56**	-	-

A = (number & percentage).
B = Mean ± S.E. 6 replicate; each resulted from treated larvae. ****Hatch. = Hatchability and Ster. = Sterility**

It can also be seen that the LC_{50} values of these insecticides exhibited higher significant efficiency on the number of deposited eggs per female. In comparison to the noticed, somewhat high gained number of deposited eggs/untreated female (733.80), followed by the gradually decreased numbers of 667.60, 617.00 and 559.40 eggs in the case of the evaluated LC_{50} values of cypermethrin, oxamyl, and profenofos, respectively, the lowest number of deposited eggs (278.60 and 402.00 eggs/female) was recorded for both spinetoram and thiamethoxam treatments. Also, all the examined LC_{50} values of the compounds exhibited a slight effect on the egg hatchability. The hatchability percentages ranged between 86.82 and 94.68% compared with 96.13 % in the untreated check, except for both treatments of indoxacarb and lufenuron, which recorded complete failure of growth.

Herein, the adverse biophysiological and hormonal effects on the development of the treated 4th instar larvae with indoxacarb and lufenuron were followed by a faster complete failure of growth. That failure could be attributed to the cumulative effect of induced recessive lethal genes in both affected pupae and resulting adults after 4th instar larval treatments, which caused unprofitable effects.

The research of **Abdel-Aal and Abdel-Wahab (2017)** on *S. littoralis* adult moths revealed that Spinosad and Lufenuron significantly impacted reproduction. **Korrat *et al.* (2012)** found that spinosad and chlorfluazuron significantly affected pupation, moth emergence, hatchability, and sterility at the LC_{25} level on 2nd instar larvae of the cotton leaf worm. The use of chlorfluazuron resulted in the maximum effectiveness in terms of deformed pupae and moths, with percentages of 14.86% and 32.76%, respectively.

Marzouk *et al.* (2012) reported that profenofos significantly prolonged the larval and pupal stages of *S. littoralis*. **Parsaeyan *et al.* (2013)** found that cypermethrin decreased the pupal weight of *H. armigera* third instar larvae, shortened the time for larvae to grow into pupae, and decreased fertility and hatchability by 50.5% and 37.9%, respectively, compared to the control group. **El-Dewy (2017)** showed that spinetoram had the lowest efficacy in affecting the reproductive capacity of the treated 4th instar larvae of *S. littoralis*. The study revealed reduced proportions of healthy pupae, adult emergence, reproductive capacity, and hatchability in all experimental groups compared to the control group.

El-Sayed *et al.* (2017) found that exposing cotton leafworm larvae to low concentrations of lufenuron and flufenoxuron led to a significant decrease in body weights, number of larvae successfully metamorphosizing into pupae, average pupae weight, and adult number of emergent larvae. The average duration of pupation for treated larvae was longer than untreated larvae, but no significant variations were observed. Pesticide application led to a decline in fertility and reproductive capacity of the larvae.

Amein and Mohammad (2022) revealed that flufenoxuron significantly enhanced the larval and pupal stages of *Agrotis ipsilon*, but significantly reduced pupation, adult emergence, adult longevity, fecundity, and fertility. The female ovaries also displayed histopathological abnormalities. **Moustafa *et al.* (2022)** found that sublethal concentrations of spinosyn group significantly extended the pupal length of the second larval stage of *Agrotis ipsilon*.

Amein and Abdelal (2023) found that teflubenzuron and Alfa-cypermethrin extended larval and pupal durations of fourth instar *Spodoptera frugiperda* larvae, while reduced pupation and adult emergence compared to the control group. **Shaurub *et al.* (2023)** revealed a significant reduction in the rate of pupation, adult emergence, and successful hatching of female *S. littoralis* insects when exposed to both individual imidacloprid and spinosad compounds, compared to the control group.

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الملخص العربى

التأثير البيولوجى لبعض الكيماويات الزراعية ضد الدودة القارضة السوداء

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تلعب المبيدات الحشرية الدور الأساسى فى مكافحة الدودة القارضة السوداء *Agrotis ipsilon* (Hufn.) . لذا أجريت هذه الدراسة لتوضيح كفاءة المبيدات المختلفة – التقليدية وغير التقليدية – طبقا لقيم تركيزاتها القاتلة ل 50% من الأفراد المعاملة على السمات البيولوجية ليرقات العمر الرابع للدودة القارضة السوداء تحت الظروف المعملية . أوضحت النتائج أن أقوى المركبات سمية هو مركب بروفينوفوس يليه فى ذلك كل من ألفا سيبرمثرين ثم إندوكساكارب بقيم تركيزات قاتلة ل 50% من اليرقات المعاملة بلغت 2.15 ، 2.59 ، 3.03 جزء فى المليون على الترتيب ؛ بينما تراوحت النسبة المئوية لليرقات الحية الناتجة بعد 15 يوم من المعاملة ما بين 6.67% إلى 48.33% لكل من معاملتى إندوكساكارب وأوكساميل على الترتيب، مقارنة بمعاملة الكنترول (96.67%)؛ كذلك أعلى متوسط للعذارى الناتجة (4.17) وجد فى معاملة بروفينوفوس ، يليه (4.00) فى معاملة أوكساميل، فى مقابل أقل قيم لمتوسطات عددية محسوبة (0.50 و 1.17) لكلا معاملتى إندوكساكارب ولوفينيورون على الترتيب . كذلك اتضح أن أقل عدد للحشرات الكاملة المشوهة لوحظ لكل من أوكساميل وإندوكساكارب وسبينتورام وكذلك ثياميثوكسام مقارنة بالإختفاء التام للفراشات المشوهة الناتجة فى باقى المبيدات المختبرة الأخرى ما عدا معاملة لوفينيورون التى سجلت أعلى عدد للفراشات المشوهة (5) . كما أظهرت النتائج ارتفاع عدد البيض الموضوع لحد ما فى الإناث غير المعاملة (733.80) متبوعا بالأعداد المتناقصة تدريجيا (667.60 ، 617.00، 559.40 بيضة) فى حالة قيم التركيز القاتل ل 50% من اليرقات المعاملة بكل من سيبرمثرين وأوكساميل وبروفينوفوس على الترتيب ، بينما كان أقل عدد بيض (278.60 و 402.00 بيضة / أنثى) قد سجل لكلا معاملتى سبينتورام وثياميثوكسام .