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RESISTANCE MONITORING OF COTTON LEAF WORM, *SPODOPTERA LITTORALIS* (BOISDUVAL) (LEPIDOPTERA: NOCTUIDAE) AGAINST CERTAIN ALTERNATIVE INSECTICIDES OF FOUR DIFFERENT FIELD POPULATIONS IN EGYPT

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ABSTRACT

Cotton leaf worm, *Spodoptera littoralis* (Boisd.) is a key pest affecting many field crops and vegetables in Egypt. Its control depends mainly on the application of various insecticides with different modes of action. In the current study, susceptibility of four field collected populations were tested to six insecticides for three consecutive years (2015-2017). These insecticides included insect growth regulators (IGRs), spinosad and emamectin benzoate. These insecticides at their variable concentrations were tested against 2^{-nd} instar larvae of *S. littoralis* under laboratory conditions. Comparing with laboratory strain, field-collected populations showed a susceptibility to very low levels of resistance to the tested IGRs. Resistance ratio (RR) recorded (1.23– 5.46-fold) to lufenuron, 2.16 – 5.57-fold to flufenoxuron, 1.69 –6.78 fold to chlorfluazuron and 0.45-2.46-fold to hexaflumuron. Furthermore, emamectin benzoate showed very low to low level of resistance (2–10 fold), in line with spinosad which recorded 1.36 - 3.40-fold. Concerning the cross-resistance between the tested insecticides was explored throughout pairwise correlation analysis. The obtained data indicated a significant correlation between the tested IGRs except for lufenuron and hexaflumuron. In contrast, spinosad showed no correlation with all other tested insecticides with reference to the negative correlation with emamectin benzoate. Similarly, emamectin benzoate showed non-significant correlation to all the tested insecticides except for chlorfluazuron. So, rotation of insecticides with none and negative cross-resistance can carry out effective control of the pest and sustain pest susceptibility to recommended insecticides.

Key words: *Spodoptera littoralis*, insect growth regulators (IGRs), spinosad, emamectin benzoate, resistance, pairwise correlation

INTRODUCTION

The cotton leafworm, *Spodoptera littoralis* Boisd. (Lepidoptera: Noctuidae) is a serious polyphagous pest attacking many field crops and vegetables **(Kandil *et al.*, 2003)**. Its high fecundity and migratory potential contribute to severe damage which occurs as a result of feeding on leaves, flower buds, fruiting buds, and bolls. Insecticides application represents a main mean to combat the pest and preserve crop yield. So, several insecticides were used to control *S. littoralis* in Egypt (**El-Sheikh 2015**). Extensive insecticides application caused resistance resurgence to major insecticides classes (**Su *et al.*, 2013; Garrood *et al.*, 2016**). Globally, documented pest resistance cases increasing by the time recording 260 pest species in 1986 (**Brattsten *et al.*, 1986**) increasing to 600 pest species in 2008 (**Whalon *et al.*, 2008**) and then recorded 954 pest species in 2014 (**Tabashnik *et al.*, 2014**).

In Egypt, chemical control of *S. littoralis* was used in large scale in 1955 with the introduction of the organochlorine, toxaphene. But, resistance to toxaphene has been resurged in 1961. Then, resistance to other members of organochlorine was documented consecutively for DDT 1963, lindane 1964 and endrin 1965 (**El-Sebae *et al.*, 1993**). After toxaphene resistance disaster, organophosphates were introduced to control the pest. Later, several reports confirmed organophosphates resistance in *S. littoralis* (**Mahran 1981; El-Nawawy *et al.*, 1981; Issa *et al.*, 1986; Smagghe and Degheele 1997**). So, new classes of insecticides such as methoxyfenozide has been used and proved more effective pest control (**Smagghe *et al.*, 2003**). Unfortunately, resistance to these insecticides has been reported in several insect pests such as in *Spodoptera litura* Fabricius (Lepidoptera: Noctuidae) (**Ahmad *et al.*, 2007; Shad *et al.*, 2012; Saleem *et al.*, 2016**) and *Spodoptera exigua* Hübner (Lepidoptera: Noctuidae) (**Ishtiaq *et al.*, 2014**). In Egypt, the extensive use of different insecticide classes creates a great necessity to monitor resistance development in *S. littoralis.* So, monitoring resistance levels of the pest to these insecticides must be assessed periodically. This will contribute effectively to select appropriate insecticides and to maintain their efficacy for a long time (**Shad *et al.*, 2012; Zhang *et al.*, 2014; Khan *et al.*, 2013**).

The main objective of the present work was to assess the status of insecticide resistance of *S. littoralis* which was collected during 2015 – 2017 from four Egyptian Governorates to six different insecticides, including insect growth regulator, spinosyn and avermectin groups and to analyze potential cross-resistance between these insecticides throughout pairwise correlation analysis.

MATERIALS AND METHODS

Test insect and insecticides:

The egg masses of cotton leafworm *S. littoralis* were collected from Behaira, Gharbia, Kafr El-sheikh and Beni Suef Governorates from 2015 to 2017. After collection, the egg masses were kept separately in 400 ml jar, covered with muslin held in position by rubber band until the eggs hatched. Laboratory strain of the *S. littoralis*, which is used in these tests, has been reared in the laboratory under the complete absence of insecticides as described by **El- Defrawi *et al.*, (1964)**. The field populations and laboratory strain were reared on fresh castor bean leaves at 25±1 ^oC, 75±5% RH.

Insecticides used presented in **Table (1).**

Table 1. List of insecticides with their trade names, active ingredients, IRAC classification and their producers

Active ingredient	Trade name	Manufacturer	Chemical group	IRAC MoA
Chlorfluazuron	Tubron	The National Company for Agrochemicals&Investment	Benzoylureas	Group 15
Flufenoxuron	Kalgeron	The National Company for Agrochemicals&Investment	Benzoylureas	Group 15
Hexaflumuron	Demeron	The National Company for Agrochemicals&Investment	Benzoylureas	Group 15
Lufenuron	Match	Syngenta	Benzoylureas	Group 15
Emamectin benzoate	Radical	Agromen Chemicals Co. Ltd	Avermectins	Group 6
Spinosad	**Spintor**	Dow AgroSciences	Spinosyns	Group 5

IRAC MoA Classification Version 8.4, May 2018

Bioassay :

A series of seven concentrations of each commercial insecticide was prepared in aqueous solution and were tested on 2^{nd} instar larvae of *S. littoralis*. Fresh castor bean leaves were dipped into insecticides solutions for 20 seconds and allowed to dry. Ten larvae of *S. littoralis* were placed on treaded leaf into Petri dishes, while, leaves dipped in tap water served as controls. Larvae were allowed to feed on treated leaves for 24-hrs and then completed with untreated leaves. Five replicates (i.e. 50 insects) for each concentration were used and mortality was recorded after 72 hrs.

Data analysis :

The mortality data were corrected for control mortality using Abbott's formula (**Abbot 1925**). The LC_{50} values, 95% confidence interval, and slopes were calculated by Probit analysis **(Finney 1971)** and if 95% FL of two treatments do not overlap, they are considered significant at 1% significance level **(Litchfield and Wilcoxon 1949)**. The resistance ratio (RR) was calculated by dividing the LC_{50} value of a field population by the corresponding LC_{50} value of the L- strain Levels of resistance were classified according to **Ahmad and Arif (2009)** as follows: susceptible (RR ≤ 1-fold), very low resistance (RR= 2-10 fold), low (RR = 11-20) moderate resistance (RR= 21-50), high resistance (RR= 51-100) and very high (RR > 100). Pearson correlation coefficient was calculated for pairwise correlation between Log LC_{50}s to interpret the cross-resistance among insecticides via the IBM SPSS (version 24) Statistics software package.

RESULTS AND DISCUSSION

In the current study, resistance to six insecticides were evaluated in four field populations of *S. littoralis* collected from different Egyptian Governorates in the period of 2015–2017. The tested insecticides include four insect growth regulators (chlorfluazuron, flufenoxuron, hexaflumuron and lufenuron), spinosad (Spinosyns) and emamectin benzoate (Avermectins insecticides).

Toxicity of the tested insecticides on field populations

Insect growth regulators (IGRs)

The tested IGRs compounds exhibited non to low resistant level **(Table 2)**. Regarding hexaflumuron, non to a very low level of resistance to hexaflumuron was recorded with RR value ranged from (o.45-2.46 fold). The most susceptible population was Behaira with RR value range (0.50-1.09 fold). Gharbia and Kafr El-shekh populations showed a similar trend as Behaira. In contrast, the least susceptible population was Beni Suif with RR value of (1.23-2.46 fold). Chlorfluazuron showed a very low resistance level with RR value ranged from 1.69 **(Gharbia 2015)** to 6.78 **(Kafr El-shekh 2017).** The most important noteworthy was the resistance factor increasing by the time in all the tested populations. Similar trends were obtained with flufenoxuron and lufenuron which exert a very low resistance level in all the tested populations. The highest flufenoxuron RR was observed with population with RR value of 5.75-fold **(Beni Suif 2017)**. Similarly, lufenuron recorded the highest resistance level with population with RR= 5.46 **(Kafr El-sheikh 2016)**.

Spinosad and emamectin benzoate

Toxicity of spinosad and emamectin benzoate on field populations compared with susceptible strain is shown in **Table (3)**. Field populations exhibited a very low resistance level to spinosad. The highest susceptible population was Behaira 2016 with RR = 0.92, and the same population, but season 2017, recorded the lowest susceptibility (RR = 4.60). The similar trend observed with emamectin benzoate as all the tested populations exhibited a very low resistance level except (Kafr El-sheikh 2017) which recorded RR value of 10. The previous data clarified that no obvious regular increase in resistance to spinosad and emamectin benzoate was noticed.

Table2. Toxicity of certain IGRs against different populations of S. *littoralis* from Egypt.

Insecticides	Population	year	Fit of probit			LC_{50} (95% FL) (mgL^{-1})	RR
			Slope ± SE	χ^2	df		
Chlorfluazuron	Lab Strain		1.69±0.15	0.79	3	0.95(0.82 – 1.10)	1.00
	Behaira	2015	1.72 ±0.15	2.76	3	2.27 (1.75 – 2.93)	2.38
		2016	1.75±0.15	0.38	3	3.02 (2.75 – 3.32)	3.17
		2017	1.89 ±0.16	3.37	3	3.19 (2.45 – 4.15)	3.35
	Gharbia	2015	1.46±0.12	1.57	4	1.61(1.37 – 1.88)	1.69
		2016	1.49± 0.14	1.36	3	2.16 (1.76 – 2.65)	2.27
		2017	1.93 ±0.16	0.59	3	2.87 (2.58 – 3.19)	3.02
	Kafr El-shekh	2015	1.55±0.15	0.72	3	3.99(3.45 – 4.59)	4.20
		2016	1.70±0.15	0.89	3	5.42 (4.67 – 6.28)	5.70
		2017	1.93±0.16	2.67	3	6.45 (5.14 – 8.10)	6.78
	Beni Suif	2015	1.78±0.16	0.26	3	3.57 (3.30 – 3.86)	3.75
		2016	1.13±0.11	0.43	4	3.58 (3.23 – 3.98)	3.76
		2017	1.86±0.16	1.01	3	5.97 (5.17 – 6.88)	6.28
Hexaflumuron	Lab Strain		1.67±0.15	2.25	3	6.54(5.16 -8.26)	1.00
	Behaira	2015	1.47±0.13	2.16	3	3.30(2.53 – 4.31)	0.50
		2016	1.60±0.15	0.40	3	4.18(3.77 – 4.64)	0.63
		2017	1.78±0.16	0.26	3	7.14(6.60 – 7.72)	1.09
	Gharbia	2015	1.54±0.15	1.44	3	2.98(2.44 – 3.65)	0.45
		2016	1.82±0.16	0.69	3	7.51(6.64 – 8.47)	1.14
		2017	1.73±0.15	2.69	3	9.11(7.10 – 11.68)	1.39
	Kafr El-shekh	2015	1.73± 0.15	1.20	3	6.70(5.62 – 7.96)	1.02
		2016	1.78±0.16	0.27	3	5.36(4.95 – 5.80)	0.81
		2017	1.65±0.16	2.00	3	8.72 (6.99 – 10.87)	1.33
	Beni Suif	2015	1.75±0.15	0.38	3	8.06(7.33 – 8.86)	1.23
		2016	1.59±0.15	0.44	3	10.43(9.32 – 11.67)	1.59
		2017	1.75±0.15	0.38	3	16.12(14.67 – 17.72)	2.46
Flufenoxuron	Lab Strain		1.99±0.17	1.22	3	6.03(5.14 – 7.06)	1.00
	Behaira	2015	1.66±0.15	0.68	3	13.04(11.47 – 14.82)	2.16
		2016	1.55±0.15	4.01	3	16.54(11.81 – 23.09)	2.74
		2017	2.30±0.20	4.20	4	23.96(20.32 – 28.24)	3.97
	Gharbia	2015	1.70±0.160	0.45	3	18.49(16.63 -20.25)	3.06
		2016	1.75±0.16	0.38	3	16.12(14.67 – 17.72)	2.67
		2017	2.06±0.17	0.99	3	25.11(21.96 – 28.70)	4.16
	Kafr El-shekh	2015	1.93±0.16	0.56	3	22.98(20.72 – 25.50)	3.81
		2016	1.98±0.17	1.63	3	27.40(22.98 – 32.64)	4.54
		2017	2.35±0.20	0.24	3	28.55(26.87 – 30.39)	4.73
	Beni Suif	2015	1.70±0.15	0.45	3	18.49(16.63 – 20.55)	3.06
		2016	1.84±0.20	8.07	2	28.28(26.30 – 30.41)	4.68
		2017	1.92±0.17	0.45	3	33.64(30.53 – 37.05)	5.57
Lufenuron	Lab Strain		1.84±0.16	8.31	3	1.76(1.68 – 1.83)	1.00
	Behaira	2015	1.67±0.15	2.28	3	2.17(1.70 – 2.75)	1.23
		2016	1.26±0.14	0.46	3	4.73(4.13 – 5.41)	2.68
		2017	2.01±0.17	0.87	3	8.43(7.40 – 9.60)	4.78
	Gharbia	2015	1.60±0.15	0.40	3	4.18(3.77 – 4.64)	2.37
		2016	1.63±0.15	2.36	3	3.83(2.97 – 4.91)	2.17
		2017	1.96±0.16	0.98	3	4.33(3.75 – 4.97)	2.46
	Kafr El-shekh	2015	1.69±0.16	0.78	3	4.35(3.80 – 4.97)	2.47
		2016	1.57±0.15	0.74	3	9.62(8.35 – 11.07)	5.46
		2017	1.60±0.15	2.25	3	8.32(6.43 – 10.71)	4.72
	Beni Suif	2015	1.85±0.16	8.66	3	3.52(3.37 – 3.68)	2.00
		2016	1.55±0.15	0.72	3	7.98(6.91 – 9.19)	4.53
		2017	1.73±0.16	2.69	3	5.69(4.43 – 7.30)	3.23

Table 3. Toxicity of new chemistry insecticides against different populations of S. littoralis from Egypt.

Insecticides	Population	date	Fit of probit			LC_{50} (95% FL) (mgL^{-1})	RR
			Slope ± SE	χ^2	df		
Spinosad	Lab Strain		1.84±0.16	0.12	3	0.25(0.23 – 0.26)	1.00
	Behaira	2015	1.77±0.16	0.24	3	0.34(0.31 – 0.36)	1.36
		2016	1.37±0.14	2.26	3	0.23(0.17 – 0.31)	0.92
		2017	1.72±0.15	0.76	3	1.15(1.00 – 1.31)	4.60
	Gharbia	2015	1.80±0.17	0.18	3	0.59(0.56 – 0.63)	2.63
		2016	1.50±0.15	1.47	3	0.47(0.38 – 0.58)	1.88
		2017	1.75±0.16	0.38	3	0.48(0.43 – 0.53)	1.92
	Kafr El-shekh	2015	1.78±0.16	0.26	3	0.34 (0.31 – 0.37)	1.36
		2016	1.48±0.14	1.18	3	0.57(0.47 – 0.68)	2.28
		2017	1.78±0.16	0.26	3	0.85(0.79 – 0.92)	3.40
	Beni Suif	2015	1.39±0.14	2.99	3	0.35(0.25 – 0.48)	1.40
		2016	1.24±0.11	3.49	3	0.32(0.21 – 0.47)	1.28
		2017	1.78±0.15	0.27	3	0.85(0.79 – 0.92)	3.40
Emamectin benzoate	Lab Strain		1.62±0.15	1.80	3	0.002(0.001 -0.003)	1.00
	Behaira	2015	1.34± 0.12	4.57	3	0.005(0.003 – 0.008)	2.50
		2016	1.85±0.16	8.66	3	0.014(0.013 – 0.015)	7.00
		2017	1.76±0.15	1.45	3	0.005(0.004 – 0.006)	2.50
	Gharbia	2015	1.71±0.15	3.09	3	0.004(0.003 – 0.005)	2.00
		2016	1.48±0.14	1.01	3	0.008(0.006 – 0.009)	4.00
		2017	1.65±0.14	0.24	3	0.009(0.008 – 0.010)	4.50
	Kafr El-shekh	2015	1.22±0.13	1.88	3	0.008(0.006 – 0.011)	4.00
		2016	1.90±0.17	0.33	3	0.011(0.010 – 0.013)	5.50
		2017	1.58±0.15	0.34	3	0.020(0.018 – 0.022)	10.00
	Beni Suif	2015	1.48±0.13	0.59	3	0.011(0.010 – 0.013)	5.50
		2016	1.71±0.16	1.46	3	0.011(0.009 – 0.014)	5.50
		2017	1.70±0.15	2.56	3	0.011(0.008 – 0.014)	5.50

Pairwise correlations analysis

Pairwise correlations analyses were conducted to explore cross-resistance possibilities among the tested insecticides. Our data showed a significant correlation between IGRs members except for lufenuron and hexaflumuron. In contrast, correlations between IGRs and spinosad were non-significant. Similarly, correlations between IGRs and emamectin benzoate were non-significant except chlorfluazuron which exhibited significant correlation. Finally, the correlation between spinosad and emamectin benzoate recorded a negative correlation **(Table 4)**.

Table 4. Pairwise correlation coefficient comparison between log LC_{50}s of the insecticides

	Chlorfluazuron	Hexaflumuron	Flufenoxuron	Lufenuron	Spinosad
Hexaflumuron	$0.634^{0.01}$				
Flufenoxuron	$0.760^{0.01}$	$0.737^{0.01}$			
Lufenuron	$0.620^{0.05}$	0.407^{ns}	$0.784^{0.01}$		
Spinosad	0.300^{ns}	0.329^{ns}	0.519^{ns}	$.507^{ns}$	
Emamectin	$0.746^{0.01}$	0.523^{ns}	0.455^{ns}	0.420^{ns}	-0.127^{ns}

Superscripts denote significance of the regression.
0.01: Correlation is significant at the 0.01 level (2-tailed).
0.05: Correlation is significant at the 0.05 level (2-tailed).
ns: non-significant

The current study investigated resistance status to six insecticides against *S. littoralis* populations collected from four different Egyptian governorates during the period 2015-2017. Resistance monitoring data is importance for resistance management **(Dennehy and Granett 1984; Zhang *et al.*, 2016)**. Tested populations exhibit various degrees of resistance to the tested insecticides. Results indicate that *S. littoralis* has the ability to develop resistance to a wide range of insecticides and suggest the prevalence of varying resistance levels **(Tong *et al.*, 2013)**. But practically, insects should not be assumed resistant until exceeding 10-fold of resistance **(Khan *et al.*, 2013)**. Pesticides resistance occurs mainly as a result of the extensive use of pesticides **(Saeed *et al.*, 2007)**. So, differences in resistance status in pest populations can contribute to differences in either selection pressure or the involvement of different resistance mechanisms. Consequently, previous reasons lead to differences in the rate of resistance development **(Silva *et al.*, 2011)**.

Insect growth regulators showed either susceptibility or very low levels of resistance in S. *littoralis* tested populations. Despite the continuous use of IGRs in the management of many pests, the very low resistance levels in IGRs might be due to an independent resistance mechanism of IGRs. Resistance to IGRs in *S. littoralis* was reported to tebufenozide and diflubenzuron **(Smagghe and Degheele 1997)**. In addition, resistance to IGRs have been reported in various lepidopteran insect pests e.g. the cut worm, *Spodoptera litura* (**Rehan and Freed 2014)**; *Spodoptera frugiperda* Smith **(Nascimento *et al.*, 2015)**, the beet armyworm; *Spodoptera exigua* **(Ishtiaq *et al.*, 2014)** and the diamondback moth, *Plutella xylostella* Linnaeus (Lepidoptera: Plutellidae) **(Cao and Han 2015)**.

Spinosad still effective insecticides and showed either susceptibility or very low level of resistance in all the tested populations. Similarly, emamectin benzoate shows a very low resistance level in all the tested populations except for Kafr El-shekh, in 2017, which exhibited low resistance level (10 fold). Our results in line with previous reports on *S. littoralis,* which showed non or very low resistance level to the new insecticides, pyridalyl **(Shoaib et al. 2014)**, spinosad and emamectin benzoate **(Ahmed *et al.*, 2016; Mostafa *et al.*, 2014)**. Other insect, in addition to *S littoralis* showed similar resistance profile to these alternatives such as the armyworm *Spodoptera litura,* which showed none to very low resistance to spinosad and emamectin benzoate, despite of their intensive use **(Ahmad and Mehmood 2015)**. In contrast, other insect species showed obvious resistance to these insecticides like, Mexican populations of beet armyworm *Spodoptera exigua* which showed significant resistance to spinosad (16- 37-fold) compared with a susceptible colony **(Osorio *et al.*, 2008)**. Also, the tomato borer *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae) exhibited high resistance levels to spinosad **(Campos *et al.*, 2015)**.

Pairwise correlation analysis revealed positive correlations and consequently cross-resistance between several insecticides. IGRs exhibited positive correlation in-between except hexaflumuron and lufenuron. Interestingly, the most attractive observation was the absence of a significant correlation between spinosad and all the tested compounds and the negative correlation between spinosad and emamectin benzoate. This implies that spinosad can be rotated with all other tested insecticides and can be rotated with emamectin benzoate for the management of insecticide resistance in S. *littoralis*. The absence of cross-resistance between spinosad and the other tested insecticides might be due to spinosad unique resistance mechanism. The different modes of action of these insecticides make cross-resistance between these insecticides unexpected. Consequently, the obtained results provide the opportunity to rotate the insecticides with different modes of action. Ultimately, rotating insecticides will reduce selection pressure resulting from the use of single insecticides for a long time **(Tikar *et al.*, 2009)**. In rotation, pesticide will be used to a short time to postpone resistance development. So, the efficacy of new insecticides will be sustained for a long time throughout optimizing their use **(Pu *et al.*, 2010)**. Cross-resistance between alternative insecticides was previously reported, in beet armyworm *Spodoptera exigua,* emamectin benzoate resistant strain showed a low level of cross-resistance to chlorfluazuron but no cross-resistance with spinosad, tebufenozide, and chlorpyrifos and lufenuron. **(Che *et al.*, 2015: Ishtiaq *et al.*, 2014)**. Similarly, the spinosad-resistant strain of the diamondback moth, *Plutella xylostella* exhibit non-cross-resistance to other spinosyns **(Sparks *et al.*, 2012)**. In cotton mealybug *Phenacoccus solenopsis* Tinsley (Homoptera: Pseudococcidae), emamectin benzoate resistant strain showed moderate, low, and no cross-resistance with abamectin, cypermethrin, and profenofos, respectively **(Afzal and Shad 2016)**.

The present study surveyed resistance levels of field-collected populations of *S. littoralis* to alternative insecticides among different governorates in Egypt. The obtained results can be used to prevent further development of insecticide resistance. To maintain effective management of insecticide resistance, spinosad and emamectin benzoate with non-cross resistance insecticides should be used in rotation against S. *littoralis*. The present study showed the importance of continuous insecticide resistance monitoring to manage insecticides resistance of S. *littoralis.*

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تقصي مستويات المقاومة في دودة ورق القطن لبعض المبيدات البديلة في أربع عشائر حقلية

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دودة ورق القطن آفة رئيسية تصيب العديد من المحاصيل الحقلية والخضروات.وتعتمد مكافحة هذة الآفة بصفة أساسية علي إستخدام العديد من المبيدات الكيماوية التي تنتمي لمجاميع مبيدات مختلفة . وقد ادي ظهور المقاومة للمبيدات التقليدية إلي إستخدام المبيدات البديلة والتي تمتاز بفعلها المختلف.ولضمان إستمرار فاعلية هذة المبيدات يلزم التتبع المستمر لحساسية الآفة تجاه هذة المركبات البديلة.وفي هذة الدراسة تم تقصي مستويات المقاومة لستة من المبيدات البديلة في أربعة محافظات وهي البحيرة،الغربية،كفرالشيخ وبني سويف في الفترة من عام 2015 إلي 2017 . وقد سجلت المبيدات التابعة لمنظمات النمو الحشرية مستويات مقاومة منخفضة تراوحت بين (1.23 – 5.46 ضعف) لليفينيرون ‘ (2.16 -5.57 ضعف) للفلوفينوكسيرون ‘ (1.69 – 6.78 ضعف) للكلورفلوزورون و (0.45 -2.46 ضعف) للهكسافلوميرون . بالإضافة الي ذلك أظهر مبيد الإيمامكتين بنزوات مقاومة تراوحت بين (2 – 10 ضعف) أما السبينوساد فأظهر (1.36 – 3.40 ضعف).واظهر إختبار تحليل الإرتباط بين المبيدات المستخدمة وجود مقاومة مشتركة بين المبيدات المنتمية لمنظمات النمو الحشرية فيما عدا الليفينيرون و الهكسافلوميرون. علي النقيض من ذلك أظهر التحليل عدم وجود أي مقاومة مشتركة بين الإسبينوساد وباقي المبيدات المختبرة ووجود إرتباط سالب بينة وبين الإيمامكتين بنزوات.لذا توصي هذة الدراسة بعمل تتابع بين المبيدات التي لاتوجد بينها مقاومة مشتركة وذلك لتحقيق مكافحة فعالة وللحفاظ علي فاعلية المبيدات أطول فترة ممكنة وتلافي ظهور المقاومة لهذه المبيدات .