ANTIFEEDANT, GROWTH INHIBTORY AND TOXICITY EFFECTS OF CHLORANTRANILIPROLE, THIAMETHOXAM AND NOVALURON AGAINST THE COTTON LEAF WORM, *SPODOPTERA LITTORALIS* (BOISD.) (LEPIDOPTERA: NOCTUIDAE) IN COTTON FIELDS

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Abstract

Antifeedant, growth inhibtory and toxicity effects of chlorantraniliprole, thiamethoxam and novaluron formulations at 1,1/2 and 1/4 field recommended rates were tested against the cotton leafworm *S. littoralis*, during the cotton seasons of 2011 and 2012. Results showed that, feeding the 4th instar larvae on treated cotton leaves at different rates decreased the food consumption. Morever, chlorantraniliprole seemes to be the most powerfull tested compounds. Feeding detrrence index for chlorantraniliprole, thiamethoxam and novaluron against 4th instar *Spodoptera* larvae were 92.5, 51.4 and 71.9 %, respectively after one day expoure, at low rats (¼ field rate) during 2011 cotton season. While, Feeding detrrence index were 92.0, 78.7 and 76.9 %, respectively during 2012 cotton season.

The relative growth rate of 4th instar *Spodoptera* larvae fed on cotton leaves treated with chlorantraniliprole, thiamethoxam and novaluron at 1, ½ and ¼ field rates was decreased. Toxicity of chlorantraniliprole, thiamethoxam and novaluron formulations was recorded clearly after two days expoure. After three days expoure, chlorantraniliprole gives 97.5, 95.5 and 95.0 percent mortality at 1, ½ and ¼ field rates, respectively against 4th instar *Spodoptera* larvae during 2011 cotton season. Thiamethoxam gives 77.5, 67.5 and 60.0 percent mortality at 1, ½ and ¼ field rates, respectively, while novaluron gives 62.5, 70.0 and 60.0 percent mortality, respectively. During 2012 cotton season, chlorantraniliprole gives 95.0, 95.0 and 92.5 percent mortality at 1, ½ and ¼ field rates, respectively, while thiamethoxam gives 90.0, 95.0 and 87.5 percent mortality, respectively. Novaluron gave 97.5 percent mortality for all field rates.

INTRODUCTION

Cotton leafworm *Spodoptera littoralis* (Boisd) (family: Noctuidae) is a serious lepidopteran pest of cotton through its different growth stages. In Egypt, larvae are heavily attacking vegetables and field crops including cotton causing severe damage and consequently reduction in the obtained yield(Pluschkell *et. al.,* 1998 and Korrat *et. al.,* 2012). Loss of about 50% of the cotton leaf area during the 1st, 2nd and 3rd generations of *Spodoptera* larvae reduced yield by 50, 65 and 40 %respectively (El-

Sherif *et. al.,* 1991). Natural defoliations by *Spodoptera* larvae (20-70%) can result in reductions in yield ≤50% (Russell *et. al.,* 1993).

Chlorantraniliprole is a new anthranilic diamide insecticide, which effectively controls pest insects belonging to Lepidoptera, Coleoptera, Diptera and Hemispheres, and has been shown to be effective against insects that have developed resistance to older classes of chemistry. Anthranilic diamides selectively bind to ryanodine receptors in insect muscles resulting in an uncontrolled release of calcium from internal stores in the sarcoplasmic reticulum (Lahm *et. al.,* 2005 and Cordova *et. al.* 2006), causing impaired regulation of muscle contraction leading to feeding cessation, lethargy, paralysis, and death of target organisms. Anthranilic diamides have very low vertebrate toxicity due to a >500-fold differential selectivity toward insect over mammalian ryanodine receptors (Cordova *et. al.* 2006).

Thiamethoxam is a broad spectrum neonicotenoid contact insecticide. The insecticidal activity of neonicotenoid is primarily attributed to their action on nicotinic acetylcholine receptors (nAChRs) (Karlin, 2002, Tomizawa and Casida, 2005). Neonicotenoid acute toxicity is ascribed primarily to their action as nicotinic agonists, acting on insect and mammal nAChRs (Tomizawa and Casida, 2003). On the other hand, several pieces of evidence in the literature show that neonicotenoid insecticides present a higher selectivity for the insect nAChRs than for the mammalian ones. Because of this selective activity, thiamethoxam has been evaluated as a seed treatment for several major field crops, including cotton (Arthur *et. al.* 2004).

Novaluron is a relatively new chitin synthesis inhibitor. It inhibits the chitin formation on larvae of various insects (Lepidoptera, Coleoptera, Homoptera and Diptera). Thus, it has a potent insecticidal activity against several important foliage feeding insect pests (Cutler *et. al.,* 2005) and very low toxicity to mammals, birds and earthworms. By inhibiting chitin formation, novaluron selectively targets immature insect stages, causing abnormal endocuticular deposition abortive molting (Rachid *et. al.* 2009).

The purpose of this study was to determine the efficacy of chlorantraniliprole, thiamethoxam and novaluron as antifeedant, growth inhibtory and toxic agent against the cotton leafworm *S. littoralis*, during the cotton seasons of 2011 and 2012 at Etay Elbaroud Agricultural Research Station, El-Beheira Governorate.

MATERIALS AND METHODS

Tested compounds

1. Coragen 20% SC (Chlorantraniliprole). It was provided by DU PONT DU NEMOURS Company.
2. Actara 25% WG (Thiamethoxam). It was provided by Syngenta Company.
3. Roxy 10% EC (Novaluron). It was provided by United Phosphorus Ltd.

Field strain of *Spodoptera littoralis*

Egg-masses of *Spodoptera littoralis* were collected from cotton fields at El-Beheira Governorate and directly transferred to the laboratory. After hatching the egg-masses were reared according to El-Defrawi *et. al.,* (1964) and 4th instar of *Spodoptera* larvae used for the experimental method.

The semi-field trial

Cotton experimental area was divided into 40 plots, each plot 1/100 feddan ($42m^2$). Randomized complete blocks design was used with four replicates for each treatment. A series of concentrations in water for chlorantraniliprole, thiamethoxam, novaluron and lufenron were used. Samples of treated leaves were randomly taken from each treatment to the laboratory where they were introduced to larvae. Fourth instar larvae of *S. littoralis* (newly moulted) with an average weight of 40-45mg were used. Four replicates of ten larvae each were used in each treatment, as well as, the control. In each replicate larvae were confined with treated leaves for 24 hours, after which they were transferred to clean glasses and provided regularly with fresh treated cotton leaves for four days. Dead larvae were discarded while the fresh weight of survivors and consumed serface area of cotton leaves discs ($530mm^2$) in each reaing glasses were recorded daily and related to the number of survivors in each experiment.

Data analsys

From test data, the following could be calculated: feeding deterrence index (FDI) = $[(C-T)/(C + T)] \times 100$, where C and T are the control and treated leaf consumed by the insect (Sadek, 2003).This index evaluates the potential of a substance to induce the cessation on feeding when tasted by an insect, and whether continues feeding in an alternative source of food.

The relative growth rate (RGR) was calculated according to (Farrar *et. al.,* 1989): RGR = $[\Delta B/BI] \times T$, where ΔB change in insect body weight (mg), BI initial larval weight and T = feeding period (days).

Percentage mortalities were corrected and calculated according to Abbott's formula, (Abbott, 1925).

RESULTS AND DISCUSSION

Antifeedant, growth inhibtory and toxicity, effects of chlorantraniliprole, thiamethoxam and novaluron formulations at 1,1/2 and ¼ field recommended rates were tested against the cotton leafworm *S. littoralis*, during the cotton seasons of 2011 and 2012. Data in table (1) summarized feeding detrrence index for chlorantraniliprole, thiamethoxam and novaluron formulations at 1, 1/2 & 1/4 field recommended rates were tested against the cotton leafworm *S. littoralis*. The data indicated that, when 4th instar *Spodoptera* larvae fed on cotton leaves treated with different rates, cotton leaves consumption for *Spodoptera* larvae is decreased. Morever, chlorantraniliprole seemes to be the most powerfull tested compounds against 4th instar *Spodoptera* larvae. Feeding detrrence index for chlorantraniliprole, thiamethoxam and novaluron against 4th instar *Spodoptera* larvae were 92.5, 51.4 and 71.9 %, respectively after one day expoure, at ¼ field rate during 2011 cotton season. While, Feeding detrrence index were 92.0, 78.7 and 76.9 %, respectively during 2012 cotton season.

Table. 1. Antifeedant activity of chlorantraniliprole, thiamethoxam and novaluron against 4th instar Spodoptera larvae at different exposure time during 2011 and 2012 coton seasons.

Time expposure	Doses (Field rats)	Feeding detrrence index (FDI)					
		2011			2012		
		Chlo	Thia	Nova	Chlo	Thia	Nova
1 day	1 f	99.3	55.3	60.2	95.8	90.1	79.0
	1/2	93.1	56.6	65.6	93.4	85.8	77.9
	1/4	92.5	51.4	71.9	92.0	78.7	76.9
2 days	1 f	99.7	81.8	86.7	100.0	99.9	96.5
	1/2	99.7	75.3	78.7	100.0	99.9	94.1
	1/4	100.0	89.8	78.2	100.0	99.8	96.9
3 days	1 f	100.0	94.6	96.4	100.0	100.0	100.0
	1/2	100.0	91.0	95.7	100.0	100.0	99.1
	1/4	100.0	96.7	98.3	100.0	99.9	100.0

FDI = [(C-T)/(C + T)] ×100, where C and T are the control and treated leaf consumed by the insect (Sadek, 2003),

Chlo= Chlorantraniliprole, Thia= Thiamethoxam, Nova= Novaluron

Table. 2. Growth inhibtory effect of chlorantraniliprole, thiamethoxam and novaluron against 4th instar Spodoptera larvae at 2011 and 2012 coton seasons.

season	Feeding period	The relative growth rate (RGR)									
		Control	Chlorantraniliprole			Thiamethoxam			Novaluron		
			1/4	1/2	1	1/4	1/2	1	1/4	1/2	1
2011	1 day	0.63	0.03	0.00	0.00	0.05	0.05	0.00	0.00	0.03	0.03
	2 days	5.00	0.00	0.00	0.00	0.45	0.15	0.10	0.10	0.10	0.10
	3 days	12.75	-0.83	-0.68	-1.13	0.15	0.08	-0.83	-0.83	-0.30	-0.68
2012	1 day	1.11	0.04	0.07	0.04	0.20	0.13	0.31	0.31	0.29	0.24
	2 days	6.44	0.00	-0.09	0.06	0.22	0.90	0.53	0.53	0.53	0.36
	3 days	14.60	-0.60	-0.93	0.33	-0.60	-0.67	0.07	0.07	0.07	0.13

RGR = [ΔB/BI] ×T, where ΔB change in insect body weight (mg), BI initial larval weight, T = feeding period (days) (Farrar *et. al.,* 1989).

At the same conditions, the relative growth rate of 4th instar *Spodoptera* larvae fed on cotton leaves treated with chlorantraniliprole, thiamethoxam and novaluron at 1, ½ and ¼ field rates were calculated (Table 2). The data indicated that, the majority of insecticides treatments decreased the relative growth rate of 4th instar *Spodoptera* larvae.

General pattern was observed for the formulations, where the toxicity is increased with increasing the time elapsed after treatment. When cotton plants were sprayed with different field rates of chlorantraniliprole, thiamethoxam and novaluron formulations, toxicites were recorded clearly after two days expoure. Data in table (3) showed that, after three days expoure, chlorantraniliprole gives 97.5, 95.5 and 95.0 percent mortality at 1, ½ and ¼ field rates, respectively against 4th instar *Spodoptera* larvae during 2011 cotton season. Thiamethoxam gives 77.5, 67.5 and 60.0 percent mortality at 1, ½ and ¼ field rates, respectively, while novaluron gives 62.5, 70.0 and 60.0 percent mortality, respectively. During 2012 cotton season, chlorantraniliprole gives 95.0, 95.0 and 92.5 percent mortality at 1, ½ and ¼ field rates, respectively, while thiamethoxam gives 90.0, 95.0 and 87.5 percent mortality, respectively. Novaluron gives 97.5 percent mortality for all field rates.

Table. 3. Toxicity of chlorantraniliprole, thiamethoxam and novaluron against 4th instar of Spodoptera larvae after application of different insecticide doses during 2011 and 2012 coton seasons.

Treatment (Field rats)	%Mortality after treatment					
	2011			2012		
	1 day	2 days	3 days	1 day	2 days	3 days
Chlorantraniliprole	20.0	92.5	97.5	22.5	60.0	95.0
Chlorantraniliprole1/2	17.5	90.0	95.5	27.5	50.0	95.0
Chlorantraniliprole1/4	22.5	85.0	95.0	20.0	52.5	92.5
Thiamethoxam	17.5	65.0	77.5	20.0	50.0	90.0
Thiamethoxam1/2	12.5	57.5	67.5	12.5	57.5	95.0
Thiamethoxam1/4	2.5	50.0	60	20.0	40.0	87.5
Novaluron	5.0	55.5	62.5	20.0	42.5	97.5
Novaluron1/2	12.5	57.5	70.0	20.0	62.5	97.5
Novaluron1/4	27.5	50.0	60.0	30.0	62.5	97.5

In summary, this study has presented the novel observation that field doses and sublethal doses of chlorantraniliprole, thiamethoxam and novaluron formulations appears antifeedant, growth inhibtory and toxic effects against the cotton leafworm *S. littoralis*. These results were agreement with those obtained by Cutler *et. al.,* (2005) and Jia *et. al.* (2011) they found that thiamethoxam, chlorantraniliprole and novaluron have a potent insecticidal activity against several important foliage feeding insect pests. Daniels *et. al.* 2009, they reported that, aphids feeding on wheat treated with thiamethoxam were reduced weight, body plan area and food consumption than aphids feeding on wheat treated with distilled water. Chlorantraniliprole causes feeding cessation, lethargy, muscle paralysis and ultimately death by activating the ryanodine receptor (Cao *et. al.,* 2010 & Cordova *et. al.* 2006 and Lahm *et. al.,* 2005). Rachid *et. al.,* (2009) showed that the highest concentrations of novaluron caused a dose-dependent growth inhibition of *Paramecium* population by reducing the chitin and cuticle of cells.

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تاثيرات منع التغذية، تثبيط النمو و السمية لكلورانترانيليبرول، الثياميثوكسام والنوفاليورون ضد يرقات دودة ورق القطن فى حقول القطن

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معهد بحوث وقاية النباتات– محطة البحوث الزراعية بايتاى البارود– مركز البحوث الزراعية

أجرى هذا البحث بمزرعة محطة البحوث الزراعية بايتاى البارود خلال موسمى 2011، 2012 لدراسة تاثيرات منع التغذية، تثبيط النمو و السمية لمركبات الكلورانترانيليبرول،الثياميثوكسام و النوفاليورون ضد يرقات دودة ورق القطن 1، ½ ، ¼ من المعدلات الحقلية على نباتات القطن معمليا و حقليا . أوضحت الدراسة انه عند تغذية يرقات العمر الرابع لدودة ورق القطن على ورق قطن معامل بتركيزات مختلفة، انخفض معدل الاستهلاك الغذائى و كان الكلورانترانيليبرول اكثر المركبات فاعلية. مؤشر منع التغذية لكلورانترانيليبرول، الثياميثوكسام و النوفاليورون هو 92.5، 51.4 و71.9% على التوالى بعد التعرض ليوم واحد بتركيزات منخفضة (ربع التركيز الحقلى) خلال موسم قطن 2011، بينما كان مؤشر منع التغذية هو 92.0، 78.7 و 76.9%، على التوالى خلال موسم قطن 2012.

تحت نفس الظروف كان معدل النمو النسبى ليرقات العمر الرابع لدودة ورق القطن التى غذيت على اوراق قطن معاملة بالكلورانترانيليبرول،الثياميثوكسام و النوفاليورون بتركيزات 1، ½، ¼ من المعدلات الحقلية انخفض خلال الموسمين. :كانت سمية الكلورانترانيليبرول،الثياميثوكسام و النوفاليورون تظهر بوضوح بعد يومين من التعرض، أن بعد ثلاثة ايام من التعرض سجل الكلورانترانيليبرول نسب مئوية للموت 97.5، 95.5 و 95.0% بمعدلات (1، ½، ¼ من المعدلات الحقلية)، على التوالى خلال موسم قطن 2011. النسبة المئوية للموت لثياميثوكسام 77.5، 67.5 و60.0%، على التوالى، بينما كانت النسبة المئوية للموت ل نوفاليورون 62.5، 70.0 و60.0%، على التوالى. أما خلال موسم قطن 2012 كانت النسبة المئوية للموت لكلورانترانيليبرول بعد ثلاثة ايام من التعرض 95.0، 95.0 و 92.5% بمعدلات (1، ½، ¼ من المعدلات الحقلية)، على التوالى، النسبة المئوية للموت لثياميثوكسام 90.0، 95.0 و 87.5%، على التوالى. بينما كانت النسبة المئوية للموت لنوفاليورون 97.5%، لكل من المعدلات الحقلية الثلاثة.