Evaluation of Ten Insecticides Distributed into Seven Sequences against Bollworms Complex

Magdy Mohamed Kamel Shekeban[1]

ABSTRACT

Ten insecticides namely chlorpyrifos, profenofos (organophosphates), alpha-cypermthrin, deltamethrin , lambda-cyhalothrin, cypermthrin, (synthetic pyrethroids), acetamiprid (neonicotinoids), emmamectin benzoate (avermectains), chlorfenapyr (halogenated pyrroles) and spinosad (bio- insecticides)] were evaluated against cotton bollworms, the pink bollworm (PBW) *Pectinophora gossypiella* (Saunders), the spiny bollworm (SBW) *Earias insulana* (Boisd.) and the American bollworm (ABW) *Heliothis armigera* (Hübner) in seven sequences in 2011 cotton growing season. The average infestation number in all experimental plots was monitored before spraying and weekly for eight weeks post insecticide sequences applications. Data show that, the infestation number prespray varied between 3 to 11 infested green bolls /100 bolls. The general means of the infestation number post treatment showed significant differences between treatments with values of 3.4, 4, 4.3, 3, 4.9, 7.4, 1.6 and 24.5 infested green bolls /100 bolls for sequences from 1 to 7 and control, respectively. Reduction percentages in the infestation were determined weekly for eight weeks through the four successive sprays with 15 days interval. Based on general reduction average it is clear that all sequence programs induced high effect representing 80.0 up to 94.6%. In the same manner, the tested sequences showed high protection for the green bolls with protection percentages ranged from 69.9% (sequence 6) to 93.5% (sequence 7). On the other hand, the tested sequences reduced the cotton yield loss in comparing with the control and the recorded yield loss percentages were 10.17, 13.7, 7.91, 14.38, 20.5, 13.82 and 6.72% for sequences 1 to 7, while it was 46.76% for the control.

INTRODUCTION

Cotton is attacked by various pests during the different stages of its development, whoever, many insect species have been reported on cotton and some of them were classified as major pests that can destroy the plants in a few days; i.e., cotton leafworm, *Spodoptera littoralis* (Boisd.), pink bollworm *Pectinophora gossypiella* (Saund.) and the spiny bollworm *Earias insulana* (Boisd.) (Abou Kahla *et al*.,1990, Mireulle *et al*., 1999). Chemical control is still considered one of the most important methods for controlling pests (Korkor *et al*., 1995) and the synthetic insecticides are often a part of management programs to control lepidopterous pests (Aydin and Gurken, 2006). The success of bollworms complex control program relies on use of insecticides belonging to different groups in certain sequences, application time and spray interval (Watson *et al*.,1986, El-Feel *et al*.,1991; Abd El-Mageed *et al*. 2007). Profitable cotton production in Egypt depend on successful and efficient insect management program which reduces the risk disastrous crop loss by pests (El-Basyouni, 2003).

Carbamate insecticides were usually used at the last or the third spray for controlling bollworms (specially the spiny bollworm). Since 2005, the Egyptian Committee for Agricultural Pesticides (ECAP) decided to not use the carbamate group through spray rotation programs. So, it is urgent to find a promising compound environmentally safe and effective against spiny bollworm to be used instead of Carbaryl®. Conventional insecticides have not provided a long-term solution to the bollworms problem, moreover as a result of continued massive use of certain synthetic insecticides against the cotton pests, tolerant and resistant strains have been developed (Schmutterer, 1985). Ministry of Agriculture in Egypt is hoping to find a safe product with low effect in the environment and satisfactory killing power especially for spiny bollworm. So, spinosad was chosen because it is classified by EPA as a reduced risk product and awarded the green chemical challenge award from the white house in the USA in 1999 (Temerak, 2003).

The most of yield and quality loss are caused by insect pest, such as cotton bollworms (Kaushik *et al*.,1969). Insects that cause loss to the fruit are frequently more destructive than those damage leaves, stems and roots, loss extend to oil contents in the seeds (Amin and Gergis, 2006). Cotton growers in Egypt have experienced severe economic loss from cotton pests due to reduced yields, low lint quality and increased costs of insecticides (Burrows *et al*., 1982). Recently, the national cotton council estimated that US cotton producers' annual loss to pink bollworm are about $21 million due to prevention control cost, and lower yield by plant damage (NCC, 2001).

The aim of this study was to introduce new insecticides (emmamectin benzoate, acetamiprid and chlorfenapyr) with new mode of actions, low dose and environmentally safe to evaluate the effectiveness of

[1]Plant Protection Station, PPI, ARC, Alexandria, Egypt.
E-mail: Magdy_shekeban@yahoo.com
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these new insecticides in their sequences against cotton bollworms (pink, spiny and American bollworms) infesting cotton green bolls and also, to determine the cotton yield loss.

MATERIALS AND METHODS

The experiment design

Field experiments were carried out in a private farm at Kafr El-Dawar District, El-Behera Governorate, Egypt, during 2011 cotton growing season. The tested insecticides are listed in Table 1. The evaluated insecticides were used in seven sequences as shown in Table 2. The fields were cultivated with Giza 86 cotton variety on May15, 2011 and the normal agricultural practices were applied

The experimental area was 2.5 feddans and it was divided into plots of 2 Kirrats each and the treatments were arranged in random complete plots with four replicates. A ground motor sprayer was used to apply the insecticide dilutions. The volume of spray solution was 400 litter /feddan.

Procedures of insecticide sequences evaluation:

Four sprays with two weeks interval were took place through the course of this study. To evaluate the effectiveness of the tested sequences treated against bollworms complex, samples of 100 green bolls per treatment (25 bolls for each replicate) were randomly dissected. The infestation numbers in the green bolls were recorded pre-spray and then boll samples were collected weekly post-sprays and then the percent of reduction was calculated according to the equation of Henderson and Tilton (1955):

Reduction of infestation% =[1- {(a/b) x (c/d)}] x100

Where: *a*= number of infestation in control pre-spray, *b*= number of infestation in control after spray, *c*= number of infestation in treatment after spray and *d*= number of infestation in treatment pre-spray.

Table 1. The tested insecticides

Common Name	Trade Name	Formulation	Applied Rate
Chlorpyrifos	Pestban®	48% EC	litter/F
Profenfos	Cord®	72% EC	750 cm^3/F
Alpha-Cypermethrin	Pestox®	15% EC	165 cm^3/F
Deltamethrin	K-othrin Kema®	5% EC	175 cm^3/F
Lambda - Cyhalothrin	Axon®	5% EC	375 cm^3/F
Cypermethrin	Cyparko®	20% EC	300 cm^3/F
Emmamectin Benzoate	Radicl®	0.5% EC	800 cm^3/F
Acetamiprid	Acetamor®	20% SP	100 gm/F
Chlorfenapyr	Pyricide®	24% EC	300 cm^3/F
Spinosad	Spintor®	24 % SC	50 cm^3/F

Table 2. The tested sequences

Sequences	Insecticides spray dates			
	7 / 8/2011	22 / 8/2011	7 /9/2011	22 /9/2011
Sequence 1	Pestban®-chlorpyrifos	K-othrin Chema® -deltamethrin	Acetamor® -acetamiprid	Cord®-profenfos
Sequence 2	Pestban®-chlorpyrifos	Axon® –lambda-cyhalothrin	Spintor®- spinosad	Cord®-profenfos
Sequence 3	Cord®-profenfos	K-othrin Chema® -deltamethrin	Radicl® -emmamectin benzoate	Pestban®-chlorpyrifos
Sequence 4	Radicl® -emmamectin benzoate	Cyparko® -cypermthrin	Cord®-profenfos	Pestban®-chlorpyrifos
Sequence 5	Pestban®-chlorpyrifos	Pestox® –alpha-cypermthrin	Spintor®- spinosad	Pestban®-chlorpyrifos
Sequence 6	Acetamor® -acetamiprid	Pestox® –alpha-cypermthrin	Pyricide®-chlorfenapyr	Cord®-profenfos
Sequence 7	Pestox® –alpha-cypermthrin	K-othrin Chema® -deltamethrin	Axon® –lambda-cyhalothrin	Cyparko® -cypermthrin

In addition, the percentages of the protected bolls were calculated according to the following equation: Protected Bolls % = [1 – (TNIT / TNIC)] x 100.

Where: TNIT= total number of infestation in treatment.

TNIC = total number of infestation in control,
Moreover, one way ANOVA test was used to compare treatments together (Costat Statistical Software, 1990).

Estimation of cotton yield loss

Randomly, one hundred cotton plants were chosen from each treatment to study the cotton yield loss caused by bollworms. The following method according to Hassan (2007) was used to estimate the cotton yield losses. The complete opened bolls (A), the 2/3 opened bolls (B), the 1/3 opened bolls, the dry bolls (D) and the green unopened bolls (E) were counted then the expected open bolls (F) were calculated as follow: F = A + B + C + D + E

The true opened bolls (G) = A + (B x 2/3) + (C x 1/3)

The number of unopened bolls (H) = F – G

The loss % (I) = (H/F) x 100 or I%= (1 – G/F) x100

RESULTS AND DISCUSSION

Efficiency of tested sequences against the cotton bollworms:

The average percent infestation in all experimental plots was monitored pre – spray and weekly for eight weeks post insecticide sequences spray. Data in Table 3 show that, the infestation number pre- spray varied between 3 to 11infested green bolls / 100 bolls. The infestation number after the first spray ranged between 7 in the first week of the inspection for sequence 6 and 2 for sequence 7 where it reached 8 in the control plots. By the second week of inspection, the greatest infestation number was counted in the control treatment (15 infested bolls) that was significantly differed compared to all sequence treatments which differed together and the lowest infestation number was zero for sequence 4.

For the second spray, the highest infestation number was detected for sequence 6 (7 infestations) in the fourth inspection week, while the lowest was for three sequences 1, 4 (week 3) and sequence 2 (week 4) and it was zero, whereas the infestation number in the control treatment reached 23 infestations by the fourth inspection week.

The infestation number at the 3rd spray represented 9 infestations in the 6th week for sequence 6 as the highest infestation between treatments and 1 in the same week for sequence 7 as the lowest infestation, whereas, the view in the control plots was higher (27 and 29 infestations for week 5 and week 6, respectively). The highest infestation number after the 4th spray was 10 infestations and it was detected in the 7th week for sequence 6 while the lowest was zero in the same week for sequence 7. For the control plots the infestation number was increased from the 7th week to the 8th week starting with 35 infestations reached to 41 infestations by the end of the experiment. The statistical analysis indicated that, there were significant differences between all treatments and the control and also between treatments, where sequence 7 (all pyrethroids) showed the superior effect in reducing the infestation number while sequence 6 showed the lowest reduced number in relation to control treatment. Also, results obtained from this Table discuss the general infestation number mean and it revealed that there were significant difference between all treatments and the control plots and also, there were significant differences between some treatments.

Table 3. Number of infested bolls pre- and post- insecticide sequences application

Insecticide Sequences	Pre-Spray	Infestation numbers Post-Spray								TIN	GINM
		1st spray		2nd spray		3rd spray		4th spray			
		1*	2	3	4	5	6	7	8		
Sequence1	7c	5abc	3c	0d	2d	4bc	4d	5d	6c	29cd	3.6cde
Sequence2	5d	4bc	2c	1cd	0e	4bc	6c	7c	8b	32cd	4cd
Sequence3	11a	5abc	3c	2c	5c	6bc	2ef	7c	6c	36c	4.3cd
Sequence4	3e	3c	0d	0d	2d	4bc	3de	5d	7bc	24d	3de
Sequence5	5d	5abc	6b	4b	3d	4bc	2ef	7c	8b	39c	4.9c
Sequence6	9b	7ab	5b	5b	7b	8b	9b	10b	8b	59b	7.4b
Sequence7	7c	2c	2c	1cd	2d	3c	1f	0e	2d	13e	1.6e
Control	4de	8a	15a	18a	23a	27a	29a	35a	41a	196a	24.5a
L.S.D 0.05	1.24	2.76	1.3	1.3	1.3	4.24	1.30	0.62	1.24	10.37	2.365

TIN= Total Infestation Number * = inspection week GINM= General Infestation Number Mean

Table 4. Bollworms infestation Reduction % after the tested sequences sprayed

Insecticide Sequences	Reduction % post- Spray								
	1st Spray		2nd Spray		3rd Spray		4th Spray		General R. Average
	1*	2	3	4	5	6	7	8	
Sequence1	64.3	88.6	100	95.0	90.1	92.1	91.8	91.6	89.2c
Sequence2	60	89.3	95.6	100	88.2	83.4	84.0	84.4	85.6d
Sequence3	77.3	92.7	96	92.1	91.9	97.5	92.7	94.7	91.9b
Sequence4	50	100	100	88.4	80.2	86.2	81.0	77.2	82.9f
Sequence5	50	68	82.2	89.6	88.2	94.5	84.0	84.4	80.0g
Sequence6	61.4	85	87.6	86.5	86.8	86.5	87.3	91.3	84.0e
Sequence7	85.7	85.2	96.8	95.0	93.7	98.0	100	97.2	94.6a
L.S.D 0.05									0.386

General R .Average = General Reduction Average * = inspection

The general infestation number mean was ordered in the following descending order: 1.6, 3, 3.6, 4, 4.3, 4.9, 7.4 and 24.5 for sequence 7, 4, 1, 2, 3, 5, 6 and the control, respectively.

These data were in harmony with the finding of many investigators. El-Sorady *et al*., 1998 mentioned that chlorpyrifos and lambda-cyhalothrin gave a good reduction in pink bollworm infestation. Younis *et al*. (2007) cited that, six weeks after pesticide treatments, the infestation averaged 4 to 7% in insecticide treatments compared to 22% in control treatment. Insecticide treatments were varied in their efficiency against bollworm. The greatest number of larvae was counted in the control treatment that was significantly different compared to all insecticide treatments. El-Aswad and Aly (2007) reported that, the results of the field experiment showed significant differences between the infestation numbers of all tested insecticides and the control. Abd El-Mageed *et al*. (2007) revealed that, the obtained data for the tested programs reduced the rate of pink bollworm and spiny bollworm larvae during the three sprays.

Reduction percentages in bollworm infestation post sprays were calculated and the general reduction averages of bollworm infestations were analyzed using ANOVA and the obtained data were tabulated in Table 4.

In general, all the tested sequences resulted in an appreciable reduction in bollworms infestation as compared with control. The highest reduction percent was 100% and it was obtained at the 2nd inspection from the 1st and 2nd sprays of the 2nd and 4th sequences (Radicl® - emmamectin benzoate and Axon® – lambda-cyhalothrin), and also at the 1st inspection from the 2nd and 4th sprays of the 1st , 4th and 7th sequences (K-othrine Chema® - deltamethrin, Cyparko® - cypermthrin and Cyparko® - cypermthrin, respectively), whereas the lowest reduction % was 50% and it was recorded at the 1st inspection from 1st spray of the 4th and 5th sequences (Radicl® - emmamectin benzoate and Pestban®-chlorpyrifos). Generally, the lowest reduction percentages were detected for the first inspection week, where it was fluctuated with upper percentages till the end of the experiment.

According to general reduction average it was clear that sequence 7 induced the highest effect representing 94.6% reduction in infestation, while sequence 5 proved to be the lowest effective one, it suppressed the infestation by 80%. Reduction in the general average of infestation after the four sprays revealed that, there were significant differences among the treated sequences.

These results are in agreement with many investigators. Allen *et al*. (1997) found that large and medium sized bollworm larvae were significantly less numerous in cyfluthrin and spinosad treated plots than in control plots. Ibrahim *et al*. (2000) reported that the calculation percentages of the infestation level of cotton bollworms (spiny and pink bollworm) were decreased after three sequential insecticidal sprays when compared with the control. Temerak (2003) reported that the pest program of field rotation trials for control of bollworms utilized chlorpyrifos + hexaflumuron, es-fenvalerate, profenofos and spinosad +oil (92% reduction). The good results of synthetic pyrethroids sequence come in agreement with the finding of El-Metwally *et al*. (2003) who reported that the average of reduction in pink bollworm larvae was 90.3, 83.6 and 73.5% for fenpropathrin, esfenvalerate and lambda-cyhalothrin, respectively. Younis *et al*. (2007), cited that the percentages of reduction in the general average of larvae counted in gamma-cyhalothrin, deltamethrin and esfenvalerate treatments were significantly higher compared to other pesticide treatments. El-Aswad and Aly (2007) reported that the pyrethroids were more effective in reducing bollworms infestation than organophosphorous compounds.

Table 5. Percentages of protected bolls in sequencial treatments post-spray

Sequences	Total Infestation Number	General Protected Bolls %
Sequence 1	29	85.2
Sequence 2	32	83.7
Sequence 3	36	81.6
Sequence 4	24	87.8
Sequence 5	39	80.1
Sequence 6	59	69.9
Sequence 7	13	93.4
Control	196	-

Table 6. Assessment of loss due to bollworms in different sequence treatments

Sequences	A	B	C	D	E	F	G	H	I %
Sequence 1	59.25	3.48	3.25	0.24	3.52	69.74	62.65	7.09	10.17d
Sequence 2	56.52	4.76	7.24	0.72	2.72	71.96	62.10	9.86	13.70c
Sequence 3	61.14	4.84	1.64	0.24	2.64	70.50	64.92	5.58	7.91e
Sequence 4	59.72	5.63	1.80	0.16	7.52	74.83	64.07	10.76	14.38c
Sequence 5	50.76	12.36	4.36	0.28	8.28	76.04	60.45	15.59	20.50b
Sequence 6	62.48	8.00	3.00	0.68	5.68	79.84	68.81	11.03	13.82c
Sequence 7	63.20	4.16	1.88	0.00	2.16	71.4	66.60	4.80	6.72e
Control	30.08	4.92	9.88	16.44	6.84	68.16	36.29	31.87	46.76a
L.S.D 0.05									1.590

A = number of complete open bolls B = number of 2/3 open bolls C = number of 1/3 open bolls
D = number of dry bolls E = green bolls F = number of theoretical open bolls G = number of observed open bolls.
H = number of un opened bolls I = Loss %

The presented data in Table 5 show the percentages of protected bolls as a result of insecticide sequences spray. The highest percent of boll protection was 93.4% it was obtained by sequence 7 (Pestox®, K-othrine Chema®, Axon® and Cyparko) and the lowest boll protection percent was 69.9% due to sequence 6 (Acetamor, Pestox®, Pyricide® and Cord®). On the other hand, all the tested sequences could be categorized into the following descending order: sequence 7, sequence 4, sequence 1, sequence 2, sequence 3, sequence 5 and sequence 6.

The results in Table 6 showed the effect of the applied sequences on the loss of cotton yield. These data pointed to high significant difference between the untreated plots and the treated plots and also, there were significant differences between some of the applied sequences. In comparison to the untreated plots (loss percent = 46.76%), the lowest estimated percent of yield loss was found with sequence 7 (loss percent = 6.72%) whereas, the highest loss percentage was detected for sequence 5 (loss percent = 20.5%).

The superiority in yield loss reduction can arrange in the following order: sequence7, 3, 1, 2, 6, 4 and 5, respectively. These results are in agreement with those obtained by many researchers. Dhawan *et al.* (1990) reported that *Earias spp*. caused a loss ranged from 12.5 to 16.6 % of shed buds, 0.9 to 2.5 % of flowers and 7.9 to 9.5 % of bolls. Karner *et al*. (2003) mentioned that cotton yield in insecticide treated plots were 9% greater compared to untreated plots. Studebaker *et al.* (2003) found that the bollworm / tobacco budworm complex has been reported to cause yield loss in cotton in range of 1.05 to 3.97%. The lower estimated percentages of the yield loss occurred with the treatments of fenpropathrin and Es-fenvelerate followed by fenvalerate, cyfluthrin and Thiodicarb (Ibrahim *et al*., 2000). Hassan (2007) reported some significant differences between control and treatments and also between treatments. The cotton yield loss% due to bollworms were 15.84, 17.8, 20.64 and 56.88% for treatment 1, treatment 2, treatment 3 and the control, respectively.

CONCLUSION

The tested new insecticides emmamectin benzoate, acetamiprid and chlorfenapyr showed superior effect individually and in their sequences, so we suggest to implement these insecticides in the integrated pest management (IPM) programs to control cotton bollworms.

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الملخص العربي

تقييم عشر مبيدات موزعة على سبعة تتابعات ضد ديدان اللوز

مجدي مُحَمَّد كامل شكيبان

لقد تم تقييم عشر مبيدات تسمى كلوربيرفوس وبروفينفوس (مبيدات فسفورية) والفاسيبرمثرين ودلتامثرين ولمباداسيهالوثرين وسيبرمثرين(مبيدات بيرثرويدية) واسيتامبريد(مبيدات نيونيكوتينويد) وامامكتين بنزوات (مبيدات افيرمكتين)وكلورفينابير (مبيدات هالوجيناتيد بيرولز) وسبينوساد(مبيدات حيوية) ضد ديدان اللوز (دودة اللوز القرنفلية, دودة اللوز الشوكية، دودة اللوز الامريكية) ولقد تم توزيع هذه المبيدات العشرة في سبعة تتابعات ثم رشها خلال موسم قطن 2011 وبفاصل زمني اسبوعين.

لقد تم احتساب متوسط عدد الاصابات بمختلف ديدان اللوز قبل بداية الرش لكل القطع التجريبية وايضا اسبوعيا بعد الرش لمدة ثماني اسابيع, حيث اشارت النتائج الى ان متوسط عدد الاصابات قبل الرش تراوح ما بين 3 الى 11 اصابة في اللوز الاخضر/ 100 لوزة. اشارت النتائج الى ان المتوسط العام للاصابة بعد الرش كان3.4 ، 4 ، 4.3، 3 ، 4.9 ، 7.4 ، 1.6 اصابة للتتابعات من 1 الى 7، على التوالي، في حين كان المتوسط العام للاصابة في قطع المقارنة 24.5 إصابة.

لقد تم تقدير النسب المئوية لخفض الإصابة بعد الرش أسبوعيا ولمدة ثمانية أسابيع وذلك خلال أربع رشات تامة وبفاصل زمني 15 يوم.

قياسا على المتوسط العام لخفض الاصابة فقد أظهرت كل التتابعات التي تم رشها تأثيرا عاليا على الإصابة بديدان اللوز حيث تراوح المتوسط العام لخفض الإصابة بين 80 % و94.5%. لقد أشارت النتائج أيضا إلى ان التتابعات التي تم رشها خلال هذه الدراسة أدت إلى حماية اللوز الأخضر بنسب تتراوح مابين 69.9% عند التتابع السادس و93.4% للتتابع السابع. لقد أدى استخدام هذه التتابعات ضد ديدان اللوز إلى خفض الخسائر في المحصول بالمقارنة الى الكنترول وكانت نسب الخفض المسجلة هي: 10.17, 13.7, 7.91, 14.38, 20.5, 13.82, 6.72% للتتابعات من 1 الى 7 على التوالي, بينما وصلت الخسارة في الكنترول الى 46.76%.