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Economic evaluation of different insecticides against spiny bollworm *Earias insulana* (Lepidoptera: Noctuidae) on okra plant

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Abstract

Field strain of spiny bollworm *Earias insulana* (Boisduval) (Lepidoptera: Noctuidae) on okra was treated by selected pesticide and natural compounds to evaluate their toxicity against *E. insulana.* Under okra field conditions, malathion, lambda, achook, and naterlo oil. The 1^{St} and 2^{nd} spraying application of achook® and naterlo oil® proved to have relatively, equal efficiency against the insect population and gave merely equal values of general mean of reduction comprised 53 , 55 . 59 and 45 % respectively. The results of the growing season of 2018 were similar to that obtained results in season of 2019 the general mean of reduction percentage for applied 1^{St} spray of achook® and naterlo oil® indicated that the efficiency of both tested oils upon the population were gave values of reduction comprised 47% and 40 % , respectively . These constant costs were expressed in the varied agricultural practices throughout the growing season of labour rases/ fed 200 for each of all performed treatments achook and naterlo oil, 100 for malathion and lambda. Moreover, extracted values of the additional return over the untreated control, in the different treatments were 24000, 18000, 48000, 42000 and 0,00 for achook, naterlo oil, malathion , lambda and control, successively. Through the profits for one Egyptian pounds investment were 2500, 2500, 10000, 10000 and 0, 00 for achook, naterlo oil, malathion , lambda and control, respectively.

Introduction

Okra (*Abelmoschus esculentus* L., Moench) is one of the most important and popular vegetables to be found in Egypt. The common names of the cultivated okra are known as Lady's finger, gumbo, ochro, okra that belongs to the Malvaceae family. This crop is a native to tropical Africa or possibly tropical Asia (Tindall, 1983) and is still found growing wild specially Ethiopia (Kochhar, 1986). The total production of okra was 4.8 million ton pods all over the world in which India contributes 70%, Nigeria 15%, Pakistan 2%, Ghana 2%, Egypt 1.7% and Iraq 1.7% (Gulsen *et al*., 2007). Net income is often used as the primary indicator of impact on poverty (Indicator 6.1). Although this is arguably the most accurate indicator for tracking impacts on poverty, the cost of collecting accurate, reliable data might be rather high FAO (2015). Shalan *et al.* (2011) showed that Egypt's cultivated area of okra during 2009 is about 22203 feddans produced nearly 134665 metric tonnes with an average of 6,065 tons\fed (Economic Affairs Sector, Agriculture Ministry and Land Reclamation, 2010). The fresh immature pods are used as cooked or fried vegetables and the dried ones were also particularly popular for adding soups and stews. and may powdered for the application as a flavoring (Tindall, 1983).

Among the most important of these have been spiny bollworms Figure (1) (Gulati, 2004). The crop damage is done via two ways, initially; the terminal portions of growing shoots are bored by the caterpillars, moving by inside it. The shoots decrease slightly downward or dry up as a result. The shoots droop downward or dry up. Second, the larvae enter the fruits by making holes, rendering them unfit for human consumption. According to an estimate the spiny bollworm can cause 36-90% loss in the fruit yield of okra (Misra *et al*., 2002). Like other insects, the population of spiny bollworms is governed by their inherent capacity to increase, under the influence of various environmental factors.

The spiny bollworm *Earias insulana* (Boisduval) (Lepidoptera: Noctuidae) is important pest of cotton along with other bollworms and mainly feed on fruiting parts of the plant, resulting in considerable losses in quantity and quality (Naser *et al*., 1980). The larvae of *Earias* spp. attack soft and growing tissues especially the terminal bud of main tissue and cause “top boring” and later on they attack the flower buds and bolls which ultimately shed (Atwal, 1994).

Figure (1): *Earias insulan* infested okra pods.

Aslam *et al.* (2004) tested ten insecticides under field conditions against the *Earias* spp. and *Helicoverpa armigera* Hübner (Lepidoptera: Noctuidae) at recommended doses. For *Earias* spp. Nighaban 20EC (Fenpropethrin) remained most effective up to 7 days after application. Gupta *et al.* (2005) tested some new insecticides along with some conventional ones against *E. vittella.* The new insecticides, abamectin, emamectin benzoate, spinosad and beta-cyfluthrin effectively protected the cotton crop with minimum incidence of cotton bollworm.

The aim of this paper is determining the comparative efficacy of different insecticides and bio insecticides against spiny bollworm on two growing season 2018 and 2019 at the experimental farm of Agricultural Research Station, Sabaheya, Alexandria and determine the economic profit of its application.

Materials and methods

1. Insecticides:

1.1. Malathion:

synthetic phosphorous compou nd and cholinesterase inhibitor that is strictly used as a topical pediculicide. Malathion exerts its action on the nervous system of the lice by irreversibly inhibiting the activity of cholinesterase, thereby allowing acetylcholine to accumulate at cholinergic synapses and enhancing cholinergic receptor stimulation.

IUPAC: Diethyl 2-[(dimethoxyphosphorothioyl) sulfanyl] butanedioate

1.2. Achook 0.15 % EC azadirachtin:

A chemical compound belonging to the limonoid group, is a secondary metabolite present in neem seeds. It is a highly oxidized tetranortriterpenoid which boasts a plethora of oxygen-bearing functional groups, including an enol ether, acetal, hemiacetal, tetra-substituted epoxide and a variety of carboxylic esters IUPACDimethyl (2a*R*,3*S*,4*S*,*R*,*S*,7a*S*,8*S*,10*R*,10a*S*,10b*R*) -10-(acetyloxy)-3,5-dihydroxy-4-[(1*S*,2*S*,6*S*,8*S*,9*R*,11*S*)-2-hydroxy-11-methyl-5,7,10-trioxatetracyclo[6.3.1.$0^{2,6}$.$0^{9,11}$] dodec-3-en-9-yl]-4-methyl-8-{[(2*E*)-2-methylbut-2-enoyl]oxy}octahydro-1*H*-furo [3',4':4,4a]naphtho[1,8-*bc*]furan-5,10a(8*H*)-dicarboxylate.

1.3. Lambada cyhalothrin 10%WP:

Pyrethroids such as cyhalothrin are often preferred as an active ingredient in agricultural insecticides because they are more cost-effective and longer acting than natural pyrethrins. λ-and γ-cyhalothrin are now used to control insects and spider mites in crops including cotton, cereals, potatoes and vegetables IUPAC R)-α-cyano-3-phenoxybenzyl (1S)-cis-3-[(Z)-2-chloro-3,3,3-trifluoropropenyl]-2,2-dimethylcyclopropanecarboxylate and (S)-a-cyano-3-phenoxybenzyl (1R)-cis-3-[(Z)-2-chloro-3,3,3-trifluoropropenyl]-2,22-dimethylcyclopropanecarboxylate.

1.4. Essential oil tested:

Naterlo oil (Soyabean oil 93% L) mixture of fatty acids triglycerides , soybean oil was first registered for use as insecticides and miticide in 1959.

2. Methods of insecticides application:

The plot size was 16 m2 (4x4). The seeds were sown in hills at distance of 25- 30 Cm apart, and in rows of 70 Cm width. The planting date of summer cultivations was fixed, and sowing date occurred on the 1st half of March. One variety of okra (lady fingers)was used during the experiment of this study. There were five treatments including untreated with three replicates, applied using a Knapsack sprayer with one nozzle (20L), the untreated plots of control treatment were sprayed by water. The experiment was divided into five lines or plots as treatments, which were divided into three sprays .The first is achook with naterlo oil, and the second achook with naterlo after 14 day, then third is to start with malathion and lambada 14 days after the second spray, and control. The insecticidal treatments were started after appearing of *E. insulana*, based on the average counts of the bollworm infestation per plant, that considered to be an indirect reflection of the efficacy of different insecticides applied.

After spraying , samples (Pods) from ten plants in each replicate were taken from the lower, middle and upper parts of each randomly sampled plant before spraying and along 1,3 and 14 days post treatment , all the collected samples examined in the laboratory. In the experiment, insecticides were used at the rates recommended by the Ministry of Agriculture.

3. Data calculation:

The percentages of infestation reduction of occurring insects were calculated according to Henderson and Tilton's equation (1955) as follows:

Reduction % = [1- (A/B x C/D)]x100

Where

A = population in treatment after spraying.

B = population in treatment before spraying.

C = population in check untreated (control) before spraying.

D = population in check untreated (control) after spraying.

Reduction percentages were calculated after 1,3 and 14 days from treatment. The 1st day represented the initial reduction of insects post application of chemical insecticides ; while the initial reduction of the tested natural and chemical-compounds was calculated after 3 days. Data were subjected to the analysis of variance test (ANOVA) as randomized complete block design. The least significant differences (LSD) at the 5% level were determined using a computer program (Costat) and Duncan's Multiple Range testes modified by Steel *et al.* (1981) and LSD values were used to compare the mean numbers of inspected pest infestation, or other characters.

Results and discussion

1. Effectiveness of the evaluated chemical and/or phyto-compounds on the inspected *Earias insulana* on okra plants:

1.1. Season of 2018:

The 1st spraying application of achook® and naterlo oil® proved to have relatively, equal efficiency against the insect population and gave merely equal values of general mean of reduction comprised 53%, 55%, respectively. After the 2nd spraying application of the same tested compounds, a highly efficiency of achook® and naterlo oil® were detected, and the estimated general mean of reduction for both treatments comprised 59% and 45% , respectively. Moreover, the performed 3rd spraying application of both tested chemical insecticides (Malathion® and lambada) gave high general mean of reduction comprised 44% and 42 % , respectively (Table 1).

1.2. Season of 2019:

The results of the growing season of 2019 were similar to that results obtained in season of 2018.The general mean of reduction percentage for applied 1St spray of achook® and naterlo oil® indicated that the efficiency of both tested oils upon the insect population gave values of reduction percentages 47 and 40% , respectively.

After the 2nd spraying application of the same tested phyto-natural Oils, these compounds showed lower values of deduced general mean of reduction percentages for achook® followed by naterlo oil® and comprised 32 % and 27 % , respectively. In the carried out 3rd spray of both evaluated chemical. Insecticides,- malathion ® and lambda ®, general mean of reduction was detected and amounted to 37% and 32 %, respectively. In this concept, the above-mentioned results elucidate the possible use of consequent applications of natural plant oils and insecticides for controlling the occurring of the seed individuals on okra plants, and in the same time reduce the rate of insecticides application which mainly cause environmental pollution and hazardous problems related to agro-ecosystem (Table 2).

Table (1): Efficiency of both tested chemical / and phyto-compounds on the calculated reduction percentages of *Earias insulana* after three subsequent spray applications on okra plant in season of 2018.

Treatment	Inspected individuals (No.) pre-spray	% Reduction – Inspection period (days) 1 A *	1 B	3 A *	3 B **	14 A *	14 B **	General reduction mean (%)
1st spray								
Achook®	30.00	21.00	45.00	19.00	50.00	12.00	65.00	53.00
Naterlo oil®	31.00	25.00	40.00	22.00	77.00	17.00	48.00	55.00
Control	35.00	33a		33a		30a		
L .S.D0.05	3.38	1.99		2.95				
2nd spray								
Achook®	26a	20b	50.00	16a	60.00	13a	67.00	59.00
Naterlo oil®	33a	24b	24.00	23a	55.00	19a	58.00	45.00
Control	35a	30a		30a		30a		
L .S .D0.05	2.61	2.06		2.06		1.77		
3rd spray								
Malathion®	33a	28	28.00	23.00	39.00	13a	65.00	44.00
Lambada®	33a	26	31.00	23a	39.00	16a	58.00	42.00
Control	36a	35		33a		26a		
L .S.D0.05	1.77	4.43		2.38		1.77		

*** A: mean number of insects **B : %Reduction .**
 # Mean followed by the same letter(s) are not significantly different at 5% level .

Table (2) :Efficiency of both tested chemical / and phyto-compounds on the calculated reduction percentages *of Earias insulana* after three subsequent spray applications on okra plant in season of 2019 .

Treatment	Inspected individuals (No.) pre-spray	% Reduction – Inspection period (days) 1 A *	1 B **	3 A *	3 B **	14 A *	14 B **	General reduction mean (%)
1st spray								
Achook®	37a	20a	45.00	20a	45.00	18.00	51.00	47.00
Naterlo oil®	30a	27a	43.00	26a	44.00	25.00	33.00	40.00
Control	30a	30a		5.67a		3a		
L .S.D0.05	1.85	2.62		2.87		2.39		
2nd spray								
Achook®	27a	23a	20.00	16.00	44.00	17a	33.00	32.00
Naterlo oil®	27a	23a	26.00	22.00	23.00	19a	34.00	27.00
Control	30a	26a		26a		23a		
3rd spray								
Malathion®	37a	33a	46.00	30a	40.00	27a	27.00	37.00
lambada®	38.00	33a	45.00	27a	37.00	25a	16.00	32.00
Control	38a	36a		31a		30.00		
L .S.D0.05	2.39	2.07		2.66		3.42		

*** A: mean number of insects **B : %Reduction .**
 # Mean followed by the same letter (s) are not significantly different at 5% level .

2. Economic and profits of the tested insecticides to control *Earias insulana* in okra plant seasons (2018 and 2019).

1. Season of 2018:

This part of investigation is focused on the use of each of tested four chemical-compounds (Achook®, naterlo oil®, malathion® and lambad®), as tool for insects management, in order to push up the yield and to increase the return on the cash crop. The harvested post yields of the performed treatments as okra green pods for local marketing (Infested and healthy pods) amounted to (1 and 4.5),(1 and 4.5), (0.5 and 5) ,(0.5 and 5) and (2 and 4) ton/fed for achook®,naterlo oil®, malathion®,lambad® and control, inrespect. The gross monetary return was worked out at 25000 pounds for healthy pods of okra pods and 10000 for infested okra pods. These returns amounted to 122500, 122500, 12970, 129710 and 120000 L.E./ fed for achook®,naterlo oil®, malathion ®, lambad® and control, in sequence. In general, spraying the different compounds gave higher yields of healthy pods rather than those obtained in the check (Table 3). In concern to the total costs of control/ fed (Treatments cost + labour costs). These constant service costs (Labourrases / fed) were expressed in the varied agricultural practices throughout the growing season of labourrases/ fed 200 (L.E.) for each of all performed treatments achook® and naterlo oil®, 100 (L.E.) for malathion ® and lambad®. Regarding the net returns; the calculated values were 122000, 122020, 129700, 129710 and 120000 L.E./ fed for achook®,naterlo oil®, malathion ®,lambad® and control, respectively. Moreover, extracted values of the additional return over the untreated control, in the different treatments were 2000, 2020, 9700, 9710 and 0,00 for achook®, naterlo oil®, malathion ®,lambad®and control, successively. Through the profits for one Egyptian pounds (L.E.) investment were 2500, 2500 , 10000, 10000 and 0,00 for achook®,naterlo oil®, malathion ®,lambad® and control, respectively (Table 3). In the light of the calculated profits data, it could be concluded that the higher value is the utmost profitable treatment. However, depending upon the investment profits, the used chemicals could be arranged in a descending order as follows: malathion®>lambad®>achook ®>naterlo oil®.

2. Season of 2019:

At to for one season of 2018, season 2019 malathion ® and lambad® also gave the highest yield of harvested green pods 1-5 and 0,5-5 ton/ fed to infest and healthy okra pods.The gross monetary return was worked out at 120000 L.E./ ton for healthy pods of okra. These returns were 138000, 132000, 162000, 156000 and 114000 L.E./ fed for achook®, naterlo oil®, malathion ®,lambad®and control, in sequence. In general, spraying the different compounds gave higher yields rather than that obtained in the chek (Table 4). In concern to the total costs of control were 500, 480, 300, 290 and 0.0 L.E./ fed for achook®,naterlo oil®, malathion ®,lambad® and control, respectively. Regarding the net returns, the calculated values L.E. / fed were 37500, 131520, 161700, 155710 and 114000 for achook®, naterlo oil®, malathion ®, lambad® and control, successively. But, for the estimated additional return over the untreated control in the different treatment ; it was comprising 23500,17520,47700,41710 and 0.00 , subsequent.(Table 4). The profits for one Egyptian pound (L.E.) investment were 24000,18000,48000, 42000 and 0.00 for achook®, naterlo oil®, malathion ®, lambad® and control. In the light of the obtained profits data, it could be mentioned that the higher value is the utmost profitable treatment. However, depending upon the investment profits; these used insecticides could be arranged descending as follows: Malathion ®>lambad ®>achook ®>naterlo oil

Table (3): Economics and profits of certain treatments against the okra insect *Earias insulana* during the growing season of (2018) compared with untreated plants ((Control).

Treatments	No. of application	Okra pods Production (Ton/fed.)		*	**		Input costs/ feddan (L.E)					
		Infested (Ton/fed.)	Healthy (Ton/fed.)	Infested Okra pods income/fed.	Healthy Okra pods income/fed.	Gross income/fed. (L.E) (a)	A treatment costs/fed. (L.E)	Labour wages/ fed. (b)	Total costs/ fed. (L.E) (C)	Net returns/fed. (L.E) (d)	Additional returns over untreated control (L.E) (e)	Profit of one pound invesment (L.E) (f)
Achook	2	1	4.5	10000	112500	122500	300	200	500	122000	2000	2500
Naterlo oil	2	1	4.5	10000	112500	122500	280	200	480	122020	2020	2500
Malathion	1	0.5	5	5000	125000	130000	200	100	300	129700	9700	10000
Lambad	1	0.5	5	5000	125000	130000	190	100	290	129710	9710	10000
Control	0	2	4	20000	100000	120000	0	0	0	120000	0	0

(a) : Worked out at L.E 25000/ ton for healthy pods of okra and 10000 for infested okra pods (ton/fed).
(b) : Worked out at L.E 100/ feddan × No. of sprays.
(c) : Total costs of control/ fedden = treatments costs +labour costs / feddan.
(d): Net returns/ feddan = (Gross income/ feddan) - (Total costs / feddan).
(e) : Additional returns= Net returns- control returns.
(f): Profit for one Egyptian pound= Additional returns† Total costs.
*** Market price for one ton/ healthy okra pods = 25000 L.E.**

Table (4): Economics and profits of certain treatments against the okra insect , *Earias insulana* during the growing season of (2018-2019) compared with untreated plants (Control).

Treatments	No. of application	Okra pods Production (Ton/fed.)		Infested Okra pods income/fed. *	Healthy Okra pods income/fed. **	Gross income/fed. (L.E) (a)	Input costs/ feddan (L.E)			Net returns/fed. (L.E) (d)	Additional returns over untreated control (L.E) (e)	Profit of one pound invesment (L.E) (f)
		Infested (Ton/fed.)	Healthy (Ton/fed.)				A treatment costs/fed.	Labour wages/ fed. (b)	Total costs/ fed. (L.E) (C)			
Achook	2	1.5	4	18000	120000	138000	300	200	500	137500	23500	24000
Naterlo oil	2	1	4	12000	120000	132000	280	200	480	131520	17520	18000
Malathion	1	1	5	12000	150000	162000	200	100	300	161700	47700	48000
lambada	1	0.5	5	6000	150000	156000	190	100	290	155710	41710	42000
control	0	2	3	24000	90000	114000	0	0	0	114000	0	0

(a) : Worked out at L.E30000/ ton for healthy pods of okra and 12000 for infested okra pods (ton/fed).

(b) : Worked out at L.E 100/ feddan × No. of sprays.

(c) : Total costs of control/ fedden = treatments costs +labour costs / feddan.

(d) : Net returns/ feddan = (Gross income/ feddan) - (Total costs / feddan).

(e) : Additional returns= Net returns- control returns.

(f): Profit for one Egyptian pound= Additional returns† Total costs.

*** Market price for one ton/ healthy okra pods = 30000 L.E.**

**** Market price for one ton / infested okra pods = 12000 L.E.**

Okra crop are liable to attack by several insect- pests, throughout the elapsing period from the early stage up to the late development and the post-harvest stage. Many insects belonging to the orders of Lepidoptera, Diptera, Hemiptera and

Homoptera are well known injurious insects of okra plants. The harvested post yields of the performed treatments as okra green pods for local marketing (infested and healthy pods) amounted to (1 and 4.5),(1 and 4.5), (0.5 and 5) ,(0.5 and 5) and (2 and 4) ton/fed for achook®, naterlo oil®, malathion ®, lambda® and control, in respect. These returns amounted to 122000, 122020, 129700, 129710 and 120000 L.E./ fed as agross income for achook®, naterlo oil®, malathion ®, lambda® and control, in sequence. These constant service costs (Labour rases / fed) were expressed in the varied agricultural practices throughout the growing season of labour rases/ fed 200 (L.E.) for each of all performed treatments achook® and naterlo oil®, 100(L.E.) for malathion ® and lambda. Moreover, extracted values of the additional return over the untreated control, in the different treatments were 2000, 2020, 9700, 9710 and 0,00 for achook®, naterlo oil®, malathion ®, lambda® and control, successively. Through the profits for one Egyptian pounds (L.E.) investment were 24000, 18000, 48000, 42000 and 0,00 for achook®, naterlo oil®, malathion ®, lambda® and control, respectively. These net returns were 137500, 131520, 161700, 155710and 114000 L.E./ fed for achook®, naterlo oil®, malathion ®, lambda® and control, in sequence season 2019. Cost of insecticide applications, development of resistance in pest population exposed to repeated insecticide treatments and adverse environmental effects of insecticides demand the minimization of chemical controls whenever possible.

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