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Field evaluation of insecticides sequences against cotton leafworm, four sucking pests, six insect predators in cotton fields and cotton yield in Egypt

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Abstract
Studied the field evaluation of seven insecticides sequences against cotton leaf worm, four sucking pests, six insect predators in cotton fields and cotton yield, during the two successive cotton seasons (2019 and 2020) in Sakha Agricultural Station Farm, Kafr El-Sheikh region Egypt. The obtained results showed that: the best insecticides sequence against the cotton Leaf worm, *Spodoptera_littoralis* (Boisd.), was (organic phosphors) (sylian), emamectin benzoate (contact) and insect growth inhibitor (IGI) (killeforon), followed by sequence (killeforon, sylian and contact) with means reductions in numbers of the egg – masses (87.90, 86.73%) in the two seasons, respectively. While, the cotton aphid, *Aphis gossypii* Glover and the jassids, *Empoasca* spp., sequence (killeforon, sylian and contact) was the best effective and the second sequence (contact, contact and contact) with means (83.62 and 72.37%) and (75.77 and 67.56%) of reduction in aphid and Jassids populations, respectively. The whitefly, B*emisia tabaci* (Genn.), the sequence (sylian, sylian and sylian) was the first effective with mean (81.14%) of reduction in population of this pest, but this sequence was the second effective of reduction in population of green stink bug, *Nezara viridula* (L.) with mean (78.12%).
The sequence of (killeforon, killeforon and killeforon) was the second effective of reduction in whitefly population with mean (72.65%), and the first effective of reduction in green stink bug population with mean (78.97%). All insecticides sequences shown high reduction of the all insect predators populations (*Paederus alferii* Koch, *Coccinella undecimpuncata* L., Scymnus spp., *Chrysoperla carnea* schn., *Syrphus* spp. And *Orius* spp.), but, the sequence of (sylian, sylian and sylian) was the first effective in reduction of the all insect predators populations with range between (69.22 – 80.94%).
The biocides sequence (Diple, Diple and Diple) was the least effective than of the other insecticide sequences throughout the treatments with range between (9.79 – 37.59%) and (19.20 – 46.77%) in reduction of the pests and predators populations, respectively. Results appeared that, the highly effective insecticidal sequence against cotton leafworm had the highly cotton yield production.

Keywords: *Spodoptera littoralis*, insect predators, sucking pests

Introduction
Cotton in the world's most important non-food agricultural commodity, which is easily damaged by cotton leafworm, S*podoptera_littoralis* (Boisd.), various sucking pests like, cotton aphid, *Aphis gossypii* Glover, whitefly *Bemisia tabaci* (Genn.), Jassids Empoasca spp. and green stink bug, Nezara viridula (L.), threatens the continued success of cotton production. The continuous use of insecticides pertaining to different chemical groups in their chemical control, created serious problem, i.e., environmental pollution and resistance development cotton leafworm acquired resistance to endosulfan, cypermethrin, fenvalerate, quinalphos and monocrotophos. Whitefly exhibited resistance to methomyl and monocrotophos in India (kranthi *et al*. (2001) and Radhika and subbaratnam (2006)).
They should be used in resistance management programs in rotation with insecticides that affect defferent target sites. Many authors found that application of insecticides in sequential use induced higher reduction in infestation of this pests compared with the reduction resulting from several applications with the same insecticides (El-Dessouki *etal*; (2006) and El-Mageed *etal*. (2007)) therefore, the objective of the present work was to evaluate the efficacy of some insecticides used in three rotations against the cotton leafworm, four sucking pests, six insect predators in cotton and cotton yield.

Materials and Methods
The effect of different insecticides in three rotations against cotton leafworm, four sucking pests, six insect predators in cotton and cotton yield during two successive seasons (2019 and 2020) was studied to select the best sequence. Experiments were carried out at Sakha Agricultural Research Station Farm, Kafr El-Sheikh Governorate. Trials were carried out on an area of about one feddan.
Treatments were arranged in complete randomized blocks with three replicates. 24 replicates were carried out all agricultural processes as usual.
All plots were planted with Giza 88 cotton variety, the data of cultivation was March 15th and 20th of the 2019 and 2020 seasons, respectively.

Insecticides used
1. sylian 72% EC (organic phosphorus).
2. contact 50WDG (emamectin benzoate).
3. killeforon 5% EC (insect growth inhibitor (IGI)).

Microbial insecticides (Biocides)
Diple-2x (Bacterial insecticides) ***Bacillus thuringiensis*** (Berliner) var Kurstaki, 2009 a.i./fed. 6.4% B.t. (32.000 IV of potency/mg).

Insecticides rotation

Tested insecticides were used in seven difference rotations as follows in Table (1):

Table 1: Treatments and sequences

Treatment	Sequence		
	1st spray	2nd spray	3rd spray
A	Contact	Killeforon	Sylian
B	Killeforon	Sylian	Contact
C	Sylian	Contact	Killeforon
D	Sylian	Sylian	Sylian
E	Contact	Contact	Contact
F	Killeforon	Killeforon	Killeforon
G	Dipel 2x	Dipel 2x	Dipel 2x

The insecticides were applied means of CP3 sprayer, applying 36 Liters insecticidal solution (9 liters/ replicate). The first application was undertaken on mid-July, the interval of two weeks between any two successive Application in the two seasons 2019 and 2020. Sequences were evaluated according to their effectiveness in reducing the infestation percentages of this pests, as well as cotton yield production. Twenty-five cotton leaves from each treatment were taken at random from different leavls of plant height (one leaf per plant) were examined every three days to recorded the numbers of the egg – masses of cotton leafworm and (adults and nymphs) of cotton aphids, whitefly, jassids and green stink bug. So, (larvae or nymphs and adults) of the six insect predators were counted weekly during aperiod extended from mid-July till early October. To calculate the percentage reduction in this-pests and predators populations, Henderson and Tilton (1955) equation was used as follows:

$$\% \text{ Population reduction} = (1 - A/B \times C/D) \times 100$$

Where

A. Number of Insect per 25 leaves in treatment after application.
B. Number of Insect per 25 leaves in treatment before application.
C. Number of Insect per 25 leaves in check before application.
D. Number of Insect per 25 leaves in check after application.

Cotton yield

At the end of the 2019 and 2020 seasons, cotton yield of each treatment was weighted separately and recorded.
Duncan's multiple range test (1955) at 5% level was used to compare the means of different treatments.

Results and Discussion

Cotton leafworm, *Spodoptera littoralis* (Boisd.)

As shown in Table (2), there are the insecticides sequence C (organic phosphorus (sylian) – emamectin benzoate (contact) – insect growth inhibitor (killeforon) was the best and showed good reduction in egg-masses of the cotton leafworm with average reduction (85.38, 90.42 and 87.90%), followed by the insecticide sequence (killeforon - sylian – contact) by average reduction (85.38, 88.07 and 86.73 %) of the first, second and mean of the seasons, respectively.

Table 2: Effect of insecticidal – sequence on the percentage reduction of infestation cotton by cotton leafworm, aphids, whitefly, plant hoppers and green stink bug during 2019 and 2020 cotton seasons in Sakha, kafr El-sheikh Governorate**.**

Insects	Cotton leafworm			Aphids			whitefly			Plant hoppers			Green stink bug		
Insecticidal sequence	2019	2020	Mean	2019	2020	mean	2019	2020	mean	2019	2020	mean	2019	2020	mean
A (C.-k.-S.)	80.09	84.71	82.40	53.59	71.82	62.71	50.27	52.66	51.47	63.66	67.57	65.62	70.97	76.92	73.95
B (K.-S.-C.)	85.38	88.07	86.73	76.27	90.69	83.62	74.38	62.36	68.37	68.62	76.12	72.37	69.89	84.62	77.26
C (S.-C.-K.)	85.38	90.42	87.90	31.86	15.89	23.88	65.37	62.63	64.00	14.45	71.51	42.98	67.74	84.62	76.18
D (S.-S.-S.)	77.14	80.75	78.94	48.27	88.90	68.54	78.72	83.55	81.14	21.67	75.58	48.63	74.19	84.62	78.12
E (C.-C.-C.)	27.37	71.15	49.26	60.91	90.63	75.77	71.86	58.48	65.17	64.33	70.83	67.56	68.82	78.21	73.52
F (K.-K.-K.)	27.37	69.11	48.24	51.40	86.48	68.94	73.90	71.39	72.65	54.40	73.81	64.11	72.04	85.90	78.97
G (D.-D.-D.)	20.06	43.12	21.06	12.56	7.02	9.79	32.48	5.06	18.77	22.35	20.22	21.29	29.03	46.15	37.59
control	6.43	9.81	8.12	60.33	170.15	115.24	1764.70	758.70	1261.70	44.30	73.70	59.00	9.30	7.80	8.55

S.= organic phosphorus (sylian): C. = emamectin benzoate (contact): K.= (killeforon) insect growth inhibitor (IGI) D.= Diple (Biocides)

The least sequence G, biocide (Diple – Diple – Diple) with average reduction (20.06, 43.12 and 21.06%) of the first, second and mean of the seasons, respectively. This results agreed with Abou-Kahla *et al.* (1990) and El-Zanan *et al.* (1994). And found highly significant differences between every treatments in the two seasons (Table 5).

Cotton aphid, Aphis gossypii Glover

Results of Table (2) show the average of reduction in aphid population, the best insecticides sequence of (killeforon – sylian – contact) by means (76.27, 90.69 and 83.62%), followed by insecticides sequence of (contact – contact – contact) by means (60.91, 90.63 and 75.77%) of the first, second and mean seasons (2019 and 2020), respectively.
The least effective of reduction was the biocide sequence (Diple – Diple – Diple) with means of (12.56, 7.02 and 9.79%) of the first, second and mean seasons, respectively. And found highly significant differences between every treatments in the two seasons (Table 5).

The whitefly, Bemisia tabaci (Genn.)

The best results of average reduction of whitefly population in Table (2) was insecticides sequence of (sylian – sylian – sylian) by means (78.72, 83.55 and 81.14%), followed the sequence (killeforon – killeforon – killerforon) by means (73.90, 71.39 and 72.65%), and the least average reduction by biocide sequence (Diple – Diple – Diple) with means (32.48, 5.06 and 18.77) of the first, second and mean seasons, respectively. And found highly significant differences between every treatments in the two seasons (Table 5).

The Jassids, Empoasca spp

In Table (2) showed the first sinsecticides sequence of

effectiveness in reduction of Jassids population, was (killeforon – sylian – contact) with means (68.62, 76.12 and 72.37%), followed by sequence (contact – contact – contact) by means (64.33, 70.83 and 67.56%), and the least reduction in biocide sequence (Diple – Diple – Diple) with average reduction (22.35, 20.22 and 21.29%), in the first, second and mean seasons, respectively. And found highly significant differences between every treatments in the two seasons (Table 5).

The green stink bug, Nezara viridula (L.)

As shown in Table (2), the every insecticides sequences were high effectiveness in reduction of green stink bug population, but the two insecticide sequences (killeforon – killiforon – killieforon) and (sylian – sylain – sylain) were the best effective with average reduction of (72.04, 74.19%), (85.90, 84.62%) and (78.97, 78.12%), and the biocide sequence (Diple – Diple - Diple) was the least effective with means (29.03. 46.15 and 37.59%), in the first, second and mean of the 2019 and 2020 seasons, respectively.

and found significant differences between every treatments in the two seasons (Table 5).

The insect predators

Data in Table (3) presented the reduction percentage of insect predators in the difference treatments during 2019 and 2020 seasons. All the populations predators of (*Paederus alfierii* Koch, *Coccinella undecimpuncta*ta L., *Scymnus* spp., *Chrysoperla carnea* (Steph.) *Syrphus* spp. and *Orius* spp.).

Table 3: Effect of insecticidal-sequence on the sex insect predators during 2019 and 2020 cotton seasons in Sakha, kafr- El-sheikh Governorate.

Insects predators	***P. alfierii***			***C. undecimpunctata***			***Scymnus spp.***			***C. carnea***			***Sryphus* spp.**			***Orius* spp.**		
sequence Insecticidal	2019	2020	mean	2019	2020	mean	2019	2020	mean	2019	2020	mean	2019	2020	mean	2019	2020	mean
A (C.-k.-S.)	58.85	83.69	71.27	61.24	69.82	65.53	55.74	82.88	69.31	59.72	62.67	61.20	71.74	73.24	72.49	42.86	64.71	53.79
B (K.-S.-C.)	60.94	85.02	72.98	74.42	81.53	77.98	62.30	77.40	69.85	63.89	72.00	67.95	69.57	78.87	74.22	57.14	72.55	64.85
C (S.-C.-K.)	66.15	85.02	75.59	69.77	80.18	74.98	67.21	74.66	70.94	55.56	69.33	62.45	60.87	77.46	69.17	60.00	72.55	66.28
D (S.-S.-S.)	63.54	90.02	76.78	76.74	81.98	79.36	72.13	86.30	79.22	65.28	77.33	71.31	71.74	90.14	80.94	60.00	78.43	69.22
E (C.-C.-C.)	67.71	49.40	58.56	72.09	80.63	76.36	67.21	82.88	75.05	59.72	76.00	67.86	63.04	77.46	70.25	51.43	50.98	51.21
F (K.-K.-K.)	60.94	84.03	72.49	70.54	71.62	71.08	60.66	73.97	67.32	62.50	70.67	66.59	78.26	80.28	79.27	60.00	70.59	65.30
G (D.-D.-D.)	28.13	32.11	30.12	17.83	22.52	20.18	42.62	28.77	35.70	26.39	12.00	19.20	45.65	47.89	46.77	17.14	27.45	22.30
control	19.20	60.10	39.65	12.90	22.20	17.55	6.10	14.60	10.35	7.20	7.50	7.35	4.60	7.10	5.85	3.50	5.10	4.30

S.= organic phosphorus, C. = (contact) emamectin benzoate, K.= (killeforon) insect growth inhibitor (IGI) D.= Diple (Biocides)

Treatments of sequence insecticides were associated with the greatest reduction in the population of the Predators, also, found unsignificant differences between every treatments in the two seasons. In contrast, Diple treatment had the minimum side effect on beneficial predators. But, the high effective of the reduction in populations of all insect preadors was (sylian – sylian - sylian) with mean between (60.00 – 76.74%), (77.33 – 90.14%) and (69.22 – 80.94%), and the least effective by biocides (Diple - Diple – Diple) by means between (17.14 – 45.65%), (12.00 – 47.89%) and (19.20 – 46.77%) in the first, second and the mean of the two seasons, 2019 and 2020, respectively.

The biocides was survival the natural enemies, this results agreed with the results obtained by El-Sorady *etal*. (1994), El- Zanan *etal*. (1994), El-Nemaky (2000), Aref (2002), El-Dessouki *etal*. (2006), Younis *etal*. (2007) and Kumar and Stanley (2010).

7- Effect of sequences insecticides on cotton yield

Data on cotton yield quantities throughout the two successive seasons were presented in Table (4). The highes cotton yield by sequence insecticides of (sylian – contact – killeforon) with means of (190, 1020 and 605 Gram/ 25 plants) followed by sequence of (killeforon – sylian – contact) with means of (170.50, 710 and 440 g/25 plants), and the least sequence of biocide, (Diple – Diple – Diple) with means of (70.50, 205 and 137.75 g/25 plants) of the first, second and mean of the two seasons (2019 and 2020), respectively. And. Also, found highly significant differences between every treatments in the two seasons (Table 5). The treatments of sequence insecticides revaled the highest amount of cotton, and the bio-pesticide Diple was the least amount of cotton. This results agreed with El-Dessouki *etal*. (2006) and Younis *etal*. (2007).

Table 4: The cotton yield quantities Gram/ 25 plants of every sequences of insecicides during 2019 and 2020 cotton seasons in Sakha Kafr El-Sheikh Governorate.

Sequence year	**A (C.-K.-S.)**	**B (K.-S.-C.)**	**C (S.-C.-K.)**	**D (S.-S.-S.)**	**E (C.-C.-C.)**	**F (K.-K.-K.)**	**G (D.-D.-D.)**	**control**
2019	160.50	170.50	190.00	110.75	120.00	110.50	70.50	60.00
2020	530.00	710.00	1020.00	440.00	420.00	390.00	205.00	198.00
Mean	345.25	440.25	605.00	275.38	270.00	250.25	137.75	129.00

S.=(sylian) organic phosphorus, C. =(contact) emamectin benzoate,
K.= (killeforon) insect growth inhibitor (IGI),
D.= Diple (Biocides)

Table 5: Combined analysis of variance of eight treatment for six treatments over two years

S.O.V.	**d.f.**	**Cotton Leafworm**	**Aphids**	**whitefly**	**planthoppers**	**Greenn stink bug**	**Yield**
Years (y)	1	425.94**	310.13**	57.32**	47.37 **	37.15*	128.94 **

Error	8	10.50	19.56	31.55	39.72	21.33	0.24
Treatments (T)	7	14361.80 **	13907.90 **	5508.64 **	5340.76 **	3120.11 *	50.96 **
(YXT)	7	40.96 *	45.42	49.99**	40.49 *	33.40*	3.25**
Error	56	19.00	22.96	11.83	19.07	8.71	0.21
C.V.%		14.71	16.93	16.42	22.11	12.70	9%

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