

Effect of Insecticide Rotations on the Susceptibility of *Spodoptera littoralis* Larvae to Insecticides

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ABSTRACT. The susceptibility to 3 insecticides of the 4th instar *S. littoralis* larvae was measured topically for the 1st generation produced from samples of the 5th and 6th instar larvae collected from the field before and after spraying of each insecticide, in two successive seasons. The single application of Endrin or the successive insecticidal rotations ending with Endrin, increased the tolerance to Endrin, while there was no tolerance to either Cytrrolane or Lannate. The single application of Cytrrolane or the successive insecticidal rotations ending with Cytrrolane, did not cause tolerance to Cytrrolane or Lannate; and the same trend was obtained for the use of Lannate or the successive insecticidal rotations ending with Lannate. Meanwhile, the susceptibility of these strains to Endrin varied in the two successive cotton seasons.

The susceptibility of the 4th instar *S. littoralis* larvae was also studied in the laboratory with the same pattern of rotations followed in the field. The data obtained showed almost the same trend of field results, after successive treatments in three successive generations. Apparently, it is advisable not to apply one insecticide (Endrin) successively within one season.

The cotton leafworm, *Spodoptera littoralis* (Boisd.) is a major polyphagous pest in Egypt. It attacks more than 60 different cultivated plants. It is annually controlled with different types of organic insecticides, with the result that field strains exhibiting different levels of resistance to insecticides appeared. The dose which may give a satisfactory control may leave, later on, a segment of the larval population that was exposed to sublethal doses. With the increase of the resistance phenomenon a study of the effect of the interactions of insecticidal applications as applied under field conditions must be considered.

In discussing the status of research on resistance, Brown (1976) stated that one of the best ways of circumventing the problem lies in "practicing the whole range of measures included in the terms of integrated control or pest management", but he

also stressed that since the bulk of agricultural crops depend on chemical insecticides for their protection, "it is pesticide management that is needed, and our deficiencies in this regard are the measure of the deficiencies of entomologists in dealing with insecticide resistance".

Georghiou (1983) discussed the concept of insecticide rotation as an anti-resistance measure and mentioned that this concept had received recently increasing attention. The challenge consists of determining the optimal sequence of use of the chemicals and the stage at which a change must be made.

The aim of the present work was to study the impact of successive applications of insecticides, as applied in the field, in certain rotations, on the susceptibility of the field strain of the cotton leafworm *Spodoptera littoralis* to Endrin, Cytrolane and Lannate. The susceptibility of the same field strain (collected before the beginning of the spraying programme) was also studied in the laboratory, with the same pattern of sequences, for comparison.

Material and Methods

Field Experiments

Field experiments were conducted during two successive cotton seasons, at Shalakan, to measure the effect of insecticides applied successively in rotations, on the tolerance of the cotton leafworm larvae, of later generations, to different groups of these compounds. The randomized treatments were executed in 30 plots, the size of each being 2.5 kirats (1 kirat = 1/25 acre). The insecticides used were Endrin 50% w.p., at the rate of 1 kg/feddan; Cytrolane 25% E.C., at the rate of 1.75 l/feddan and Lannate 90% w.p., at the rate of 200 g/feddan. Knapsack sprayers were used for spraying at the rate of 200 liters/feddan.

On the 4th day after each application, samples of survived fifth and sixth-instar larvae were collected from the different plots (replicates). These larvae are supposed to have been in their fourth instar at the time of pesticide application. The larvae collected after each treatment were taken to the laboratory and allowed to feed, for the first 24 hr, on insecticide-treated cotton leaves brought from the respective replicates. Feeding after the first day was continued on untreated cotton leaves till pupation, *i.e.* for about another three days. The egg masses laid by the moths that emerged from the pupae, representing the different treatments, were reared on untreated cotton leaves till the larvae reached the fourth instar. The susceptibility of the larvae to 3 insecticides was then tested. The measurement of *S. littoralis* susceptibility to Endrin, Cytrolane and Lannate was performed using the technical materials of each insecticide dissolved in acetone. The topical application method was followed using 0.5 μ l/larvae on the dorsum of the mesothorax. This

procedure, before and after every spray was carried out for two successive seasons.

The three field applications of Endrin, Cytrolane and Lannate in the different sequences and combinations formed the following rotations.

No. of rotation system	Applications		
	1 st	2 nd	3 rd
1	Endrin	Endrin	Endrin
2	Endrin	Cytrolane	Lannate
3	Endrin	Lannate	Cytrolane
4	Cytrolane	Cytrolane	Cytrolane
5	Cytrolane	Endrin	Lannate
6	Cytrolane	Lannate	Endrin
7	Lannate	Lannate	Lannate
8	Lannate	Endrin	Cytrolane
9	Lannate	Cytrolane	Endrin

Laboratory Experiments

The susceptibility to 3 insecticides of 4th instar *S. littoralis* larvae was determined through the topical application method. The larvae were collected from Shalakan early in the season (before the chemical control season) and reared for one generation in the laboratory under constant temperature (25°C) and relative humidity (60%). The larvae were fed on cotton leaves untreated with insecticides. The technical materials of Endrin, Cytrolane and Lannate were used topically in measurement tests. The LD₁₀ in µg/larva of each insecticide was calculated and applied topically on each 4th instar larva, in different rotations, for three successive generations in the laboratory. Surviving larvae were fed on untreated cotton leaves and rearing was maintained at 25°C and 60% R.H. In these experiments, the pattern of rotations of the different insecticides was similar to that followed in the field experiments.

In the 1st generation, the larvae reared from the Shalakan field strain were divided into three main groups, each comprising approximately 500 fourth instar larvae. Every larva was given a LD₁₀ of the insecticidal compound in the following manner.

1. Main group I, 0.26 µg/larva (4.06 µg/g body weight) of Endrin.
2. Main group II, 0.04 µg/larva (1.01 µg/g body weight) of Cytrolane.
3. Main group III, 0.01 µg/larva (0.25 µg/g body weight) of Lannate.

In the second generation, the larvae reared from those of main group I (treated with Endrin) were divided into three sub-groups of 4th instar larvae and treated as follows:

1. 1st sub-group with 0.26 µg/larva of Endrin.
2. 2nd sub-group with 0.04 µg/larva of Cyrolane.
3. 3rd sub-group with 0.01 µg/larva of Lannate.

In the third generation, the larvae (4th instar) resulting from each of the above sub-groups were treated as follows:

1. 1st sub-group with 0.26 µg/larva of Endrin.
2. 2nd sub-group with 0.01 µg/larva of Lannate.
3. 3rd sub-group with 0.04 µg/larva of Cyrolane.

The same pattern of treatments and rotations was applied to the larvae of main group II (treated with Cyrolane) and main group III (treated with Lannate) as mentioned before.

After the treatment with each insecticide, in any generation, a susceptibility test to Endrin, Cyrolane and Lannate was conducted for the following generation. The LD₅₀ value was obtained by plotting the mortality data on logarithmic probit paper and regression line was drawn according to Finney (1952). The tolerance ratio (T.R.) was obtained by dividing LD₅₀ of the insecticide after application by LD₅₀ of the same insecticide before application.

Results and Discussion

The obtained results indicated that the application of Endrin, or the successive insecticidal applications ending with Endrin, increased the tolerance to Endrin, while there was no tolerance to either Cyrolane or Lannate.

The application of Cyrolane or the successive insecticidal applications ending with Cyrolane did not cause tolerance to Cyrolane or Lannate. However, the susceptibility of these strains to Endrin was variable with no obvious trend during the two successive seasons.

Regarding the application of Lannate, or the application of successive insecticides ending with Lannate, the obtained data varied from a slight tolerance in the first season to more susceptibility to Endrin in the second season. The strains were either more susceptible or with no tolerance to Cyrolane and Lannate as

compared with data before applications with different rotations of insecticides ending with Lannate in the two successive seasons (Table 1).

Table 1. Tolerance ratio (T.R.) values for Endrin, Cytrolane and Lannate after 3 successive insecticidal applications in the field.

Rotations	Tolerance Ratio (T.R.)*					
	Endrin		Cytrolane		Lannate	
	(a)	(b)	(a)	(b)	(a)	(b)
En.	1.13	2.28	0.16	0.50	0.38	0.71
En./En./En.	> 6.16	10.44	0.21	1.02	0.83	0.66
Lan./Cyt./En.**	> 6.18	4.71	0.21	0.92	0.82	0.41
Cyt./Lan./En.	2.23	4.99	0.12	0.84	0.38	0.57
Cyt.	4.25	0.98	0.48	0.32	0.34	0.71
Cyt./Cyt./Cyt.	0.57	9.73	0.10	1.25	0.18	0.54
Lan./En./Cyt.	1.96	1.64	0.11	1.18	0.44	0.83
En./Lan./Cyt.	> 6.18	0.46	0.16	0.29	0.80	0.83
Lan.	5.67	0.24	0.34	0.23	0.17	0.54
Lan./Lan./Lan.	4.31	1.03	0.10	1.52	0.47	0.65
Cyt./En./Lan.	2.23	6.72	0.49	0.92	0.35	0.23
En./Cyt./Lan.	> 6.18	1.29	0.40	0.90	0.44	0.96

$$* (T.R.) = \frac{LD_{50} \text{ of the insecticide after applications}}{LD_{50} \text{ of the same insecticide before applications}}$$

(a) and (b) denote two successive cotton seasons.

** Lan. = Lannate; Cyt = Cytrolane; En. = Endrin.

The field strain collected before the chemical control season was treated in the laboratory with the same pattern of rotation followed in the field, and the obtained data showed no increase in tolerance for Cytrolane or Lannate after the successive treatments in three successive generations ending with Endrin. The tolerance of this strain to Endrin showed almost the same trend.

The tolerance of these strains after treatments for three successive generations with different insecticides in certain rotations ending with Cytrolane decreased for Cytrolane and Lannate. The tolerance of these strains to Endrin was variable with no obvious trend.

There was no tolerance to Cytrolane, Lannate, and in some cases to Endrin, after treatment for successive generations ending with Lannate (Table 2).

Table 2. Tolerance ratio for Endrin, Cytrolane and Lannate after 3 successive insecticidal treatments in the laboratory.

Rotations	Tolerance Ratio*		
	Endrin	Cytrolane	Lannate
En./En./En.	0.80	0.14	0.29
Cyt./Lan./En.**	0.52	0.20	0.33
Lan./Cyt./En.	0.77	0.15	0.33
Cyt./Cyt./Cyt.	0.31	0.15	0.14
En./Lan./Cyt.	0.65	0.27	0.42
Lan./En./Cyt.	1.87	0.20	0.29
Lan./Lan./Lan.	0.98	0.52	0.53
En./Cyt./Lan.	2.10	0.10	0.33
Cyt./En./Lan.	0.23	0.36	0.24

$$* \text{ Tolerance Ratio} = \frac{\text{LD}_{50} \text{ of the insecticide after treatments}}{\text{LD}_{50} \text{ of the same insecticide before treatments}}$$

** Cyt. = Cytrolane; Lan. = Lannate; En. = Endrin.

Apparently, it is advisable not to apply one insecticide (Endrin) successively within one season. According to Georghiou (1983), the challenge consists of determining the optimal sequence of use of the chemicals and the stage at which a change must be made. Ali and Ayad (1975) reported that there was a close connection between the history of insecticidal usage in the field, the development of tolerance, and the increase in the population of the cotton leafworm.

According to El-Sebae (1977), the cotton leafworm *Spodoptera littoralis* (Boisd.) in Egypt has become resistant successively to several organochlorine, organophosphate, and carbamate insecticides; and the chitin synthesis inhibitor diflubenzuron.

References

- Ali, A.M. and Ayad, F.A. (1975) The Egyptian cotton leafworm, a unique case of resistance, *Proceedings 8th British Insecticide and Fungicide Conference*, 763-769.
- Brown, A.W.A. (1976) How have entomologists dealt with resistance?, *Proc. Amer. Phytopath. Soc.* **3**: 67.
- El-Sebae, A.H. (1977) Incidents of local pesticide hazards and their toxicological interpretations, *Proc. Univ. Calif/AID*, Univ. Alexandria Seminar Pesticide Management, Alexandria, Egypt, pp. 137-52.

- Finney, D.J.** (1952) *Probit Analysis*, 2nd ed. Cambridge Univ. Press, Cambridge, p. 318.
- Georghiou, G.P.** (1983) Management of resistance in arthropods. in: **G.P. Georghiou** and **T. Saito** (Eds.), *Pest Resistance to Pesticides*, Plenum Press, New York, p. 784.

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تأثير تعاقب المبيدات على حساسية يرقات دودة ورق القطن للمبيدات الحشرية

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أجريت اختبارات قياس الحساسية بطريقة المعاملة الموضعية للجيل الأول (عمر رابع) لعينات من دودة ورق القطن (عمر يرقي خامس وسادس) جمعت من الحقل قبل وبعد أربعة أيام من رش المبيد، خلال موسمين متتاليين. وجد أن رش الأندرين أو تعاقبات مختلفة تنتهي برش الأندرين يؤدي لزيادة تحمل دودة ورق القطن للأندرين بينما لم يظهر تحمل لمبيد اللانث والسيترولين. وفي حالة رش السيترولين أو تعاقبات مختلفة تنتهي بالسيترولين وكذلك في حالة رش اللانث أو تعاقبات مختلفة تنتهي باللانث لم تظهر اليرقات تحملاً للسيترولين أو اللانث بينما لم يكن هناك إتجاه واضح لمستوى تحمل يرقات دودة ورق القطن للأندرين.

درست أيضاً حساسية العمر اليرقي الرابع من الحشرة للمبيدات تحت ظروف المعمل قبل المعاملة بالمبيدات وفي الجيل التالي لكل معاملة بالمبيد في ثلاثة أجيال متتالية. كان إتجاه النتائج متفقاً مع نتائج الدراسات الحقلية وبذلك يمكن التوصية بعدم تكرار رش نوع مبيد واحد خلال موسم المكافحة بل تستخدم مبيدات مختلفة في عملية الرش وخلال تعاقب مدروس.