RESULTS & DISCUSSION

PART I

DEVELOPMENT OF MONITORING TECHINQUES FOR INSECTICIDE RESISTANCE IN FIELD PAPULATION OF THE PINK BOLLWORM

PART I

DEVELOPMENT OF MONITORING TECHNIQUES FOR INSECTICIDE RESISTANCE IN FIELD OPULATIONS OF THE PINK BOLLWORM

1.1 TOPICAL APPLICATION TECHNIQUE

1.1.1 Organophosphate Resistant Monitoring

Toxicity data and resistant ratios (RR) for selected organophosphorus insecticides (OP), profenofos and chlorpyrifos, in three field colonies of pink bollworm, *Pectinophora gossypiella,* collected from cotton fields of different locations during 1998 - and 1999 - late seasons are presented in (Tables 2 & 3) and (Figures 1 & 2).

Data of Resistant Monitoring in 1998 season for profenofos (Table 2 and Fig. 1) showed that, at LD_{50} level, Kafr El-Sheikh colony exhibited somewhat resistance to profenofos by 4.43 - times, in comparison with laboratory (reference) strain. Also, Menoufia and Beni-Suef colonies seemed to be more tolerant to this compound by 3.54- and 3.02- times, respectively, than laboratory strain. Resistant ratios (RR) estimated at LD_{90} level did not exhibit high levels of resistance (from 1.68- to 2.04- times) to profenofos in the selected field colonies in comparison with those estimated at LD_{50} level.

TABLE 2

Toxicity and monitoring resistance of profenofos (organophosphate) in pink bollworm moths collected from selected cotton fields during 1998 and 1999 seasons, using topical application technique.

Strain	Slope ± SE	LD_{50} [a] (95 % FL)	LD_{90} [a] (95 % FL)	RR [b] at LD_{50}	RR [b] at LD_{90}
		1998 – Season			
Menoufia	0.484±0.070	1.71 (1.33-2.20)	4.40 (3.55-5.74)	3.54	1.72
Kafr El-Sheikh	0.416±0.063	2.14 (1.69-2.50)	5.23 (4.22-7.04)	4.43	2.04
Beni-Suef	0.453±0.071	1.46 (0.77-2.61)	4.29 (2.97-8.57)	3.02	1.68
Laboratory (reference)	0.616±0.110	0.483 (0.0135-1.390)	2.56 (1.56-10.90)	--	--
		1999 – Season			
Menoufia	0.162±0.0257	3.19 (0.538-6.970)	11.9 (718-29.62)	8.18	5.00
Kafr El-Sheikh	0.220±0.032	2.74 (0.60-5.97)	8.58 (5.57-22.62)	7.03	5.00
Beni-Suef	0.162±0.023	6.78 (5.51-8.64)	14.68 (12.01-19.30)	17.38	6.1
Laboratory (reference)	0.787±0.120	0.39 (0.041-1.52)	2.39 (1.34-3.19)	--	--

[a] Dosage are expressed in micrograms (AI) of insecticide per moth .

[b] Resistance ratio (RR) calculated by dividing the LD_{50} for resistant-field strain by the LD_{50} for laboratory (reference) Strain.

In 1999 - late season, the monitoring data for resistance to profenofos in selected field populations of pink bollworm from different locations showed an obvious increase in Resistant levels in comparison with those reported during 1998 - season (Table 2 and Fig. 1). However, there was no consistent resistance pattern by strain for this compound.

LD_{50} values of profenofos on pink bollworm moths from selected field colonies : Beni-Suef (6.78 µg / moth), Menoufia (3.19 µg / moth), and Kafr El-Sheikh (2.74 µg / moth) highly increased than that on laboratory (reference) strain (0.39 µg / moth), indicating resistant ratios by 17.38-, 8.18- and 7.03-times, respectively. However, the pattern of Resistant levels to this compound in the three strains, at LD_{90} values, were not at the same trend compared to those found at LD_{50} level.

Dose-mortality data and resistant ratios (RR) for the organophosphorus insecticide chlorpyrifos against 1998- and 1999-field collections of pink bollworm are presented in Table 3 and illustrated in Fig. 2. The data of 1998 monitoring showed that oll selected strains were more tolerant to chlorpyrifos than profenofos. LD_{50} and LD_{90} values in laboratory strain (1.57 and 4.66 µg / moth, respectively) were rather low than those in the selected field collections : Kafr El-sheikh (7.54 and 20.78 µg / moth), Menoufia (5.76 and 16.87 µg / moth) and Beni-Suef (2.01 and 7.80 µg / moth, respectively).

At LD_{50} level, resistant ratios (RR) to chlorpyrifos in the three field collections of pink bollworm were as low as those

TABLE 3

Toxicity and monitoring resistance of chloropyrifos (organophosphate) in pink bollworm moths collected from selected cotton fields during 1998 and 1999 seasons, using topical application technique.

Strain	Slope ± SE	LD_{50} [a] (95 % FL)	LD_{90} [a] (95 % FL)	RR [b] at	
				LD_{50}	LD_{90}
		1998 – Season			
Menoufia	0.115 ± 0.016	5.76 (3.25 – 9.86)	16.87 (11.92 – 30.81)	3.67	3.62
Kafr El-Sheikh	0.097 ± 0.013	7.54 (14.63 – 12.98)	20.78 (14.63 – 38.43)	4.80	4.46
Beni-Suef	0.221 ± 0.034	2.01 (0.123 – 4.77)	7.80 (4.94 – 23.20)	1.27	1.67
Laboratory (reference)	0.415 ± 0.062	1.57 (0.65 – 2.74)	4.66 (3.28 – 9.00)	--	--
		1999 – Season			
Menoufia	0.103 ± 0.0136	7.97 (4.85 – 13.32)	20.41 (14.55 – 36.70)	9.61	4.20
Kafr El-Sheikh	0.102 ± 0.0129	9.89 (6.67 – 15.68)	22.5 (16.39 – 37.94)	11.93	4.63
Beni-Suef	0.163 ± 0.0245	4.23 (2.47 – 6.93)	12.08 (8.68 – 21.41)	5.10	2.49
Laboratory (reference)	0.318 ± 0.057	0.829 (0.19 – 2.30)	4.86 (3.0 – 19.44)	--	--

[a] Dosage are expressed in micrograms (AI) of insecticide per moth .

[b] Resistance ratio (RR) calculated by dividing the LD_{50} for resistant-field strain by the LD_{50} for laboratory (reference) Strain.

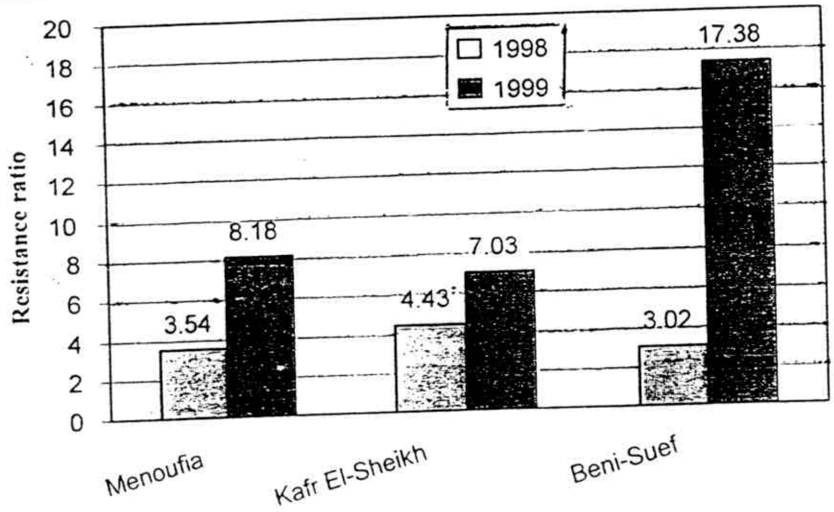

Fig. (1) : Resistance ratio of Profenfos (Orgonanophosphate) to three pink bollworm field colony moths collected from different governorates by using topical application technique at 1998 and 1999 cotton seasons .

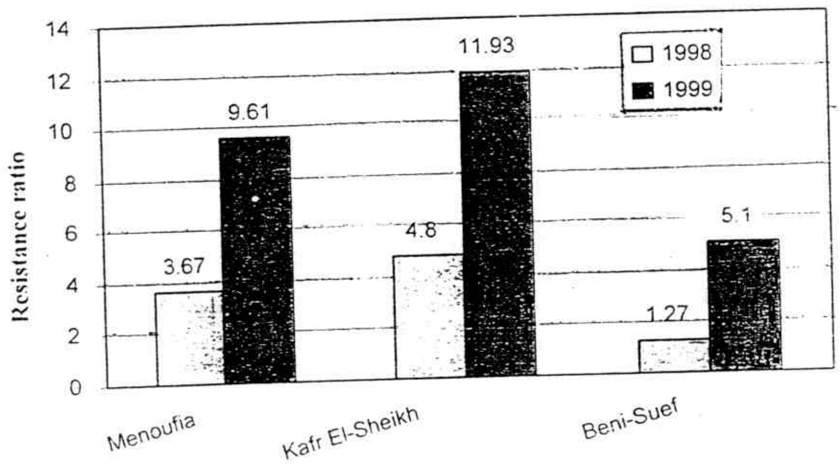

Fig. (2) : Resistance ratio of chloropyrifos (Orgonanophosphate) to three pink bollworm field colony moths collected from different governorates by using topical application technique at 1998 and 1999 cotton seasons .

observed to profenofos (Table 2). Resistant ratio for Kafr El-Sheikh was 4.80 times followed by 3.67- and 1.27- times in Menoufia and Beni-Suef colonies, respectively.

Monitoring data of 1999- late season (Table 2 and Fig. 2) indicated that LD_{50} and LD_{90} values of chlorpyrifos against pink bollworm moths from different field collections were rather increased than those reported in 1998 season. LD_{50} value in laboratory strain (0.829 µg / moth) was much lower than those observed in field colonies from Kafr El-Sheikh (9.89 µg / moth), Menoufia (7.97 µg / moth) and Beni-Suef (4.23 µg / moth). Consequently, resistant ratios (RR) determined on basis of LD_{50} level were greater in Kafr El-Sheikh colony (11.93 times) as compared to Menofia (9.61-times) or Beni-Suef (5.10-times).

1.1.2 *Carbamate Resistant Montoring*

Dose-mortality data and resistant ratios (RR) for selected carbamates, thiodicarb and carbaryl, against 1998 and 1999 field collections of pink bollworm are presented in (Tables 4 & 5) and illustrated in (Figs. 4 & 5).

In 1998, the LD_{50} values of thiodicarb (Table 4 and Fig. 3) presented (Table 4) for selected field colony (Menoufia, Kafr El-Sheikh and Beni-Suef) were slightly increased (7.80, 12.13 and 15.86 µg / moth, respectively) as compared to that of laboratory strain (6.33 µg / moth). Consequently, resistance

TABLE 4

Toxicity and monitoring resistance of thiodicarb (carbamate) in pink bollworm moths collected from selected cotton fields during 1998 and 1999 seasons, using topical application technique.

Strain	Slope±SE	LD_{50} [a] (95 % FL)	LD_{90} [a] (95 % FL)	RR [b] at LD_{50}	RR [b] at LD_{90}
		1998 – Season			
Menoufia	0.047±0.0072	7.80 (2.7-20.41)	35.27 (21.82-118.63)	1.23	1.99
Kafr El-Sheikh	0.047±0.0074	12.13 (5.40-23.71)	39.36 (26.41-87.26)	1.91	2.23
Beni-Suef	0.043±0.0068	15.86 (8.44-32.62)	45.58 (30.17-108.70)	2.51	2.58
Laboratory (reference)	0.113±0.0162	6.33 (3.53-10.64)	17.68 (12.58-32.26)	--	--
		1999 – Season			
Menoufia	0.032±0.0047	18.09 (4.02-43.93)	57.64 (36.35-173.66)	2.98	3.2
Kafr El-Sheikh	0.029±0.0039	26.51 (14.57-48.83)	70.90 (48.66-144.74)	4.37	3.9
Beni-Suef	0.027±0.0037	33.72 (21.79-56.53)	81.45 (58.01-148.0)	5.56	4.54
Laboratory (reference)	0.108±0.0166	6.07 (3.04-10.04)	17.95 (12.88-32.44)	--	--

[a] Dosage are expressed in micrograms (AI) of insecticide per moth .
[b] Resistance ratio (RR) calculated by dividing the LD_{50} for resistant-field strain by the LD_{50} for laboratory (reference) Strain.

ratios (RR) to thiodicarb for these selected field populations were rather low (1.23-, 1.91, and 2.51- times, respectively).

Data of Resistant Monitoring to thiodicarb in 1999-late season (Table 4 and Fig. 3) reported some increases in Resistant levels for this compound, at LD_{50} level, in the three field populations : Menoufia (2.98-times), Kafr El-Sheikh (4.37-times) and Beni-Suef (5.56-times).

Comparisons at LD_{90} level indicated generally similar values of resistant ratios reported for selected field colonies, at LD_{50} level. Values of resistant ratios in selected field colonies were 3.2- (Menoufia), 3.9- (Kafr El-Sheikh) and 4.54- (Beni-Suef) times. In general, Resistant levels reported to this compound in the three selected field colonies during 1998 or 1999 season indicated the same trend.

For toxicity data of carbaryl against pink bollworm moths (Table 5 and Fig. 4)) in 1998 season, it appears that all selected strains were more susceptible to this compound as compared to the other carbamate insecticide tested, thiodicarb (Table 4) indicating rather low values of LD_{50} and LD_{90}. Again, Beni-Suef strain seemed to be more resistant than the other field collections from Kafr El-Sheikh and Menoufia, at LD_{50} level, indicating resistant ratios or 6.83-, 5.10- and 3.30- times, respectively, relative to the laboratory reference strain. However, resistant ratios, at LD_{90} level were lower than those reported at LD_{50} level, indicating 3.06-, 2.38- and 1.74- times, respectively.

TABLE 5

Toxicity and monitoring resistance of carbaryl (carbamate) in pink bollworm moths collected from selected cotton fields during 1998 and 1999 seasons, using topical application technique.

Strain	Slope ± SE	LD_{50} [a] (95 % FL)	LD_{90} [a] (95 % FL)	RR [b] at LD_{50}	RR [b] at LD_{90}
		1998 – Season			
Menoufia	0.316±0.048	1.47 (0.051-4.35)	5.52 (3.32-23.09)	**3.30**	**1.74**
Kafr El-Sheikh	0.241±0.034	2.27 (0.45-5.18)	7.60 (4.87-20.43)	**5.10**	**2.38**
Beni-Suef	0.207±0.029	3.04 (1.33-6.02)	9.24 (6.18-20.72)	**6.83**	**3.06**
Laboratory (reference)	0.497±0.083	0.445 (0.089-2.118)	3.02 (1.67-6.98)	--	--
		1999 – Season			
Menoufia	0.110±0.0162	6.36 (1.87-13.24)	18.05 (11.90-46.53)	**15.90**	**5.42**
Kafr El-Sheikh	0.080±0.0116	9.05 (3.04-20.09)	25.09 (16.25-69.08)	**22.63**	**7.53**
Beni-Suef	0.045±0.0069	16.30 (8.11-33.28)	44.84 (29.80-108.51)	**40.75**	**13.47**
Laboratory (reference)	1.39±0.27	0.40 (0.25-0.58)	3.33 (1.89-10.71)	--	--

[a] Dosage are expressed in micrograms (AI) of insecticide per moth .

[b] Resistance ratio (RR) calculated by dividing the LD_{50} for resistant-field strain by the LD_{50} for laboratory (reference) Strain.

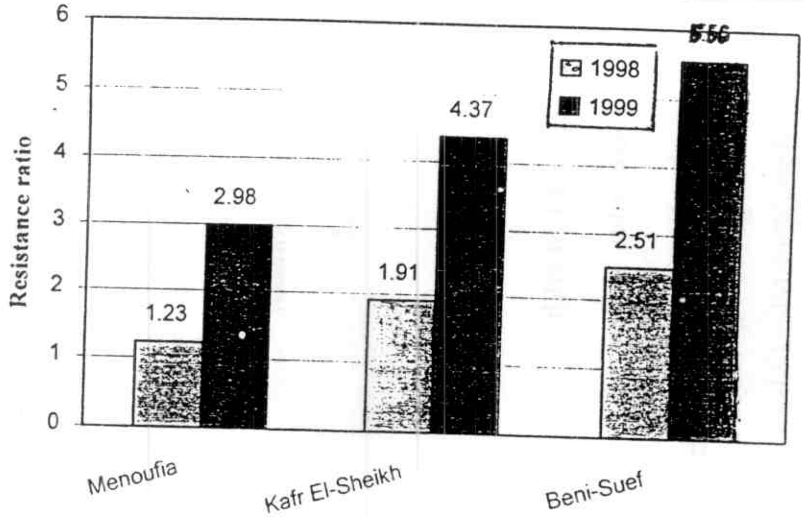

Fig. (3) : Resistance ratio of Thiodicarb (Carbamate) to three pink bollworm field colony moths collected from different governorates by using topical application technique at 1998 and 1999 cotton seasons .

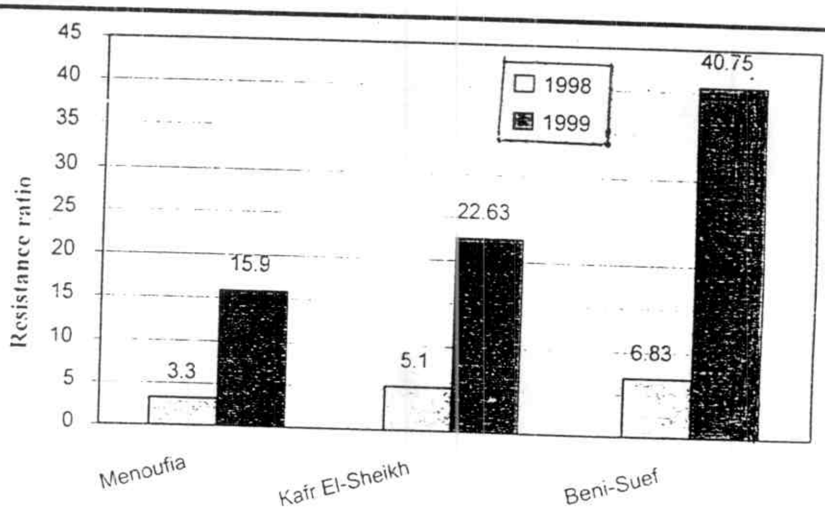

Fig. (4) : Resistance ratio of Carbaryl (Carbamate) to three pink bollworm field colony moths collected from different governorates by using topical application technique at 1998 and 1999 cotton seasons .

Data of carbaryl toxicity and resistant ratios in pink bollworm moths from different field collections in 1999 season are presented also in (Table 5). The toxicity data showed an obvious increase in LD_{50}s (ranged from 6.36 to 16.30 µg / moth) and LD_{90}s (ranged from 18.05 to 44.84 µg / moth) for carbaryl in the three pink bollworm field collections in comparison with those in the laboratory strain (0.40 and 3.33 µg / moth, respectively).

Data of resistant ratios for carbaryl in the pink bollworm field collections (Table 5 and Fig. 4) in 1999 season showed a remarkable increase as compared to that reported during 1998 season. At LD_{50} level, Beni-Suef strain, again, showed the highest level of resistance to carbaryl (RR = 40.75 times) followed by Kafr El-Sheikh (RR = 22.63-times) and Menoufia (RR =15.90- times) and indicating the same trend as that observed during Resistant Monitoring in 1998 season. Similar trend was also observed, at LD_{90} level, showing resistant ratios for this compound in the three selected field locations, i.e. Beni-Suef (13.47-times), Kafr El-Sheikh (7.53-times), and Menoufia (5.42- times).

1.1.3 ***Pyrethroid Resistant Monitoring***

The responses of selected field populatins of pink bollworm from different locations (Menoufia, Kafr El-Sheikh, and Beni-Suef) during 1998 and 1999 cotton growing seasons to selected pyrethroids are presented in (Tables 6 & 7) and illustrated in (Figures 5 & 6).

TABLE 6

Toxicity and monitoring resistance of esfenvalerate 5 EC (Sumi-Alpha) (pyrethroid) in pink bollworm moths ollected from selected cotton fields during 1998 and 1999 seasons, using topical application technique.

Strain	Slope ± SE	LD_{50} [a] (95 % FL)	LD_{90} [a] (95 % FL)	RR [b] at LD_{50}	RR [b] at LD_{90}
		1998 – Season			
Menoufia	0.235±0.038	1.058 (0.028-3.87)	6.51 (3.77-35.78)	1.41	2.77
Kafr El-Sheikh	0.400±0.062	1.06 (0.013-2.33)	4.26 (2.77-10.63)	1.41	1.81
Beni-Suef	0.192±0.026	3.48 (1.68-7.01)	10.15 (6.76-22.81)	4.62	4.32
Laboratory (reference)	0.804±0.131	0.753 (0.25-1.27)	2.35 (1.68-4.36)	--	--
		1999 – Season			
Menoufia	0.162±0.0257	3.19 (0.538-6.970)	11.9 (718-29.62)	4.35	5.04
Kafr El-Sheikh	0.220±0.032	2.74 (0.60-5.97)	8.58 (5.57-22.62)	3.74	3.64
Beni-Suef	0.162±0.023	6.78 (5.51-8.64)	14.68 (12.01-19.30)	9.25	6.22
Laboratory (reference)	0.787±0.120	0.733 (0.512-0.988)	2.36 (1.90-3.16)	--	--

[a] Dosage are expressed in micrograms (AI) of insecticide per moth.
[b] Resistance ratio (RR) calculated by dividing the LD_{50} for resistant-field strain by the LD_{50} for laboratory (reference) Strain.

At LD_{50} level, resistant ratios for esfenvalerate, 5 EC (Sumi-Alpha®) in the selected field collections of pink bollworm moths, in 1998 season (Table 6 and Fig. 5) were as low as 1.41-times (Menoufia colony), 1.41-times (Kafr El-Sheikh colony), and 4.62-times (Beni-Suef strain), relative to the laboratory (reference) strain. At LD_{90} level, values of resistant ratios (RR) were somewhat increased in Menoufia colony (2.77-times) and Kafr El-Sheikh colony (1.81-times), whereas RR in Beni-Suef colony was 4.32-times.

Data of toxicity and Resistant Monitoring for esfenvalerate in 1999 season are presented in Table 6 and in Fig. 5. It was obvious that all LD_{50} and LD_{90} values reported for the three fied collections of pink bollworm were higher than those observed in the 1998 season. At LD_{50}, Resistant levels reported for esfenvalerate in the selected field locations seemed to follow the same trend as those reported in the 1998 season. Beni-Suef strain was the highest tolerant strain to this compound indicating 9.25- times, greater than that of laboratory strain, followed by Menoufiya (4.35-times) and Kafr El-Sheikh (3.74-times). Resistant ratios for esfenvalerate, at LD_{90} level, in the selected field colonies followed similar trend indicating 6.22-, 5.04- and 3.64-times in Beni-Suef, Menoufia and Kafr El-Sheikh colonys, respectively.

The toxicity data and resistant ratios of the other pyrethroid tested, esfenvalerate 20 EC (Sumi-Gold) on the selected field collections of pink bollworm are presented in

TABLE 7

Toxicity and monitoring resistance of esfenvalerate 20 EC (Sumi - Gold) (pyrethroid) in pink bollworm moths collected from selected cotton fields during 1998 and 1999 seasons, using topical application technique.

Strain	Slope ± SE	LD_{50} [a] (95 % FL)	LD_{90} [a] (95 % FL)	RR [b] at LD_{50}	RR [b] at LD_{90}
		1998 – Season			
Menoufia	0.506±0.077	0.89 (0.175-1.78)	3.42 (2.29-746)	1.31	1.84
Kafr El-Sheikh	0.224±0.032	2.57 (0.96-5.53)	8.29 (5.40-20.40)	3.78	4.46
Beni-Suef	0.226±0.034	1.806 (0.0124-4.52)	7.47 (4.67-22.26)	2.66	4.02
Laboratory (reference)	1.084±0.160	0.68 (0.41-1.04)	1.86 (1.40-3.00)	--	--
		1999 – Season			
Menoufia	0.768±117	0.99 (0.55-1.68)	2.66 (1.88-5.06)	1.90	1.68
Kafr El-Sheikh	0.122±0.026	6.02 (3.82-12.83)	16.54 (10.87-4033)	11.55	10.47
Beni-Suef	0.188±0.031	2.40 (0.45-5.24)	9.22 (5.98-23.72)	4.61	5.84
Laboratory (reference)	0.946±0.163	0.521 (0.081-0.726)	1.58 (0.95-6.11)	--	--

[a] Dosage are expressed in micrograms (AI) of insecticide per moth .
[b] Resistance ratio (RR) calculated by dividing the LD_{50} for resistant-field strain by the LD_{50} for laboratory (reference) Strain.

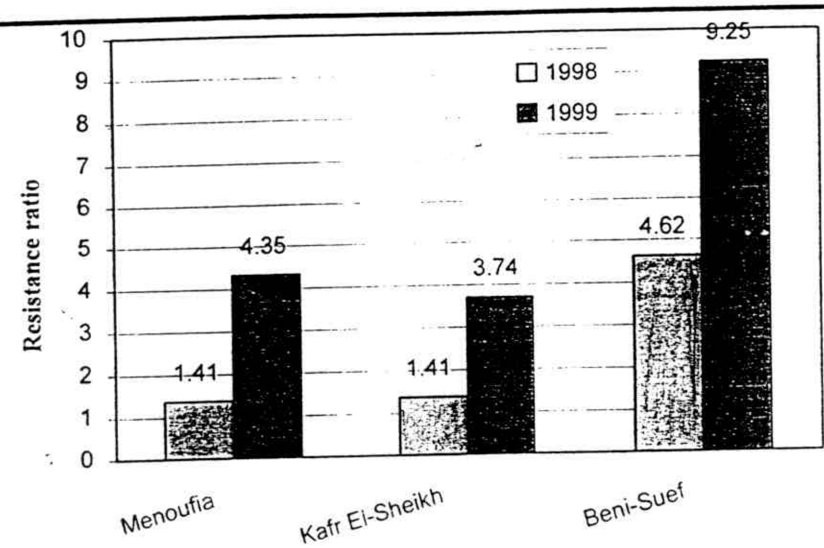

Fig. (5) : Resistance ratio of Esfenvalerate 5% (Pyrethroid) to three pink bollworm field colony moths collected from different governorates by using topical application technique at 1998 and 1999 cotton seasons .

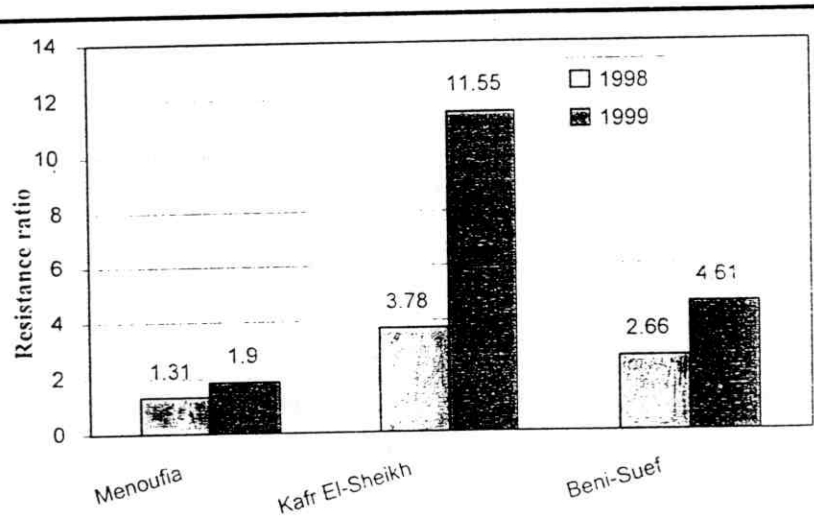

Fig. (6) : Resistance ratio of Esfenvalerate 20% (Pyrethroid) to three pink bollworm field colony moths collected from different governorates by using topical application technique at 1998 and 1999 cotton seasons .

(Table 7) and (Fig. 6). The data of resistance patterns in selected field colonies of pink bollworm to this compound appeared to be similar to that observed for the other formulation of esfenvalerate tested (Sumi-Alpha, 5 EC). Data of Resistant Monitoring to this compound in the 1998 growing cotton season showed that Kafr El-Sheikh colony had somewhat Resistant level by 3.78-fold greater than that of the laboratory strain. The other strains, Beni-Suef and Menoufia had slight increase in LD_{50} values, as compared to that of laboratory strain, indicating resistant ratios of 2.66- and 1.31- times, respectively. At LD_{90} level, resistant ratios reported were also as low as those observed at LD_{50} level indicating 1.84-, 4.46-, and 4.02-times in Menoufia, Kafr El-Sheikh and Beni-Suef colonies, respectively.

Data of Resistant Monitoring for esfenvalerate (Sumi-Gold, 20 EC) in selected field colonies of pink bollworm, during the 1999 growing cotton season (Table 7 and Fig. 6) indicated that an increase of Resistant level, at LD_{50} level was particularly marked in Kafr El-Sheikh colony (11.55-fold) in comparison with the other selected strains of Beni-Suef (4.61-fold) and Menoufia (1.90- fold). Similar data of resistant ratios were reported, at LD_{90} level, indicating an increase in Resistant level to this compound in Kafr El-Sheikh colony by 10.47-fold, followed by Beni-Suef (5.84-fold) and Menoufia (1.68-fold) strains.

TABLE 8

Toxicity and monitoring resistance of profenofos (organophosphate) in pink bollworm moths collected from selected cotton fields during 1998 and 1999 seasons, using vial contact film technique.

Strain	Slope ± SE	LC_{50} [a] (95 % FL)	LC_{90} [a] (95 % FL)	RR [b] at LC_{50}	RR [b] at LC_{90}
		1998 – Season			
Menoufia	0.22±0.049	2.64 (1.36-3.85)	8.25 (6.11-13.33)	3.90	2.48
Kafr El-Sheikh	0.015±0.030	4.02 (2.44-6.10)	12.72 (9.56-19.70)	6.37	3.83
Beni-Suef	1.02±0.37	1.58 (0.41-3.24)	28.22 (8.72-35.15)	2.50	8.5
Laboratory (reference)	0.477±10.12	0.631 (0.009-1.197)	3.32 (2.39-5.81)	--	--
		1999 – Season			
Menoufia	0.147±0.031	4.02 (2.44-6.09)	12.72 (9.56-19.69)	8.61	6.66
Kafr El-Sheikh	0.127±0.025	5.72 (3.87-8.38)	15.85 (12.02-24.05)	12.25	8.30
Beni-Suef	0.325±0.067	1.78 (0.228-3.97)	5.72 (3.68-15.61)	3.81	3.00
Laboratory (reference)	1.12±0.274	0.467 (0.029-0.637)	1.91 (1.11-2.23)	–	--

[a] Concentration are presented in milligrams (AI) of insecticide per vial.
[b] Resistance ratio (RR) calculated by dividing the LC_{50} for resistant-field strain by the LC_{50} for laboratory (reference) Strain.

1.2 GLASS VIAL CONTACT FILM TECHNIQUE

1.2.1 *Organophosphate Resistant Monitoring*

Toxicity data and Resistant Monitoring for two selected organophosphorus insecticides, profenofos and chlorpyrifos, in three field collections of pink bollworm, *P. gossypiella,* were reported during two successive growing cotton seasons (1998 and 1999) by using vial contact film technique.

In 1998, toxicity data of profenofos in selected field colonies (Table 8 and Fig. 7) showed remarkable increase of LC_{50} value in Kafr El-Sheikh colony (4.02 mg / vial) as compared to that observed in the laboratory strain (0.631 mg/vial) indicating resistant ratio of 6.37-times. However, the other colonies tested, i.e. Menoufia and Beni-Suef, had low levels of resitance by 3.90- and 2.50-times greater than the laboratory strain, respectively. The toxicity data, at LC_{90} level, showed moderate levels of resistance to profenofos in all selected field colonies : Kafr El-Sheikh (3.83-times), Menoufia (2.48-times), and Beni-Suef (8.50-times).

In 1999 season (Table 8 and Fig. 7), an increase in LC_{50} values of profenofos was observed in all selected field colonies, particularly Kafr El-Sheikh (5.72 mg / vial) and Menoufia (4.02 mg / vial) as compared to that in the laboratory strain (0.467 mg / vial) indicating resistant ratios of 12.25- and 8.61-times, respectively. Also, Beni-Suef colony had somewhat increase in LC_{50} value (1.78 mg / vial), this was 3.81- fold increase as compared to that of the laboratory strain. At LC_{90} level, similar trend was observed, however lower levels of resistance to

TABLE 9

Toxicity and monitoring resistance of chloropyrifos (organophosphate) in pink bollworm moths collected from selected cotton fields during 1998 and 1999 seasons, using vial contact film technique.

Strain	Slope ± SE	LC_{50} [a] (95 % FL)	LC_{90} [a] (95 % FL)	RR [b] at LC_{50}	RR [b] at LC_{90}
		1998 – Season			
Menoufia	1.561±0.052	1.84 (0.87-3.29)	12.19 (5.45-403.6)	4.27	2.97
Kafr El-Sheikh	0.147±0.038	2.32 (0.013-6.91)	9.81 (5.88-41.78)	5.38	3.82
Beni-Suef	0.429±0.099	0.74 (0.015-2.28)	3.73 (2.22-17.47)	1.72	1.45
Laboratory (reference)	0.600±0.160	0.431 (0.016-1.23)	2.57 (1.60-10.18)	--	--
		1999 – Season			
Menoufia	0.092±0.019	6.74 ((2.16-15.77)	20.69 (13.19-58-70)	20.73	21.11
Kafr El-Sheikh	0.08±0.017	8.79 (4.36-18.52)	24.86 (16.35-61.03)	27.05	25.37
Beni-Suef	0.191±0.039	3.05 (0.55-6.85)	9.76 (6.28-26.94)	9.38	9.96
Laboratory (reference)	1.694±0.418	0.325 (0.077-0.402)	0.98 (0.72-1.71)	--	--

[a] Concentration are presented in milligrams (AI) of insecticide per vial.

[b] Resistance ratio (RR) calculated by dividing the LC_{50} for resistant-field strain by the LC_{50} for laboratory (reference) Strain.

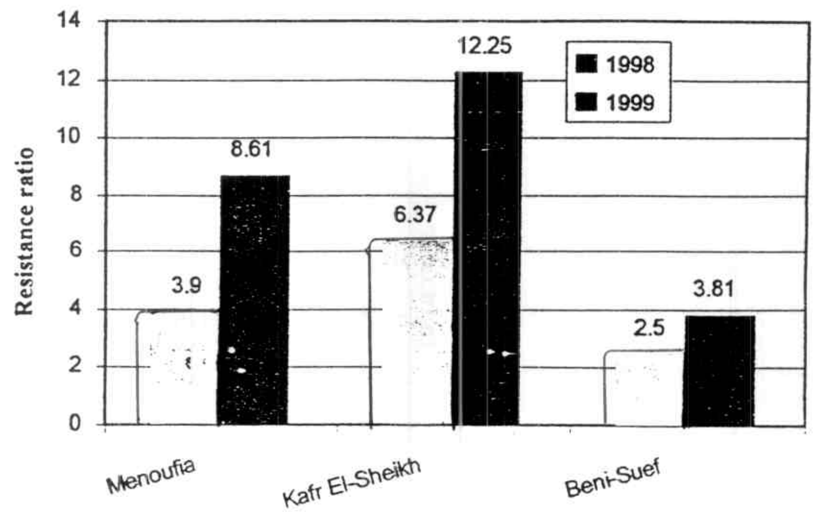

Fig. (7) : Resistance ratio of Profenfos (Orgonanophosphate) to three pink bollworm field colony moths collected from different governorates by using Vial contact film technique at 1998 and 1999 cotton seasons .

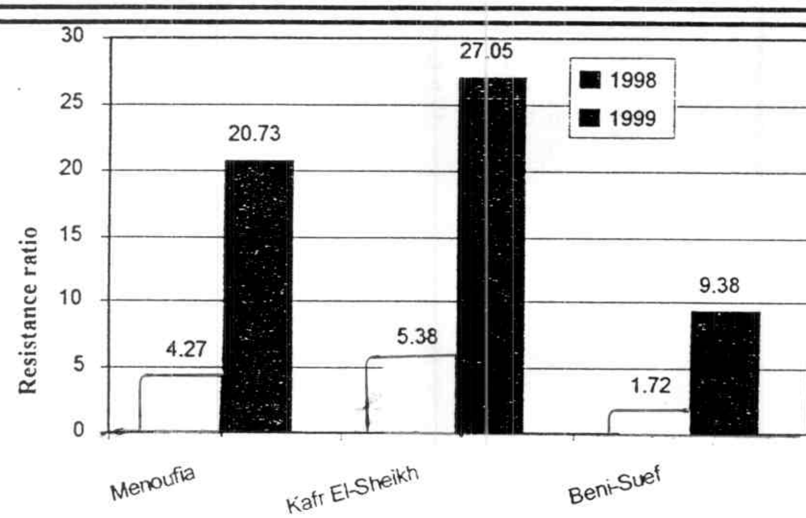

Fig. (8) : Resistance ratio of chloropyrifos (Orgonanophosphate) to three pink bollworm field colony moths collected from different governorates by using Vial contact film technique at 1998 and 1999 cotton seasons .

profenofos were estimated : 8.3-times. (Kafr El-Sheikh colony), 6.66-times (Menoufia colony), and 3.00-times (Beni-Suef colony).

For toxicity data of chlorpyrifos (Table 9 and Fi. 8), the LC_{50} values reported for the selected field colonies of pink bollworm, in 1998 season, were nearly as low as those reported for profenofos, i.e. 2.32 mg vial (Kafr El-Sheikh), 1.84 mg vial (Menoufia), and 0.74 mg vial (Beni-Suef) in comparison with LC_{50} of 0.431 mg / vial in laboratory strain. Resistant ratios estimated at LC_{50} level were 5.38- (Kafr El-Sheikh), 4.27- (Menoufia), and 1.72- (Beni-Suef)-times greater than the laboratory strain. Where, resistant ratios, at LC_{90} level, were 3.82-, 2.97-, and 1.45-times, respectively.

Toxicity and Resistant Monitoring data for chlorpyrifos in the 1999 season were also presented in (Table 9). The LC_{50} and LC_{90} values of chlorpyrifos were markedly increased in the three selected field locations of pink bollworm, from 1998 season to 1999 season. The highest LC_{50} (8.79 mg / vial) was observed, again, in Kafr El-Sheikh colony, followed by that in Menoufia (6.74 mg / vial) and Beni-Suef (3.05 mg / vial), compared to that in laboratory strain (0.325 mg / vial). This indicates resistant ratios of 27.05- (Kafr El-Sheikh), 20.73- (Menoufia), and 9.38- (Beni-Suef) times, as compared to the laboratory strain. Similar trend was also observed for resistant ratios of this compound, at LC_{90} level, showing 25.37- times (Kafr El-Sheikh), 21.11-times (Menoufia), and 9.96-times (Beni-Suef).

TABLE 10

Toxicity and monitoring resistance of thiodicarb (carbamate) in pink bollworm moths collected from selected cotton fields during 1998 and 1999 seasons, using vial contact film technique.

Strain	Slope ± SE	LC_{50} [a] (95 % FL)	LC_{90} [a] (95 % FL)	RR [b] at LC_{50}	RR [b] at LC_{90}
		1998 – Season			
Menoufia	0.097±0.023	3.63 (0.61-10.18)	16.87 (10.27-73.97)	**1.75**	3.50
Kafr El-Sheikh	0.066±0.015	6.096 (0.88-20.40)	25.46 (14.93-148.40)	**2.93**	5.30
Beni-Suef	0.056±0.0115	12.50 (8.10-18.51)	35.50 (26.83-54.80)	**6.01**	7.40
Laboratory (reference)	0.105±0.029	2.08 (0.25-4.81)	4.81 (1.2-26.21)	--	--
		1999 – Season			
Menoufia	0.036±0.007	17.27 (4.47-36.86)	52.75 (34.44-134.45)	**14.65**	14.71
Kafr El-Sheikh	0.030±0.006	26.11 (17.84-37.62)	68.57 (52.54-102.52)	**22.15**	19.12
Beni-Suef	0.026±0.005	32.66 (23.05-47.32)	81.66 (62.14-124.57)	**27.70**	22.77
Laboratory (reference)	0.532±0.128	1.179 (0.434-1.83)	3.587 (2.70-5.756)	--	--

[a] Concentration are presented in milligrams (AI) of insecticide per vial.

[b] Resistance ratio (RR) calculated by dividing the LC_{50} for resistant-field strain by the LC_{50} for laboratory (reference) Strain.

1.2.2. *Carbamate Resistant Monitoring*

Data of toxicity and Resistant Monitoring for carbamate insecticides, thiodicarb and carbaryl, determined by using vial technique in three selected field colonies of pink bollworm during two successive growing cotton seasons (1998 and 1999) are presented in (Tables 10 & 11) and illustrated in (Figures 9 & 10).

In 1998, the susceptibily of three field colonies of pink bollworm moths to thiodicarb was obviously different than that of the laboratory strain particularly when compared at LC_{90} level (Table 10 and Fig. 9). At LC_{50} level, resistant ratios for thiodicarb were 6.01-, 2.93- and 1.75-times in Beni-Suef, Kafr El-Sheikh, and Menoufia colonys, respectively, as compared to the laboratory strain. Similar trend was observed, at LC_{90} level, with somewhat increasing in resistant ratios : i.e. 7.4-times (Beni-Suef strain), 5.3-times (Kafr El-Sheikh colony), and 3.50-times (Menoufia colony).

Toxicity data of thiodicarb determined in the 1999 season (Table 10 and Fig. 9) indicated that loss of susceptibility was markedly observed to this compound in all three selected field populations of pink bollworm as compared to that reported in 1998 season. At LC_{50} level, all the three field colonies : Beni-Suef (32.66 mg / vial), Kafr El-Sheikh (26.11 mg / vial), and Menoufia (17.27 mg / vial), showed high resistant ratios of 27.70-, 22.15-, and 14.65-times, respectively as compared to that of the laboratory strain (1.179 mg / vial). Similar trend was observed when compared at LC_{90} level, where resistant ratios reported in the field colonies from Beni-Suef, Kafr El-Sheikh or / and Menoufia areas were 22.77-, 19.12-, and 14.71-times, respectively, greater than the laboratory strain.

TABLE 11

Toxicity and monitoring resistance of carbaryl (carbamate) in pink bollworm moths collected from selected cotton fields during 1998 and 1999 seasons, using vial contact film technique.

Strain	Slope ± SE	LC_{50} [a] (95 % FL)	LC_{90} [a] (95 % FL)	RR [b] at LC_{50}	RR [b] at LC_{90}
		1998 – Season			
Menoufia	0.121±0.024	4.61 (2.27-7.15)	15.18 (11.36-24.20)	8.38	3.74
Kafr El-Sheikh	0.065±0.013	8.46 (0.96±8.81)	28.21 (18.19-76.20)	15.38	6.95
Beni-Suef	0.052±0.011	13.28 (8.61-19.67)	37.71 (28.51-58.20)	24.15	9.28
Laboratory (reference)	1.48±0.41	0.55 (0.19-0.91)	4.06 (2.16-23.84)	--	--
		1999 – Season			
Menoufia	0.030±0.006	20.73 (12.37-31.35)	63.74 (47.9-99.5)	42.31	14.75
Kafr El-Sheikh	0.025±0.005	29.16 (19.22-43.58)	81.43 (61.08-128.26)	59.51	18.85
Beni-Suef	0.023±0.005	37.96 (26.91-56.06)	93.90 (70.62-147.46)	77.47	21.74
Laboratory (reference)	1.36±0.38	0.49 (0.23-0.84)	4.32 (1.93-51.03)	--	--

[a] Concentration are presented in milligrams (AI) of insecticide per vial.

[b] Resistance ratio (RR) calculated by dividing the LC_{50} for resistant-field strain by the LC_{50} for laboratory (reference)

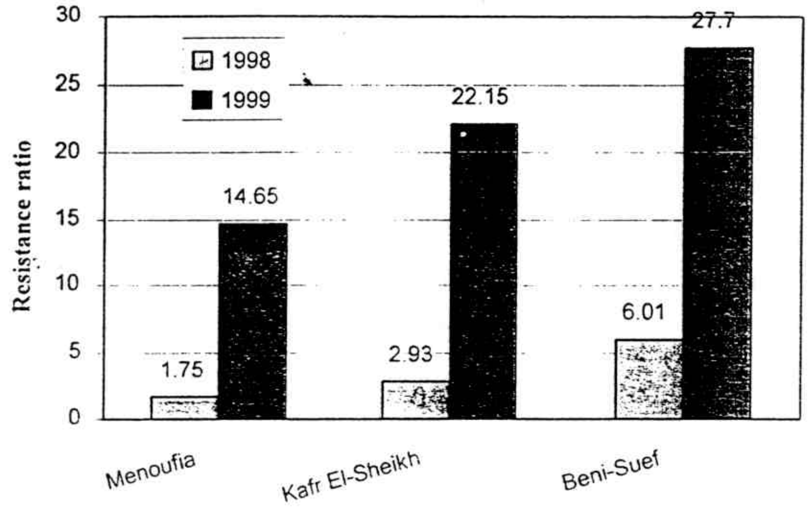

Fig. (9) : Resistance ratio of Thiodicarb (Carbamate) to three pink bollworm field colony moths collected from different governorates by using Vial contact film technique at 1998 and 1999 cotton seasons .

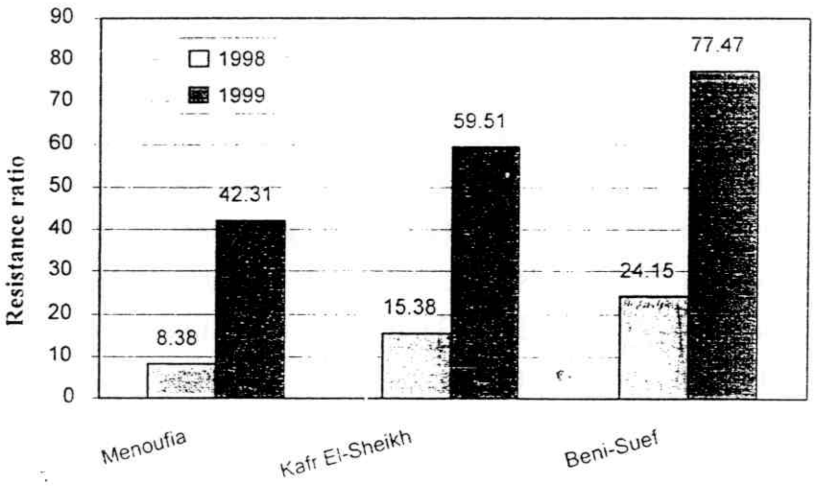

Fig. (10) : Resistance ratio of Carbaryl (Carbamate) to three pink bollworm field colony moths collected from different governorates by using Vial contact film technique at 1998 and 1999 cotton seasons .

On the other hand, toxicity data for carbaryl (Table 11 and Fig. 10)) showed high levels of resistance in the field colonies of pink bollworm from selected areas during two successive growing cotton seasons (1998 and 1999). In 1998, the LC_{50} values of carbaryl were much higher in the field colonies : i.e. Beni-Suef (13.28 mg / vial), Kafr El-Sheikh (8.46 mg / vial), and Menoufia (4.61 mg / vial) than that of the susceptible (0.55 mg / vial) indicating much higher resistant ratios of 24.15-, 15.38- and 8.38-times, respectively. However, values of resistant ratios reported at LC_{90} level were obviously lower and indicating 9.28-, 6.95- and 3.74-times in Beni-Suef, Kafr El-Sheikh, and Menoufia colonys, respectively, greater than the laboratory strain.

In 1999, a remarkable loss of susceptibility to carbaryl was clearly observed in all three selected field colonies of pink bollworm in comparison with the laboratory strain (Table 11). LC_{50} values of the three field colonies were much higher than that reported for the laboratory strain as follows : 37.96 mg / vial (Beni-Suef), 29.16 mg / vial (Kafr El-Sheikh) 20.73 mg / vial (Menoufia) and 0.49 mg / vial (laboratory strain). Consequently, a remarkabley high levels of resistance to carbaryl were observed by 77.47-, 59.51-, and 42.31-times, respectively. However, resistant ratios reported to carbaryl at LC_{90} level in these field colonies were 21.74-, 18.85- and 14.75- times, respectively.

TABLE 12

Toxicity and monitoring resistance of esfenvalerate 5 EC (Sumi-Alpha) (pyrethroid) in pink bollworm moths collected from selected cotton fields during 1998 and 1999 seasons, using vial contact film technique.

Strain	Slope ± SE	LC_{50} [a] (95 % FL)	LC_{90} [a] (95 % FL)	RR [b] at LC_{50}	RR [b] at LC_{90}
		1998 – Season			
Menoufia	0.819±0.171	0.792 (0.488-1.186)	2.36 (1.78-3.66)	**6.14**	**4.63**
Kafr El-Sheikh	1.333±0.297	0.456 (0.256-0.697)	1.42 (1.06-2.27)	**3.53**	**2.78**
Beni-Suef	0.471±0.092	1.49 (0.994-2.196)	4.22 (3.21-6.34)	**11.55**	**8.27**
Laboratory (reference)	3.374±0.812	0.129 (0.018-0.219)	0.510 (0.377-0.838)	--	--
		1999 – Season			
Menoufia	0.224±0.048	1.82 (0.019-6.55)	7.54 (4.37-44.64)	**16.54**	**11.09**
Kafr El-Sheikh	0.456±0.098	1.01 (0.084-3.142)	3.82 (2.27-18.91)	**9.18**	**5.62**
Beni-Suef	0.187±0.038	3.08 (0.287-8.58)	9.93 (6.08-36.46)	**28.00**	**14.6**
Laboratory (reference)	1.61±0.41	0.11 (0.05-0.17)	0.68 (0.37-3.19)	--	--

[a] Concentration are presented in milligrams (AI) of insecticide per vial.

[b] Resistance ratio (RR) calculated by dividing the LC_{50} for resistant-field strain by the LC_{50} for laboratory (reference) Strain.

1.2.3 *Pyrethroid Resistant Monitoring*

Toxicity and resistance parameters for the pyrethroid insecticide, esfenvalerate (5 EC and 20 EC) in selected field colonies of pink bollworm during 1998 and 1999 seasons are presented in (Tables 12 & 13 and in (Figures 11 & 12).

In 1998, the LC_{50} values of esfenvalerate (5 EC) (Table 12 and Fig. 11) in selected field colonies of pink bollworm were 1.49 mg / vial (Beni-Suef), 0.792 mg / vial (Menoufia) and 0.456 mg / vial (Kafr El-Sheikh) compared to that in the laboratory strain (0.129 mg / vial). This indicates resistant ratios by 11.55-, 6.14- and 3.53-times, for Beni-Suef, Menoufia, and Kafr El-Sheikh colonys, respectively. Comparisons at LC_{90} values, also showed somewhat Resistant levels of 8.27-, 4.63-, and 2.78-times in Beni-Suef, Menoufia, and Kafr El-Sheikh colonys, respectively.

The toxicity data for this compound reported in 1999 season (Table 12) showed a remarkable increase in LC_{50} values of all selected field colonies of pink bollworm moths in comparison with that in 1998 season. At LC_{50} level, resistant ratios were 28.0-, 16.54-, and 9.18-times in Beni-Suef, Menoufia, and Kafr El-Sheikh colonys, respectively, greater than the laboratory strain. Also, comparisons at LC_{90} level, indicated resistant ratios of 14.6- (Beni-Suef), 11.09- (Menoufia), and 5.62- (Kafr El-Sheikh) times greater than that of the laboratory strain.

TABLE 13

Toxicity and monitoring resistance of esfenvalerate 20 EC (Sumi-Gold) (pyrethroid) in pink bollworm moths collected from selected cotton fields during 1998 and 1999 seasons, using vial contact film technique.

Strain	Slope ± SE	LC_{50} [a] (95 % FL)	LC_{90} [a] (95 % FL)	RR [b] at	
				LC_{50}	LC_{90}
		1998 – Season			
Menoufia	0.381±0.094	0.833 (0.028-2.68)	4.21 (2.48-26.70)	**1.62**	**2.34**
Kafr El-Sheikh	0.239±0.053	2.16 (0.235-4.753)	7.53 (4.87-20.20)	**4.20**	**4.18**
Beni-Suef	0.330±0.079	1.29 (0.427-2.161)	5.18 (3.77-8.86)	**2.51**	**2.88**
Laboratory (reference)	0.97±0.237	0.514 (0.171-0.828)	1.80 (1.34-2.95)	--	--
		1999 – Season			
Menoufia	0.294±0.061	2.06 (0.51-4.29)	6.42 (4.22-15.70)	**5.51**	**3.89**
Kafr El-Sheikh	0.090±0.021	6.80 (2.95-14.90)	21.12 (13.71-55.04)	**18.18**	**12.8**
Beni-Suef	0.14±0.028	4.24 (1.07-9.69)	13.45 (8.61-36.78)	**11.34**	**8.15**
Laboratory (reference)	1.02±0.251	0.374 (0.074-0.957)	1.653 (1.021-6.110)	--	--

[a] Concentration are presented in milligrams (AI) of insecticide per vial.

[b] Resistance ratio (RR) calculated by dividing the LC_{50} for resistant-field strain by the LC_{50} for laboratory (reference) Strain.

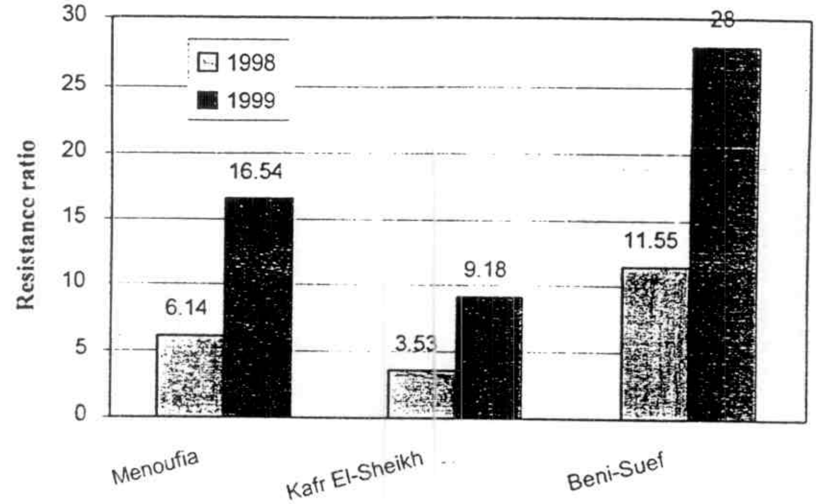

Fig. (11) : Resistance ratio of Esfenvalerate 5% (Pyrethroid) to three pink bollworm field colony moths collected from different governorates by using Vial contact film technique at 1998 and 1999 cotton seasons .

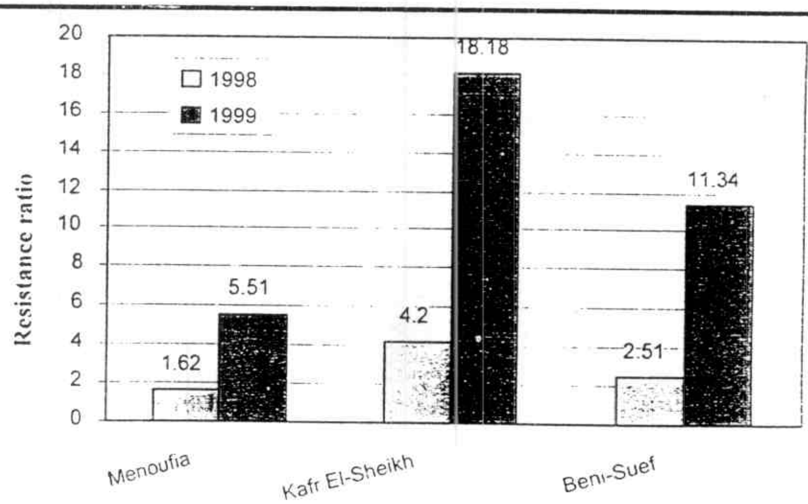

Fig. (12) : Resistance ratio of Esfenvalerate 20% (Pyrethroid) to three pink bollworm field colony moths collected from different governorates by using Vial contact film technique at 1998 and 1999 cotton seasons .

Toxicity data and resistant ratios for esfenvalerate (20 EC) in selected field colonies of pink bollworm during 1998 and 1999 seasons are presented in (Table 13 and Fig. 12). Data of 1998 season indicated that resistant ratios, at LC_{50} level, to this compound was much lower than that to esfenvalerate 5 EC, particularly in Menoufiya (RR = 1.62-) and Beni-Suef (RR = 2.51-) strains. Also, at LC_{90} level, low resistant ratios for this compound were reported in the selected field colonies : Kafr El-Sheikh (4.18-fold), Beni-Suef (2.88-fold) and Menoufia (2.34-fold) strains.

Toxicity data, in 1999 season (Table 13), showed a remarkable increase in LC_{50} values for esfenvalerate 20 EC, particularly in field colonies from Kafr El-Sheikh (6.80 mg / vial) and Beni-Suef (4.24 mg / vial) as compared to that of the laboratory strain (0.374 mg / vial). This indicated resistant ratios of 18.18-times (Kafr El-Sheikh colony), 11.34-times (Beni-Suef strain), and 5.51-times (Menoufiya strain). Where, resistant ratios for this compound, at LC_{90} level, showed 12.80-, 8.15-, and 3.89-times in field colonies from Kafr El-Sheikh, Beni-Suef, and Menoufiya, respectively.

1.3 MONITORING FOR INSECTICIDE RESISTANCE BY A DISCRIMINATING - CONCENTRATION TECHNIQUE

Responses of pink bollworm, P. gossypiella, moths of the susceptible-laboratory strain to different insecticides are shown in Table (14). At LC_{50}, it was obvious that the selected pyrethroid insecticide,

TABLE 14

Toxicity of selected insecticides to susceptible – laboratory strain of the pink bollworm , *P.gossypiella* ,mothes.

Insecticides (Class)[c]	Slope ± SE	LC_{50} [a,b] (95% FL)	LC_{99} [a,b] (95% FL)
Profenofos (OP)	0.8671 ± 0.1883	0.46 (0.21 – 0.89)	2.2 (0.43 – 20.69)
Chloropyrifos (OP)	0.9139 ± 0.1495	0.33 (0.18 – 0.63)	1.2 (0.24 – 2.25)
Thiodicarb (CAR)	0.7628 ± 0.1401	0.85 (0.44 – 2.04)	5.9 (1.14 – 7.98)
Carabaryl (CAR)	0.7751 ± 0.1710	0.16 (0.09 – 0.32)	6.3 (5.03 – 30.7)
Esfenfalerate 5 EC (PY)	0.7610 ± 0.1860	0.11 (0.07 – 0.46)	0.81 (0.14 – 2.0)
Esfenfalerate 20 EC (PY)	0.5750 ± 0.1813	0.22 (0.09 – 2.36)	2.5 (2.30 – 5.88)

[a] Concontrations are expressed in mg [A I] of insecticide per glass vial.
[b] Data of 24 h after exposure of moths to an insecticide.
[c] **OP** , Organophosphate ; **CAR** , carbamate ; **P. Y** ,pyrethoid .

esfenvalerate (either 5 % or 20 % EC), and the carbamate, carbaryl were highly effective ($LC_{50}s$ = 0.11, 0.22, and 0.16 mg [AI] / glass vial) against the moths in comparison with the other insecticides tested. Thiodicarb (carbamate) seemed to be the least effective compound (LC_{50} = 0.85 mg / vial) followed by the organophosphorus insecticides, i.e. profenofos (0.46 mg / vial) and chlorpyrifos (0.33 mg / vial).

Based on results of the concentration-mortality bioassay, we chosed a single discriminating (or diagnostic) concentration for testing the Resistant levels in field populations of *P. gossypiella* to the tested insecticides. At the concentrations chosen of different insecticides, mortality for the moths of susceptible-laboratory strain were close to 99 % (Table 14). In assessing this technique, **Daly and Murray (1988)** suggested that the discriminating dose used by **Gunning *et al.* (1984)** (the LD_{99} for susceptible insects) killed a substantial proportion of resistant larvae of *Heliothis armigera* (Hübner).

The single diagnostic concentration technique was tested for monitoring of resistance to insecticides in *P. gossypiella* moths collected from different cotton field locations during growing season of 2000. Based on estimates of the LC_{99} of the tested insecticides in susceptible-laboratory strain, 2.2, 1.2, 5.9, 6.3, 0.81, and 2.5 mg [AI] / vial were selected for profenofos, chlorpyrifos, thiodicarb, carbaryl, esfenvalerate (5 EC), and esfenvalerate (20 EC), respectively, for use as diagnostic concentrations. These concentrations consistently killed≈ 99 % of the susceptible - laboratory strain of pink bollworm moths (Table 14), in comparison with the resistant field colonies tested in the early growing season of 2000 (Table 15).

TABLE 15

Response of pink bollworm , *P. gossypiella* , moths collected from three field locations of cotton durig to early season of discriminating 2000 concentrations of different insecticides using surface film technique.

Insecticides	Conc[a] mg(AI) per vial	Field Strains					
		Menoufia		Kafr- Elsheikh		Beni-Suef	
		Mortality[b] (%)	Resistance[c] (%)	Mortality[b] (%)	Resistance[c] (%)	Mortality[b] (%)	Resistance[c] (%)
Profenofos	**2.2**	90.0	9.10	96.7	2.32	80.0	19.2
Chlorpyrifos	**1.2**	86.7	12.42	90.0	9.09	96.7	2.32
Thiodicarb	**5.9**	50.0	49.5	60.0	39.4	70.0	29.3
Carbaryl	**6.3**	50.0	49.5	70.0	29.3	50.0	49.5
Esfenvalerate 5EC	**0.81**	83.3	15.86	80.0	19.2	93.3	5.76
Esfenvalerate 20EC	**2.5**	83.3	15.86	96.7	2.32	90.0	9.09

a Discriminating cocentrations .
b Mortality data after 24 h of exposure of moths to an inceticide.
c Resistance percentage by using the formula = 100 - [(% M at discriminating conc. in field strain) / (% M at discriminating conc. in susceptible strain) x 100] .

As shown in (Table 15) and (Figure 13) mortality percentages of pink bollworm moths collected from different field locations varied for the same selected insecticide indicating different levels of estimated Resistant percentages. It seems, generally, that moths collected from Menoufia fields were more resistant to most insecticides tested, except profenofos and esfenvalarate (50) EC, as compared to those collected from either Kafr El-Sheikh or Beni-suef fields. For example, Resistant percentage estimated for chlorpyrifos in field colony from Menoufia fields was 12.42 % followed by those from Kafr El-Sheikh (9.09 %) and Beni-Suef (2.32 %) fields. Also, similar trend was observed for thiodicarb, at which Resistant percentages estimated in the field colony from Menoufia was 49.5 % followed by those from Kafr El-Sheikh (39.4%) and Beni-Suef (29.3 %). However, the field colony from Beni-Suef exhibited Resistant percentage to profenofos (19.2 %) more than that estimated in both strains from Menoufia (9.10 %) and Kafr El-Sheikh (2.32 %); indicating that resistant levels in pink bollworm moths to certain insecticides could vary in different areas. This indicates, also, that an insecticide that used successfully in an area may be not appropriate in another area.

Resistant levels estimated to selected insecticides in samples collected from cotton fields in late growing season of 2000 are summarized in Table (16). and illustrated in Figure (14). Based on mortality percentages of pink bollworm moths exposed to diagnostic concentrations of selected insecticides. The resistant levels were estimated for each tested strain. In comparison with resistant levels estimated in samples collected in the early season (May 2000), the data of late season

TABLE 16

Respons & Pink bollworm , *P. gossypiella* ,moths collected from three field locations of cotton durig late season of 2000 to discriminating concentrations of different insecticides using surface film technique.

Insecticides	Conc.[a] mg(AI) per vial	Field Strains					
		Menoufia		Kafr- Elsheikh		Beni-suef	
		Mortality[b] (%)	Resistance[c] (%)	Mortality[b] (%)	Resistance[c] (%)	Mortality[b] (%)	Resistance[c] (%)
Profenofos	**2.2**	80.0	19.2	93.3	5.76	70.0	29.3
Chlorpyrifos	**1.2**	80.7	18.5	83.3	15.86	90.0	9.09
Thiodicarb	**5.9**	46.7	52.8	50.0	49.5	60.0	39.4
Carbaryl	**6.3**	40.0	59. 6	60.0	39.4	40.0	59.6
Esfenvalerate 5EC	**0.81**	70.0	29.3	70.0	29.3	86.3	12.83
Esfenvalerate 20EC	**2.5**	73.3	26.0	93.3	5.76	83.3	15.86

a Discriminating cocentrations .

b Mortality data after 24 h of exposure of moths to an inceticide.

c Resistance percentage by using the formula = 100 - [(% M at discriminating conc. in field strain) / (% M at discriminating conc. in susceptible strain) x 100] .

(Sept. 2000) showed, generally, higher levels of resistance in all samples from the three field collections. Again, moths collected from Menoufia fields seemed to be more resistant to most insecticides tested than those collected from Kafr El-Sheikh and Beni-Suef. Where Resistant percentages estimated in Menoufia colony were 18.5, 19.2, 26.0, 29.3, 52.8, and 59.6 % for chlorpyrifos, profenos, espen valerate 20 EC, espen valerate 5 EC, thiodicarb, and carbryl, respectively. Also, field colony from Kafr El-Sheikh showed high levels of resistance % to all insecticides tested in the late season, especially for chlorpyrifos (15.86 %), carbaryl 39.4 % thiodicarb (49.5 %) and esfenvalerate 5 EC (29.3 %). For Beni-Suef colony, the Resistant percentages to chlorpyrifos (9.09 %), thiodicarb (39.4 %), esfenvalerate 5 EC (12.83 %) were much lower than those estimated for the other field colonys tested. However, resistant level to profenofos (29.3 %) in Beni-Suef colony was higher than those estimated in both Menoufia (19.2 %) and Kafr El-Sheikh (5.76 %).

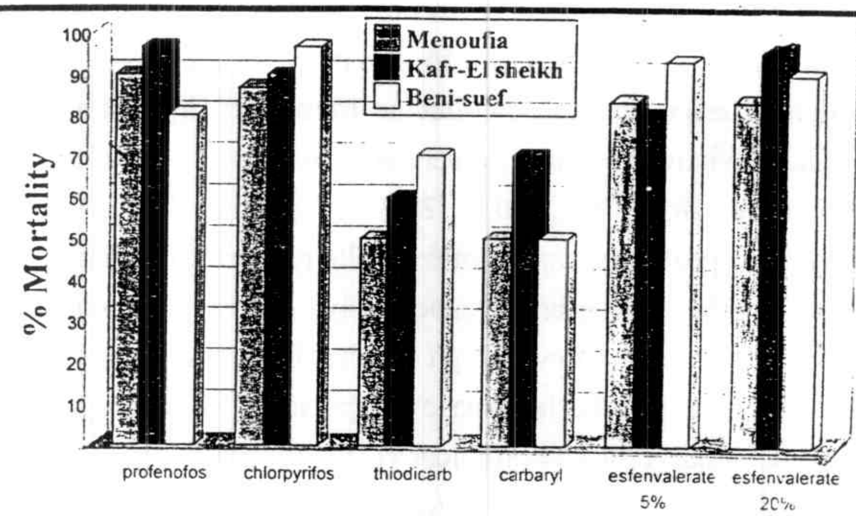

Fig (13) : Response of Pink bollworm , *P. gossypiella* ,moths collected from three field locations of cotton during early season of 2000 to discriminating concentrations of different insecticides using surface film technique.

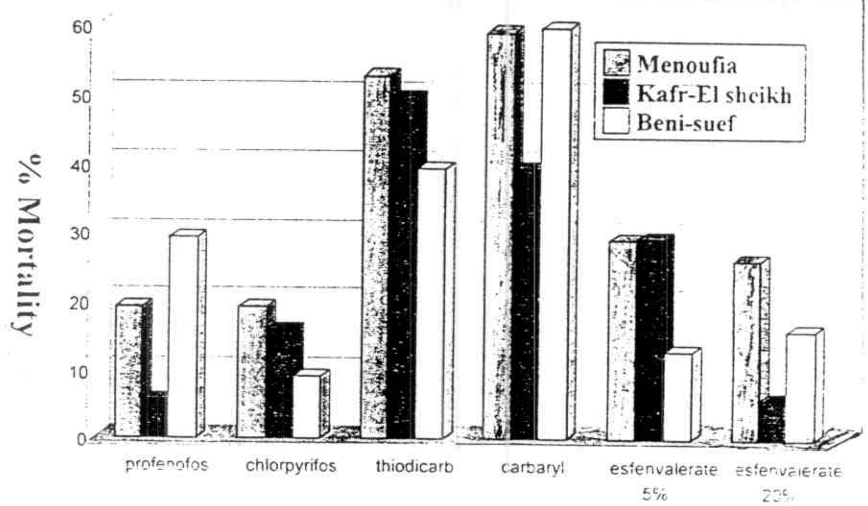

Fig (14) : Response of Pink bollworm , *P. gossypiella* ,mothes collected from three field locations of cotton durig late season of 2000 to discriminating concentrations of different insecticides using surface film technique.

DISCUSSION

Bioassay Techniques

The bioassay methods compared in this study are based on contact exposure. It seems that the greater range of resistant ratio values suggests that the vial contact film technique is more sensitive for most selected insecticides as compared to topical application (Table 17). Dahm et al. (1961) concluded that topical application of DDT on houseflies produced a more significant regression line than the residue on glass method. They suggested that the topical method gave greater sensitivity as indicated by the steeper slope of the regression line. However, in other studies (Hinkle et al., 1985; Roush and Luttrell, 1987), the residue on glass technique (for pyrethroids) produced a higher slope or better correlation values (or both) than for topical application. These studies suggest that the bioassay method considerably effects LC values as reflected by the interaction between insect and insecticide.

One potential disadvantage of using the vial method is the fumigation effect within the enclosed vial; this may contribute significantly to higher mortality (Prabhaker et al., 1996). An effect of this type could lead to an artificially low estimate of resistance if the resistant members of the insect population were fumigated. Another possible problem that may arise with the use of glass vials is the deterioration, or through avoidance behaviour in the treated glass vial (Prabhaker et al., 1996).

TABLE 17

Comparison of resistance ratios to select insecticides in three field strains of the pink bollworm, *P.gossypiella*, moths collected from cotton fields in 1998 and 1999 seasons, using topical and vial techniques.

Insecticide	Field [a] Strain	Resistance ratios (RR) [b] 1998 Season Topical	1998 Season Vial	1999 Season Topical	1999 Season Vial
Profenofos	MEN	3.54	3.90	8.18	8.61
	KSH	4.43	6.37	7.03	12.25
	BSU	3.02	2.50	17.38	3.81
Chlorpyrifos	MEN	3.67	4.27	9.61	20.73
	KSH	4.80	5.38	11.93	27.05
	BSU	1.27	1.72	5.10	9.38
Thiodicarb	MEN	1.23	1.75	2.98	14.65
	KSH	1.91	2.93	4.37	22.15
	BSU	2.51	6.01	5.56	22.70
Carbaryl	MEN	3.30	8.38	15.90	42.31
	KSH	5.10	15.38	22.63	59.51
	BSU	6.83	24.15	40.75	77.47
Esfenvalerate 5EC	MEN	1.41	6.14	4.35	16.54
	KSH	1.41	3.53	3.74	9.18
	BSU	4.62	11.55	9.25	28.0
Esfenvalerate 20EC	MEN	1.31	1.62	1.90	5.51
	KSH	3.78	4.20	11.55	18.18
	BSU	2.66	2.51	4.61	11.34

[a] MEN, Menoufia strain ; KSH, Kafr-Elsheikh Strain; and BSU, Beni-Suef strian.

[b] RR = LD_{50} or (LC_{50}) of field populations divided by LD_{50} or (LC_{50}) of the reference laboratory strian.

Our results of probit regressions for the fields atrains of pink bollworm, P. gossypiella, studied to different insecticides, either in topical or vial technique, had low slope values (< 1.0) for most insecticides, indicating that a high degree of genetic heterogeneity exists among these strains. Meinke (1977) indicated that flat lines seemed to be a normal response of beet armyworm, Spodoptera exigua (Hübner), population to methomyl because it was detoxified by several enzymes in the insect at any given time.

The objective of a resistant monitoring program is to detect resistance before a control failure occurs. The monitoring program should measure resistance frequencies as well as monitor changes in the frequency of resistance with time (Schouest and Miller, 1988). However, this implies a fine precision in estimating the frequency of resistance individuals, since resistant levels must be detected at 1 % levels (Tabashnik and Croft, 1982). When large numbers of animals are required to determine if resistance is present, resistant monitoring by standard bioassay methods may not be practical. Some have adopted a diagnostic or discriminatory dose approach (Gunning et al., 1984), while others (Reidl et al., 1985; Haynes et al., 1986, 1987; Schouest and Miller, 1988) have developed a new approach using pheromone technology to aid in determining toxicological responses of field populations. This later approach had allowed the monitoring of resistance without time-consuming rearing of field populations. Our present results confirmed that results depend on the bioassay methods (topical, vial, and diagnostic techniques) used. Schouest and Miller

(1988) measured toxicities of synthetic pyrethroids by three different bioassay methods (topical application, vial-discriminating dose, and sticky-trap attracticide) at different temperatures and exposure times

on adult males of pink bollworm. They concluded that variations in toxicity and slopes of dose response regressions for each bioassay were dependent on the temperature and the total time of exposure to a concentration. They also suggested that the vial assay be performed, at lower temperature and for 48 h, and was a good predictor of possible resistance. They indicated that different LC_{50} from different biassays indicate that the monitoring bioassay used in resistance management must be chosen carefully.

Laboratory bioassays that closely simulate the field situation help to establish a correlation between the laboratory bioassay and the field by establishing consistent LDP relationships (Ball, 1981; Roush and Miller, 1986). Various types of toxicity bioassays (topical, feeding, residual, discriminating dose, terminal bud, and attracticide) can be used in combination to determine the appropriate field use of an insecticide. However, for effective implementation of resistance management programs, both intrinsic and extrinsic factors need to be considered before recommending an insecticide for field use (Robertson and Haverty, 1981).

Resistant Monitoring

Although Plapp et al. (1990) suggested that dose-mortality lines may not be the most appropriate method for determining the proportion of resistance individuals in a population, initial surveys of this type are necessary for establishing a baseline for commonly used insecticides. Once the basic data are available for various compounds against field populations of an insect, the proportion of resistance individuals may be detected better by the use of a discriminating dose (Roush and Miller, 1986; ffrench Constantt and Roush, 1990; Plapp et al., 1990).

Results from our present study suggested that resistant levels monitored in the field colonys of pink bollworm to all selected insecticides with the vial system, increased to great extent in 1999 season than those monitored in 1998 season. Variations in resistant levels to different insecticides were observed between the three field populations tested (Table 17). Field populations of pink bollworm moths collected from Beni-Suef seemed to be highly resistant to thiodicarb (22.7-fold), carbaryl (77.47-fold), and esfenvalerate 5 EC (28.0-fold) as compared to other field populations collected from Menoufia or Kafr-Elsheikh (Table 17). However, high levels of resistance to the organophosphours insecticides, profenofos and chlorpyrifos, as well as the pyrethroid esfenvalerate 20 EC were

observed in field populations from Kafr-Elsheikh, indicating 12.25-, 27.05-, and 18.18-fold, respectively, in comparison with those found in the other populations (Table 17). These elevated resistant ratios to most tested insecticides through two successive growing seasons, were probably related to the grower's pesticide programs that included most of these insecticides, Current levels of resistance estimated in 1999 season, with the vial system, particularly to both carbamate insecticides used, i.e. thiodicarb and carbaryl in all three field locations; the OP, chlorpyrifos, in Menoufia and Kafr-Elsheikh strains, as well as the pyrethroid esfenvalerate 5 EC in Menoufia and Beni-Suef colonys were great extent; as compared to those of 1998 season. The rapid development of higher levels of resistance to the insecticides is usually related to the previous intensive use of such compounds (Tables 18 - 20).

Because resistance is mainly a consequence of past and present insecticides used, comparisons are meeded for decision-making in insect control (Aldosari et al., 1996). Therefore, the geographic and temporal variation in insect response to the insecticides tested suggested the need for proper insecticide management to avoid further development of resistance, which may render the chemicals ineffective control agents.

Knowledge of the level of resistance present in a population before insecticide use can reduce the numbers of ineffective applications. The resulting benefits of reduced pest control costs, environmental contamination, and human exposure to pesticides are desirable (Brewer and Trumble, 1989). The vial and diagnostic techniques allow monitoring of susceptibility levels over time, as well as in different field locations that have different histories of insecticide selection pressure. Such information is critical for developing effective resistance management programs.

TABLE 18

Schedule program of insecticides sequence application which was followed in Menoufia governorate, during 1996 – 1998 cotton growing seasons.

Season	Insecticide Sequence	Time of application
1996	Profenofos.	From 15 July to 1 Aug.
	Esfenvalerate 5%, Esfenvalerate 20%, Cynofos.	From 1 Aug. to 30 Aug.
	(Methomyl 27% + diflubenzuron 4%), Thiodicarb(Liquid), Thiodicarb(Dust),Carbaryl.	From 15 Aug. to 10 Sept.
	(Profenofos 72% + chlorfluazuron 2%), (chloropyrifos EC48% + diflubenzuron).	From 1 Sept. to 20 Sept.
1997	Profenofos.	From 19 July to 6 Aug.
	Esfenvalerate 5%, Esfenvalerate 20%, Betacyfluthrin, Cynofos, Lambda-cyhalothrin.	From 2 Aug. to 10 Sept.
	Thiodicarb.	From 20 Aug. to 9 Sept.
1998	Profenofos.	From 20 July to 5 Aug.
	Esfenvalerate 5%, Betacyfluthrin.	From 2 Aug. to 12 Sept.
	Thiodicarb.	From 23 Aug. to 2 Oct.
	(Profenofos 72% + chlorfluazuron 2%) .	From 5 Sept. to 2 Oct.

TABLE 19

Schedule program of insecticides sequence application which was followed in Kafr-El Sheikh governorate,during 1996 – 1998 cotton growing seasons.

Season	Insecticide Sequence	Time of application
1996	Chloropyrifos, (cloropyrifos 48%EC + diflubenzuron), (profenofos 72% + chlorfluazuron 2%), (methomyl 27% + diflubenzuron 4%), profenofos.	From 25 June to 20 Aug
	Chloropyrifos, profenofos, (chloropyrifos 48% EC+ diflubenzuron), pirimifos-ethyl, Cynofos.	From 12 July to 14 Aug.
	Esfenvalerate 5%, Cynofos, Lambda-cyhalothrin, Profenofos, chloropyrifos.	From 30 July to 30 Aug.
	Carbaryl, Thiodicarb, Cynofos, (Chloropyrifos 48% EC + diflubenzuron).	From 11 Aug. to 11 Sept.
	Carbaryl, Thiodicarb, Profenofos, (Profenofos 72% + chlorfluazuron 2%).	From 27 Aug. to 20 Sept.
	Profenofos, Pirimifos-ethyl, Carbaryl.	From 10 Sept. to 6 Oct.
1997	(Chloropyrifos 48% EC + diflubenzuron),(profenofos 72% + chlorfluazuron 2%)	From 28 June to 15 Aug.
	Profenofos, (profenofos 72% + chlorfluazuron 2%), Lambda-cyhalothrin, Esfenvalerate 5%, Cynofos.	From 11 July to 1 Sept.
	Betacyfluthrin, Lambda-cyhalothrin, Esfenvalerate 5%, Esfenvalerate 20%, (chloropyrifos 48% EC + diflubenzuron).	From 2 Aug. to 15 Sept.
	Thiodicarb, Profenofos, (Profenofos 72% + chlorfluazuron 2%).	From 20 Aug. to 28 Sept.
	Thiodicarb, Profenofos, Betacyfluthrin, Lambda-cyhalothrin.	From 27 Aug. to 30 Sept.
	Betacyfluthrin, Thiodicarb, Lambda-cyhalothrin, Profenfos.	From 12 Sept. to 2 Oct.
1998	Chlorfluazuron, (Profenofos 72% + Chlorfluazuron 2%), (chloropyrifos 48%EC+ diflubenzuron), benzoylphenyl urea, flufenoxuron, tebufenozide.	From 21 June to 25 Sept.
	Profenofos, Esfenvalerate 5%, (Profenofos 72% + chlorfluazuron 2%), Esfenvalerate 20%	From 16 July to 30 Aug.
	Esfenvalerate 5%, Esfenvalerate 20%, Betacyfluthrin, Profenofos, (Profenofos 72% + chlorfluazuron 2%).	From 2 Aug. to 8 Sept.
	Thiodicarb, Profenofos, Betacyfluthrin, (Profenofos 72% + chlorfluazuron 2%)	From 17 Aug. to 8 Oct.
	Thiodicarb, (Profenofos 72% + chlorfluazuron 2%), Betacyfluthrin, Esfenvalerate 20%, Profenofos.	From 1 Sept. to 10 Oct.
	Thiodicarb, Betacyfluthrin.	From 20 Sept. to 5 Oct.

TABLE 20

Schedule program of insecticides sequence application which was followed in Beni-Suef governorate, during 1996 – 1998 cotton growing seasons.

Season	Insecticide Sequence	Time of application
1996	Profenofos, Chloropyrifos, (Chloropyrifos 48% EC + diflubenzuron), (Profenofos 72% + chlorfluazuron 2%), Cynofos, Pirimiphos-ethyl.	From 15 June to 22 Aug.
	Lambda-cyhalothrin, Esfenvalerate 5%, deltamethrin.	From 20 July to 30 Aug.
	Thiodicarb(Dust), Carbaryl, Thiodicarb(Liquid).	From 7 Aug. to 14 Sept.
1997	Profenofos, Lmabda-cyhalothrin, Pirimiphos-ethyl, (methomyl 27% + diflubenzuron 4%), (chloropyrifos 48% EC + diflubenzuron), chloropyrifos, deltamethrin.	From 30 June to 22 Aug.
	Profenofos, Pirimiphos-ethyl, cynofos, chloropyrifos.	From 15 July to 7 Sept.
	Profenofos, Esfenvalerate 5%, betacyfluthrin, Esfenvalerate 20%, Lambda-cyhalothrin, Chloropyrifos, deltamethrin.	From 4 Aug. to 5 Sept.
	Profenofos, Thiodicarb, Esfenvalerate 5%, betacyfluthrin, Esfenvalerate 20%, Chloropyrifos.	From 20 Aug. to 27 Sept.
	Profenofos, Thiodicarb.	From 2 Sept. to 27 Sept.
1998	Profenofos, Thiodicarb,(chloropyrifos 48%EC+ diflubenzuron), (Profenofos 72% + chlorfluazuron 2%).	From 28 June to 6 Sept.
	Esfenvalerate 5%, Esfenvalerate 20%, Betacyfluthrin, (Profenofos 72% + chlorfluazuron 2%).	From 15 July to 6 Sept.
	Profenofos, Thiodicarb, (Profenofos 72% + chlorfluazuron 2%), Esfenvalerate 5%, betacyfluthrin.	From 2 Aug. to 12 Sept.
	Profenofos, Thiodicarb, (Profenofos 72% + chlorfluazuron 2%), Esfenvalerate 5%, Betacyfluthrin.	From 15 Aug. to 15 Sept.
	Profenofos, Thiodicarb.	From 15 Aug. to 15 Sept.

Sawicki and Denholm (1987) suggested four areas in which methods of insecticide resistance management must be improved. First, reliable, quick, and inexpensive techniques must be developed to distinguish between susceptible and resistant individuals. Second, the establishment of the relevance of such assays in terms of effectiveness of application rates against susceptible and resistant insects in the field is essential. Third, sampling procedures must be developed to provide representative and statistically reliable estimates of the frequency of resistance individuals in the field (Dennehy and Granett, 1984; Roush and Miller, 1986). Finallyh, the assays must provide a means to determine the critical frequency at which resistance impairs control in the field.