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Studies on economic injury levels of insect pests of cotton

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Studies on economic injury levels of insect pests of cotton were carried out during 1985 and 1986. The results are summarised as under :

The results show that the thrips can easily reach a level of 9 to 13 specimens per leaf without significantly affecting yields. For jassids, a population of around 1 specimen per leaf upto early September does not significantly reduce yields.

Earias species started to appear around June, July. However, the first serious population build up was observed early August, while 2nd population peak appeared approximately 20 days later, at the end of that month. A 3rd population appeared mid September, while a 4 th up surge might occur in October. This population trend seems to be similar for the area of Sindh Province located between 25° - 30° and 28° latitude. The impact of each population depends on the planting date and crop development.

The last insecticide application 30 days before harvest (90 % open bolls) might not be very important. It seems therefore that infestation levels in the period from 70 until 105 days after planting are having the most significant impact. When a bollworm population reaches a level of 2 % live larvae (stick method) or 4% live larvae (free method) approximately 75 days after planting, an insecticide application is advisable, to be repeated 15 to 20 days later of the population reaches again the aforementioned levels. A total of 2 sprays against

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bollworms should suffice, with a last 3rd application to be given not latter than 40 days before harvest if absolutely necessary.

Introduction

Various definitions have been forwarded for economic injury level. Stern et al. (1959) defined it as the lowest pest population density that cause economic damage where as Headley (1972) has defined the economic injury level as the pest population that produces incremental damage equal to the cost of preventing the damage.

Thus the economic damage is the amount of injury that justifies the cost of artificial control measures. Consequently, the economic injury level may vary from crop to crop, region to region, season to season and with man's changing scale of economic values.

In Pakistan, integrated pest management in cotton is gaining rapid importance. Hence the knowledge of economic injury levels is a prerequisite to develop a successful pest management programme. Keeping the importance of the subject in mind, preliminary investigations on this aspect were carried out during 1985 and 1986. The results thus obtained have been reported in this paper.

Materials and Methods

During 1985, preliminary economic threshold experiments were conducted at three different localities. The details of each experiments are given in Table 1.

Table 1. Insecticide application schedule for three economic injury level experiments conducted by CRI-Sakrand during 1985

Insecticides	Dosage/ acre	*Application dates	Spray schedule in the plots						
			1	2	3	4	5	6	7
1. At village Muhammed Zardari, Tehsil Nawabshah									
Dimethoate 40 EC	500 ml	8/7		x					
Monocrotophos 40 EC	800 ml	12/8		x					
2. At village Hamid Shah near CRI-Sakrand									
Dimethoate 40 EC	500 ml	2/7						x	
Quinalphos 25 EC	600 ml	14/7					x	x	
Quinalphos 25 EC	800 ml	3/8				x	x	x	
Monocrotophos 40 EC	800 ml	25/8				x	x	x	
Polytrin C 440 EC	600 ml	8/9				x	x	x	
3. At Agriculture Research Institute, Tandojam									
Dimethoate 40 EC	500 ml	4/7							x
Quinalphos 25 EC	750 ml	21/7						x	x
Quinalphos 25 EC	750 ml	6/8					x	x	x
Polytrin C 440 EC	600 ml	26/8				x	x	x	x
Triazophos 40 EC	1000 ml	7/9			x	x	x	x	x

*Insecticides applied by power sprayer in to 10 to 15 liters of water/1000 m^2

Experiment 1

During a field survey in early July 1985 a high thrips infestation was observed in cotton field near village Muhammad Zardari, Tehsil Nawabshah. Plant stand in the field was uniform and accordingly it was decided to carry out a simple experiment consisting of 2 treatments replicated 2 times. Plot size was 700 m^2, one treatment was the check while in the second plot Dimethoate 400 EC at 500 ml product per acre on 8-7-1985 and Monocrotophos 40 EC at 800 ml product per acre were applied on 12th August. Thrips, jassids and Earias sp. were sampled at weekly intervals from 14th July onwards. Yield data were obtained by harvesting in each plot an area of 100 m^2 on 13th October.

Experiment 2

Trial was carried out at Village Hamid Shah, near CRI-Sakrand. Treatments consisted of 3 insecticide schedules and 3 check plots replicated 4 times (details in Table 1). Plot size was 1000 m^2. The objective of this schedule was to create different levels of pest populations with seedcotton yields. Pest populations were sampled at weekly intervals starting early June. Variety NIAB-78 was sown by the grower on 30th April, 1985. Yield data were obtained by harvesting in each plot 100 m^2.

Experiment 3

In this experiment treatments consisted of 5 insecticide schedules and 2 checks replicated 4 times. Plot size was 1000 m^2. Qalandri was sown on 20th May, 1985.

During 1986, again 3 experiments were conducted as a fallow-up of previous season's trials. Each experiment had a Randomized Block Design with 6 treatments and replicated 2 times. Insecticide application schedule is given in Table 2. Plot size was 1000 m^2. Treatment 1 was the check. In treatment 2 and 3, only jassids and thrips were regulated while in treatments 4 and 5 bollworms were controlled also. Insecticides were used only when a certain infestation level was reached. Treatment 6 was an extra in which 3 low dosage insesticide treatments were given to study their effect on bollworm population development. Insect population were sampled at weekly intervals similarly as in 1985. Yield results were obtained by harvesting from each plot, two sub-plots of 50 m^2 each. Data was analysed by ANOVA and DMR test where applicable.

Two sampling procedures were used in recording the population trend of sucking and bollworm complex. One is the stick method for sucking insects as well as for bollworms and the other, free method for sampling bollworms only.

Table 2. Insecticide application schedule for three economic threshold experiments conducted by CRI-Sakrand, during 1986

Insecticides	Dosage/ acre	*Application dates	Spray schedule in the plots 1	2	3	4	5	6
1. At Agriculture Research Institute, Tandojam								
Monocrotophos 40 EC	500 ml	19/7			x		x	x
Monocrotophos 40 EC	500 ml	2/8						x
Triazophos 40 EC	400 ml	13/8			x			
Triazophos 40 EC	1000 ml	13/8					x	
Triazophos 40 EC	400 ml	24/8						x
Polytrin C 440 EC	600 ml	24/8					x	
Polytrin C 440 EC	600 ml	30/8 **				x		
Polytrin C 440 EC	600 ml	13/9						x
2. At Cotton Research Station, Ghotki								
Monocrotophos 40 EC	500 ml	17/7			x		x	
Triazophos 40 EC	1000 ml	7/8					x	
Triazophos 40 EC	1000 ml	4/9				x		
Polytrin C 440 EC	600 ml	4/9					x	
Polytrin C 440 EC	600 ml	2/10					x	
Polytrin C 440 EC	400 ml	2/10				x		
3. At Village Hamid Shah, near CRI-Sakrand								
Monocrotophos 40 EC	500 ml	1/7						x
Monocrotophos 40 EC	500 ml	15/7			x		x	x
Triazophos 40 EC	400 ml	5/8						x
Polytrin C 440 EC	600 ml	2/9					x	

* Insecticides applied by motor sprayer in 10 to 15 liters of water/ 1000 m^2

** Insecticides applied by handsprayer in 50 liters of water/1000 m^2

In the stick method, four plant rows of 52.25 each (1/1000 acre based on a row spacing of 2.5) were selected at random in a field of approximately 5 acres. Thrips, jassids, mites and immature of whiteflies were recorded per leaf from a total of 25 leaves selected at random, 9 from the top, 8 from the middle and 8 from the bottom of plants. Specimens were counted in the field with a 5X magnification lense. All the squares, flowers and bolls were also examined from the plants in those for sampled rows. The number of damaged fruiting bodies and live larvae found were expressed in percentages of the total fruiting bodies observed. Open bolls were counted but the damaged ones were not included in the damage percentage.

In the free method, one hundred squares or bolls were examined at random while walking diagonally through the field. The number of damaged fruiting bodies and live larvae found were expressed in percentages. Whenever the slightest damage was observed in square, flower or a boll, the fruiting form was opened and examined for the presence of larvae.

Results

1. Results of 1985 season

Experiment 1

The crop was mainly attacked by thrips and jassids (Table 3) thrips population was high when the trial was initiated with the bottom and middle leaves being silvery and curled inwards at edges. The mean infestation level of thrips was 9.9 specimens per leaf with maximum of 45.4 specimens/leaf on 14th July in the check plots then gone to 6.0 specimens/leaf on 4th August. In the plots treated with Dimethoate, the population remained steady at 6.0 specimens/leaf from 14 to 28th July with the seasonal average of 3.8/leaf.

The jassid started to build up by the end of July with 2.5 specimens/leaf, approximately 10 times larger in the check, than in the treated plots. At a population level of 2 to 3 specimens/leaf, a yellow discoloration started to appear at the leaf edges which began to curl, where as the population of whitefly was negligible.

Bollworm damage was mainly caused by Earias sp. but the infestation was of no economic importance at the seasonal average of 3.7 % live larvae sampled with free method, coinciding with 1.2 % by the stick method.

Yield loss was 450 kgs of seed cotton/ha (17 %), although not verified by statistical analysis, gives a preliminary indication of the importance of the insect complex. Jassids may be attributed to be the main cause of yield loss due to the fact that (a) population in the checks were significantly higher ($P<.01$) than in the treated plots, (b) thrips were considerably higher in the check plots only from 8 to 21 July and their impact was therefore of lesser importance as expressed by the non-significant difference between treatment and (c) bollworms were of no economic importance as the infestations in checks as well as treated plots were similar.

Table 3. Population trend of sucking as well as bollworm complex and seedcotton yield from three economic injury level experiments conducted by the Cotton Research Institute Sakrand, during 1985

Insecticide applications	Seedcotton yields (kgs/ha)	Percentages*			Mean number per leaf**		
		Boll-worm damage	Earias live larvae	Pectino. live larvae	Thrips	Jassids	White-flies
At village Mohammad Zardari, Tahsil Nawabshah							
1.Check	2150	8.6 %	2.3 %	-	9.9	1.8	2.0
2.Insecticide 2X	2600	6.1 %	1.2 %	-	3.8	0.7	0.9
F-Test	n.s.						
At Village Hamid Shah, near CRI-Sakrand							
1.Check	1365	2.4 %	1.7 %	-	5.6 a b	0.8	0.1
2.Check	1584	5.6 %	1.0 %	-	5.6 a b	0.6	0.1
3.Check	1465	6.3 %	1.4 %	-	4.4 c	0.5	0.1
4.Insecticide 3X	1663	5.6 %	1.2 %	-	6.0 a	0.7	0.1
5.Insecticide 4X	1315	6.0 %	1.2 %	-	3.0 d	0.5	0.1
6.Insecticide 5X	1588	6.2 %	1.4 %	-	3.2 d	0.4	0.1
F-Test	n.s.	n.s.	n.s	-	-	n.s	
At Agriculture Research Institute, Tandojam							
1.Check	2300	6.8 % a b	1.4 %	1.9 %	2.8	1.1	0.2
2.Check	2400	8.9 % a	1.3 %	1.5 %	3.2	1.3	0.1
3.Insecticide IX	2300	7.0 % a b	0.7 %	1.8 %	2.9	0.9	0.1
4.Insecticide 2X	2250	8.6 % a	1.1 %	0.8 %	3.1	1.1	0.1
5.Insecticide 3X	2800	5.2 % a b	0.8 %	0.5 %	2.9	0.8	0.2
6.Insecticide 4X	2400	6.8 % a b	1.1 %	0.9 %	3.1	0.8	0.1
7.Insecticide 5X	2670	5.6 % b	0.9 %	0.7 %	2.7	0.9	0.1
F-Test	n.s.	-	n.s	n.s	n.s	n.s	n.s.

* Mean percentages calculated from number of fruiting bodies observed from a total of 10 samples (5 dates, 18/8 to 01/10) in experiment 1, 44 samples (11 dates, 17/7 to 16/10) in experiment 2 and 32 samples (8 dates, 8/8 to 24/10) in experiment 3

** Mean number per leaf from total of 420 leaves in experiment 1 (30 leaves per plot, 7 dates, 2 reps), 480 leaves in experiment 2 (15 leaves per plot, 8 dates, 4 reps) and 420 leaves (15 leaves per plot, 7 dates, 4 reps) in experiment 3

Note : For insecticide application details, refer to Table 1. Means followed by similar letter are not significantly different from each other according to the DMR test.

Experiment 2

Infestation remained low (Table 3) and no significant differences could be detected between treatments. Maximum mean seasonal infestation level in check and treated plots (17/7 to 16/10) for Earias live larvae was 1.7 and 1.4 %, respectively. While maximum mean seasonal populations in check and treated plots (17/7 to 18/9) for thrips, jassids and whiteflies were 5.6, 0.8 and 0.1 and 6.0, 0.7 and 0.1 specimens per leaf, respectively. Maximum yield of 1663 kgs/ha was obtained from the plots which received three pesticide applications, but the treatments were non-significant. Results clearly show that fixed or calender spray programmes do not automatically imply increased yields.

Experiment 3

The results are given in Table 3 infestations were low with sucking complex populations of no economic importance. Although there were yield differences between treated and non-treated polts, the results were not significant and therefore ought to be interpreted very carefully. The 3, 4 and 5 insecticide sprays gave a mean yield of 2633 kgs seed cotton per ha (calculated on the basis of 100 m^2 plot) as compared to the average 2350 kgs per ha in the check plots. This gives and advantage of 273 kgs per ha. Seasonal averages of live bollworm larvae (Earias and Pectinophora) were 1.5 and 0.93 % in the check and treated plots with an average of 7.85 and 6.64 % damage, respectively. Thus it seems that a seasonal mean infestation of 1.5% live larvae caused a yield loss of 273 kgs seed cotton per ha. This relationship is by no means confirmed and can therefore only serve as an indication from which to start.

2. Results of 1986 season

The over all results of the three tests are given in Table 4 and experiment-wise results are discussed as under :

Experiment 1

In this experiment, thrips, jassids and whiteflies were of no economic importance. The mean population of 4.5 thrips/leaf, in 2 check plots from 6 July until 30 August was significantly higher than those in treatments 3 and 6, in which sucking incests got reduced to 2.4 and 1.7 specimens/leaf with low dosage insecticide applications (Table 2). However, yield of seedcotton in treatments 1, 2, 3 and 6 was not significantly different. Populations of jassids and whiteflies were very low and no significant difference was detected between treatments. This would mean that a seasonal mean of 4 thrips/leaf would not cause economic damage.

Bollworms, especially Earias species caused significant damage. Highest yield was obtained from treatment 5, with 3300 kgs per ha, 40 % higher than 1979 kg/ha (average) in the check plots. Yield from treatment 4 was second highest (2514 kgs/ha) with 21% increase over the checks. Seasonal bollworm damage in the checks was an average of 9.7 % according to the stick method as compared to 3.5 % in treatment 5. The corresponding figures for Earias live larvae were 2.3 and 0.9 %, respectively.

Table 4. Population trend of sucking as well as bollworm complex and seedcotton yield from three economic injury level experiments conducted by CRI-Sakrand during 1986

Insecticide applications	Seedcotton yields (kgs/ha)	Percentages* Boll-worm damage	Earias live larvae	Pectino. live larvae	Number/leaf** Thrips	Jassids	White-flies
At Agriculture Research Institute, Tanjom							
1.Check	1964 a	10.5 a	2.7 a	0.1	4.0 a b	0.8	0.1
2.Check	1994 a	8.8 a b	1.9 a	0.1	4.9 a	0.7	0.1
3.Insecticide 2X	1988 a	10.4 a	2.6 a	0.1	2.4 c	0.4	0.2
4.Insecticide 1X	2514 b	5.4 c	1.0 b	0.0	3.1 b c	0.5	0.1
5.Insecticide 4X	3300 c	3.5 a	0.9 b	0.0	1.9 c	0.5	0.1
6.Insecticide 3X	1938 a	8.1 b	1.9 a	0.3	1.7 c	0.6	0.1
F-Test				n.s		n.s	n.s
C.V.	8 %	30%	47%		69%	82%	
At Cotton Research Station, Ghotki							
1.Check	1212 a	11.2 a	4.0 a	0.3	3.8 a	1.1a b	0.2
2.Check	1188 a	10.7 a	3.7 a	0.2	3.6 a	1.2a	0.3
3.Insecticide 1X	1188 a	10.5 a	4.0 a	0.2	1.8 b	0.7c	0.2
4.Insecticide 2X	1526 b	6.4 b	1.9 b	0.1	4.0 a	1.3a	0.3
5.Insecticide 4X	1912 c	6.2 b	1.5 b	0.1	2.1 b	0.8b c	0.4
C.V	6%	32%	42%		70%	47%	
At Village Hamid Shah, near CRI-Sakrand							
1.Check	2000	4.9	1.5	0.1	3.9 a	0.3a	0.3
2.Check	1900	4.3	1.3	0.1	3.9 a	0.3a	0.4
3.Insecticide 1X	2020	5.8	1.1	0.1	2.1 b	0.1b	0.5
4.Check	1720	6.5	1.9	0.1	4.5 a	0.3a	0.3
5.Insecticide 2X	2320	3.4	0.9	0.1	2.1 b	0.2b	0.5
6.Insecticide 3X	2200	5.6	1.3	0.1	1.1 b	0.2b	0.1
F-Test	n.s	n.s	n.s	-	-	-	-
C.V.	14%	57%	69%		73%	93%	

* Mean percentages calculated from number of fruiting bodies observed in 2 samples of 52.25" plant row, from a total of 24 samples observed in experiments 1 and 3 (6 dates, 20/8-4/10), and 36 samples in experiment 2 (9 dates, 13/8-16/10)

** Mean number per leaf from total of 240 leaves observed in experiments 1 and 2 (8 dates, 6/7-12/9), and 360 leaves in experiment 3 (12 dates, 3/6-26/8)

Note : For insecticide applications please refer to Table 2. Means followed by similar letters are not significantly different from each other according to the DMR tests.

The population dynamics of Earias species according to both the stick and free sampling methods is explained graphically in Fig. 1. THe 1st population peak appeared in the 1st week of August, the 2nd peak approximately 20 days later (end of August) and the 3rd peak again 20 days later in mid September. The 1st insecticide application in treatment 5 on 19 July was against sucking insects in conjuncture with treatment 3. The 2nd appliacation on 13 August (80 days after planting) against bollworm could have been made a week earlier, however was still early enough to slow down the development. Applications 3 and 4, given at 20 days intervals, significantly reduced the population.

The relationship between bollworm infestations and seedcotton yield, according to stick and free methods, is given in Table 5.

Table 5. Relationship between bollworm infestations and yield of seedcotton according to stick and free methods of sampling in an economic threshold experiment at Tandojam conducted by CRI-Sakrand, during 1986

Treatment plots	X Bollworm* damage (B) s.m.	f.m.	X Live larvae (A)* *Earias* species s.m.	f.m.	*Pectinophora* s.m	f.m.	Seedcotton yield (kgs/ha)
Repl .I-1	13.05	24.67	3.28	7.00	0.19	0.67	1825
2	9.75	15.67	2.33	6.33	0.17	2.00	1835
3	11.30	18.67	2.68	6.33	0.27	0.34	2175
4	5.57	10.67	1.20	2.67	0.00	0.66	2625
5	3.72	4.33	0.87	1.00	0.00	0.00	3200
6	8.87	20.67	2.32	4.67	0.25	1.66	1975
Repl.II-1	7.95	16.00	2.05	3.00	0.00	0.00	2100
2	7.82	15.00	1.55	3.35	0.07	0.34	2150
3	9.40	16.67	2.52	4.67	0.00	0.00	1800
4	5.23	11.67	0.85	3.00	0.00	0.33	2400
5	3.32	7.33	0.93	1.33	0.00	0.34	3400
6	7.35	14.33	1.37	3.67	0.10	0.66	1900

* Each infestation level mean percentage from total number of fruiting bodies in 2 samples of 1.54 m plant row (stick method) and 50 green bolls (free method) randomly selected on 6 sampling dates (30/8 to 4/10)

Linear regression equations :

A $Y = 31.52 - 4.51X$ $(P<.01)$; $r = 0.74$
B $Y = 34.57 - 1.51X$ $(P<.001)$; $r = 0.83$ } by stick method (s.m.)

A $Y = 30.88 - 1.79X$ $(P<.01)$; $r = 0.77$
B $Y = 34.68 - 0.81X$ $(P<.001)$; $r = 0.84$ } by free method (f.m.)

The expected yield losses at different infestation levels of bollworms, determined by both methods, and arrival at by using the regression equations, for Tandojam and Ghotki experiments are given in Table 6. A mean infestation level of 0.7 % Earias live larvae from mid August onwards, according to the stick method, would cause a yield loss of 302 kg seedsotton/ha, while a 0.9 % live larvae infestation according to the free method would cause a loss of 162 kg. When we refer back to Figure 1, we see that the Earias live larvae population was approximately 11 % by mid August, and that by controlling it at that level 70 to 80 days after planting, it was possible to keep the infestation at a mean of 0.9 % live larvae from 30 August onwards (approx. 90 days after planting) when bolls were forming rapidly.

Experiment 2

Yield results and mean infestation levels of five pest species are given in Table 4. Populations of both thrips and jassids were significantly lower in treatment 3 where one insecticide application had been given 53 days after planting as compared to the two check plots. Bollworm populations and seedcotton yield were identical in these 3 treatments. It can be concluded that a mean population of 4 thrips and 1 jassid per leaf, from mid July until mid September does not cause economic damage.

Mean bollworm damage in the two check plots was 11 % as compared to 6.2 % in treatment 5, while mean infestation of Earias live larvae was 3.9 % and 1.5 %, respectively. The different infestation levels of bollworms gave a mean yield of 1200 kg seedcotton/ha in the two check plots and 1912 kg in treatment 5; an increase of 712 kg/ha or 37 %, while in treatment 4, the increase was 326 kg/ha or 21 %.

The population curves for Earias species in treatments 1 and 5 are given in Figure 2. Infestation levels were again evaluated according to both the stick and the free methods. The Earias population appeared to follow a similar trend as in Tandojam experiment. The species started to appear in mid July, and a 1st peak was observed early August, while 2nd peak appeared in the later part of that month. A 3rd peak flared-up in mid September, while the 4th accured in the 1st half of October.

The 1st insecticide application against bollworms was given 74 days after planting, 2nd in early September (102 days after planting and could have been made a week earlier) and the 3rd, 130 days after planting and was not that necessary being 20 days before 1st picking.

The apparent importance of controlling the 1st peak population early August can be seen when comparing treatments 4 and 5. In the former treatment, 1st insecticide application was given 102 day after planting in the 1st week of September. Yield increase was 21 %, while in treatment 5, it was 37 %, Triazophos was used on 4 September, while Polytrin C was used in treatment 5. Moreover, Polytrin C was used at a lesser dosage in treatment 4 than in treatment 5 on 4 October. More research is needed as to which bollworm population at a particular crop development stage is more important with regard to causing economic loss in yield.

Linear regression equations with respect to bollworm infestations and seedcotton yield are given in Table 7. The equations are only significant at 5 % level, however, the correlation coefficients are almost similar to those in experiment 1. According to these results then, a mean infestation level of 1.1% Earias live larvae (stick method) from approximately 80 days after planting onwards would cause a yield loss of 238 kg seedcotton per ha (Table 6). The different results obtained in experiments 1 and 2 (Table 4 and 6), with regard to the relationships of bollworm infestations and seedcotton yield loss, should be looked at in the light of differences in yield potential of the crop with respect to plant density, soil fertility, etc.

Table 6. Expected yield losses at different infestation levels of Earias species, approximate 80 days after planting onwards, in two economic injury level experiments at Tandojam and Ghotki conducted by CRI-Sakrand, during 1986

Sampling procedures	Damage	Earias live larvae		Expected yield loss (kgs/ha)	
		Tandojam	Ghotki	Tandojam	Ghotki
Free method	1 %	0.5 %	0.6 %*	81	60
	2 %	0.9 %	1.3 %*	162	120
	5 %	2.3 %	3.2 %*	405	300
	10 %	4.5 %	6.4 %*	810	600
Stick method	1 %	0.3 %	0.5 %	151	119
	2 %	0.7 %	1.1 %	302	238
	5 %	1.7 %	2.6 %	755	595
	10 %	3.4 %	5.3 %	1510	1190

* Calculated from non-significant equation ($P<0.05$)

Note : Refer to Table 5 for data and equations from wich the relationships were calculated.

Table 7. Relationship between bollworm infestations and yield of seed-cotton according to stick and free methods of sampling in an economic threshold experiment at CRS-Ghotki conducted by CRI-Sakrand, during 1986

Treatment plots	Bollworm* damage (B) f.m.	Bollworm* damage (B) s.m.	Live larvae (A)* *Earias* species f.m.	Live larvae (A)* *Earias* species s.m.	*Pectinophora* f.m	*Pectinophora* s.m.	Seedcotton yield (kgs/ha)
Repl.I-1	10.42	19.56	3.53	7.56	0.36	-	1475
2	9.91	20.67	3.49	7.00	0.28	0.22	1325
3	10.29	17.89	4.12	7.56	0.28	-	1375
4	6.30	15.11	1.84	5.78	0.10	-	1675
5	6.60	7.00	1.81	1.33	0.10	-	2200
Repl.II-I	11.94	21.56	4.45	9.11	0.13	-	950
2	11.40	17.44	3.84	4.67	0.14	0.22	1050
3	10.64	17.33	3.86	5.22	0.12	-	1000
4	6.44	11.11	1.98	3.22	0.13	-	1375
5	5.79	11.22	1.24	2.89	-	-	1625

* Each infestation level mean percentage from total number of fruiting bodies in 2 samples of 1.54 m plant row (stick method) and 50 green bolls (free method) randomly selected on 9 sampling dates (13/8 to 16/10)

Linear regression equations :

$$A\text{-}Y = 21.26 - 2.26X \quad (P<.05);\ r = 0.73$$
$$B\text{-}Y = 24.72 - 1.19X \quad (P<.05);\ r = 0.76$$
stick method (s.m.)

$$A\text{-}Y = 19.16 - 0.93X \quad (P<.05);\ r = 0.61$$
$$B\text{-}Y = 23.58 - 0.60X \quad (P<.05);\ r = 0.76$$
free method (f.m.)

Experiment 3

Results are given in Table 4 and Figure 3. Sucking insects again were of no economic importance and findings are similar to those in experiments 1 and 2.

Bollworm populations were low and no yield differences occurred between treatments. Interesting is the fact that in treatment 5 insecticide treatment was given early September (118 days after planting and around 30 days before harvest) and the population of *Earias* species was similar during September as in experiment 1. However, this final treatment did not have any effect on yield.

Discussion

Actually it is very difficult to calculate and maintain the economic injury level or economic threshold levels (ETLs) particularly in a crop like cotton which is attacked by varieties of insect pests. Anyhow attempts to improve ETLs and make them more realistic and "simple ETLs" are now prevalent in many countries which are either provisional or tentative and have been developed and adopted for use in several cotton-growing countries (Frisbie, 1983). In Texas, USA, an ETL of 35 eggs/100 terminals used for Heliothis since 1942 was adjusted to 25 % worm damaged squares or 10-15 % damaged green bolls in 1972 (Frisbie, 1983). In California, an ETL of 4/100 cotton plants infested eggs of Heliothis recommended since 1969 or 4 bollworms/100 plants were considered invalid an a provisional level of 15 treatable larvae (1st and 2nd instars)/100 plants was employed and this level may not represent a true ETL (Napompeth, 1987). In 1973, a more reliable ETL of 20 small worms/100 plants for Heliothis was recommended and this level was acceptable and compatible with the release of Trichogrammma egg parasite (Dietrick, 1981).

A more sophisticated scheme of ETLs for cotton insect pests in Australia was developed by taking into consideration the stages of cotton development, sampling units and varying treatment level as shown in Table 8 (Evenson et al., 1977).

Table 8. Treatment levels for cotton insect pests in Lockyer Valley, Queensland, Australia

Phase	Pest species	Sample unit	Treatment level
Plant establishment	Aphids	Terminal leaf buds	25 % damaged
		Plant terminals	50 % infested
	Heliothis/Earias	Plant terminals	50 % damaged
			25 % with eggs
Fruit Formation	Jassids	Leaves	75 % mottled
	Leaf feeders	Leaves	75 % damaged
	Heliothis (eggs)	Plant terminals	50 % infected
	Heliothis (Larv.)	Plant terminals	10 % infected
	Heliothis/Earias	Squares damaged	20 % till bloom
			15 % after bloom
			10 % damaged bolls
Boll growth and maturation	Heliothis eggs	Plant terminals	50 % infected if no previous treatment.
		Plant terminals	25 % infected if previously treated.
	Heliothis/Earias	Plant terminals	10 % infected
	Larvae	Squares	25 % damaged
		Bolls	10 % damaged
	Leaf feeders	Leaves	75 % damaged

In India, the ETLs for cotton pests were 2 insects per leaf for cotton jassids, and 5 eggs per 10 plants or 10 larvae per 10 plants or 10 % infected fruiting bodies for Heliothis (Bhale, 1985). In Pakistan, the ETLs for cotton pest were 1-2 insects/leaf for jassids, 4-5 insects/leaf for whiteflies, 5-10 % damage to flowers and bolls for Pectinophora and Earias, and 2-25 larvae/100 plants for Heliothis (Anonymous, 1983). In another report (Ahmad, 1985), it is 15 % damage upto 15th August for Pectinophora, 10 % damage during August 15-30 for Earias and 5 % damage from September/onwards for Heliothis.

Before discussing the present results and in the light of various economic thresholds given in the preceding paragraphs, it may further be explained that economic threshold is the pest density at which control measures should be determined to prevent the increasing pest population from reaching the economic injury level. It should also be noted that economic threshold is always lower than economic injury level to permit significant time for the initiation of control measures and for those measures to take effect before the population reaches the economic injury levels.

Since the economic threshold cannot be determined in the absence of damage, yield loss or economic data is the pre-requisite and since it varies with each control option, once established in the context of a particular control policy, it cannot hold good if the control practice changes or the cost or object of control is altered. In the present investigations, Earias species started to appear around June, July. However, the first serious population build-up was observed early August, while 2nd population peak appeared approximately 20 days later, at the end of that month. A 3rd population appeared mid September, while a 4th upsurge might occur in October. This population trend seems to be similar for the area of Sindh Province located between 25^{o}, 30^{o} and 28^{o} 00', latitude. The impact of each population depends on the planting date and crop development.

As observed in experiment 3, it seems that the last insecticide application 30 days before harvest (90 % open bolls) might not be very important. It seems therefore that infestation levels in the period from 70 until 105 days after planting are having the most significant impact as observed in experiments 1 and 2. When we look now at Tables 3 and 4 we can conclude that when a bollworm population reaches a level of 2 % live larvae (stick method), or 4 % live larvae (free method), approximately 75 days after planting, an insecticide application is adviseable, to be repeated 15 to 20 days later if the population reaches again the aforementioned levels. A total of 2 sprays against bollworms should suffice, with a last 3rd application to be given not later than 40 days before harvest if absolutely necessary.

Our results showed that trips can easily reach a level of 9 to 11 specimens per leaf (on 22/7 and 7/8 i.e. 76 days after planting) without significantly affecting yields. For jassids, data show that a population of around 1 specimens per leaf up to early September does not significantly reduce yields.

When we refer now once again to the relationship of bollworm infestation and yield loss (Table 6), it appears that a certain bollworm population can do more damage to the cotton crop with a high yield potential. To substantiate these findings, more similar experiments need to be conducted under different conditions so as to obtain more quantitative data on this subject.

Özet

Pamukta zararlı bazı böceklerin ekonomik zarar düzeyleri üzerinde çalışmalar

Bu çalışmada, pamukta zararlı olan bazı böceklerin, üründe yaratacakları zarar düzeyleri konusunda 1985 ve 1986 yıllarında Pakistan'da yürütülen çalışmaların sonuçları verilerek, aynı konuda diğer ülkelerde elde edilen sonuçlarla karşılaştırılmalarda bulunulmaktadır.

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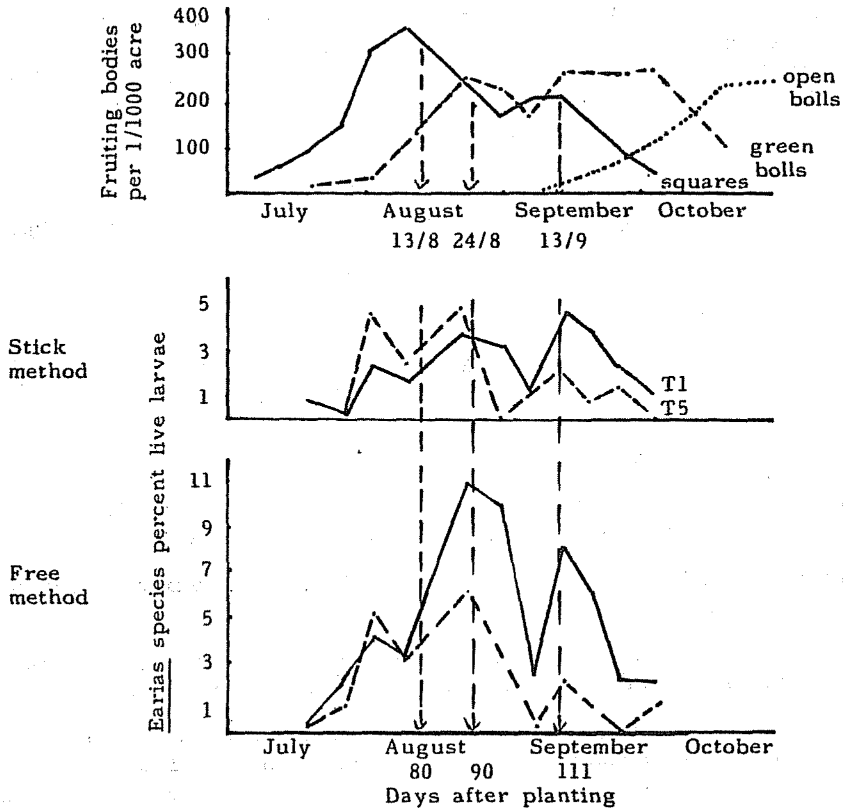

Figure 1. Evaluation of control of _Earias_ species on cotton by two sampling methods from an economic threshold trial at ARI-Tandojam, 1986 (T1=Check; T5=3 insecticide applications; Harvest= 20.10.1985, 148 days after planting)

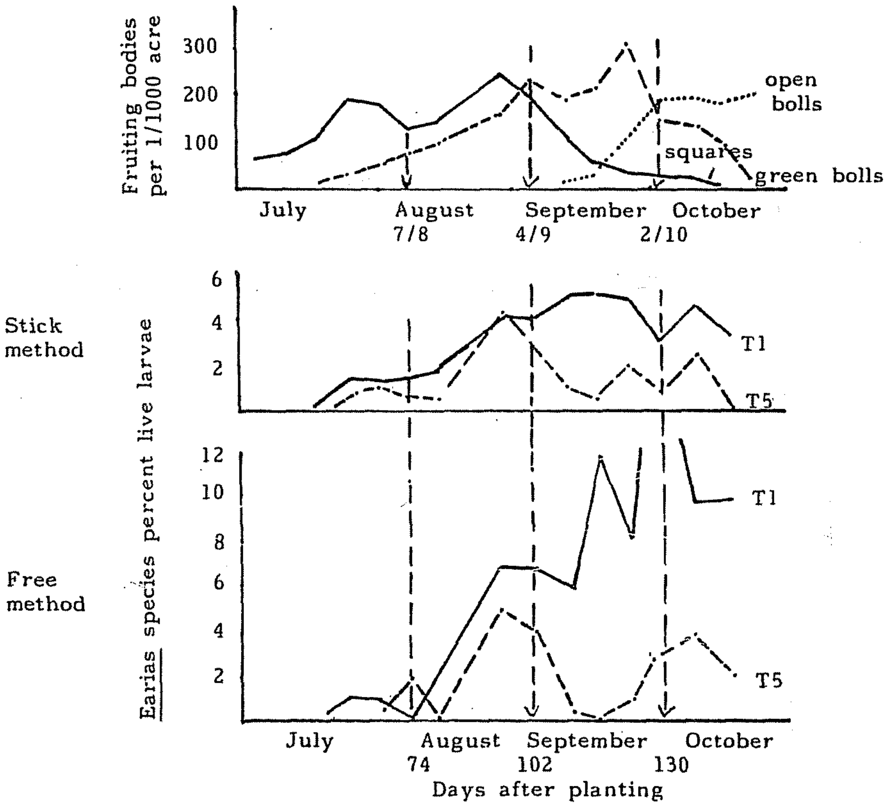

Figure 2. Evaluation of control of Earias species on cotton by two sampling methods from an economic threshold experiment at CRS-Ghotki, 1986 (T1=Check; T5= 3 insecticide applications; Harvest= 28.10.1986, 150 days after planting)

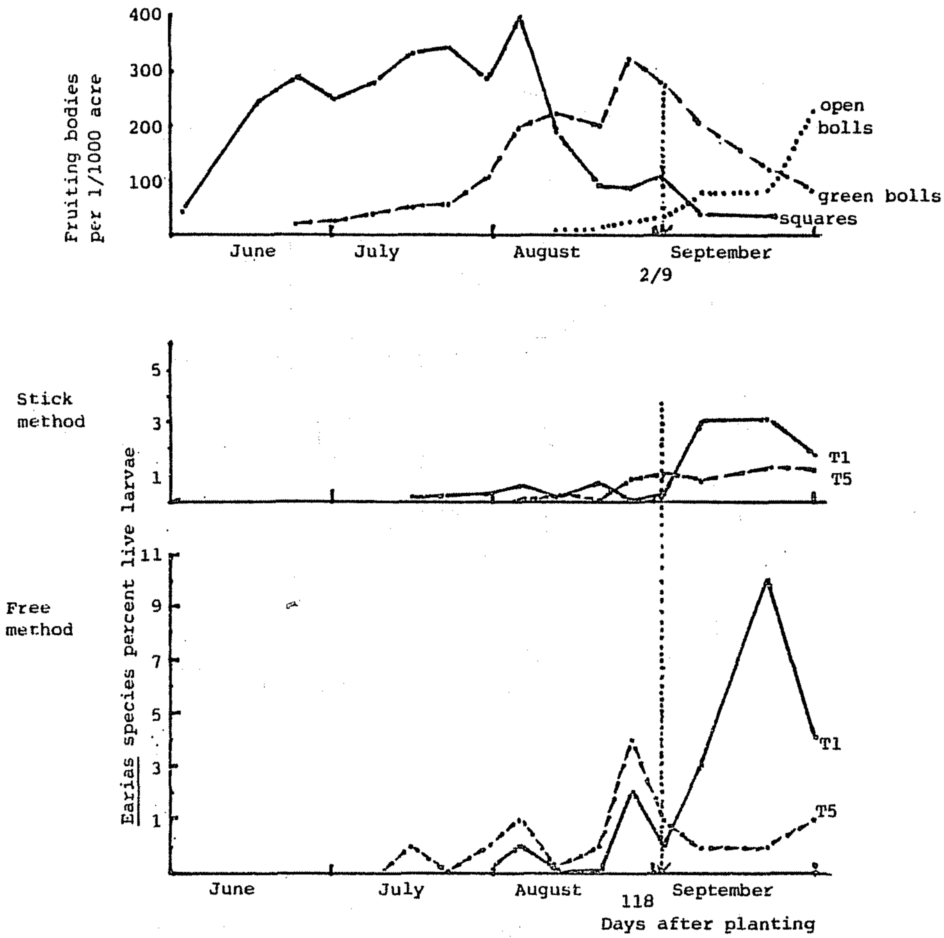

Figure 3. Evaluation of control of Earias species on cotton by two sampling methods in an economic threshold experiment at Village Hamid Shah, 1986 (T1=Check; T5= One insecticide application; Harvest= 11.10.1986; 157 days after planting)