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Significance and Cost Benefit of Using Pheromones in Conjunction with Parasitoids for the Management of Cotton Bollworms

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Abstract.- Field studies were conducted to evaluate the augmentative releases of egg parasitoids, *Trichogramma chilonis* in conjunction with pheromones to suppress the infestation of cotton bollworms. Studies revealed that integrated treatment of parasitoids in combination with pheromones, suppressed the bollworms infestation effectively. Separate treatment of pheromones or parasitoids was less effective, and required supplemental measures. The population of the parasitoids was low in the hot months of June and July; thereafter it gradually increased in the proceeding months. Maximum number of the parasitoids was observed in the month of October. The cotton bollworm management cost by the application of pheromones, PB/SB-ROPE in combination with the parasitoids was less than insecticide treatments.

Key words: Cotton bollworms, pheromones, parasitoids, management cost.

INTRODUCTION

Cotton is an important cash crop of Pakistan. It is attacked by a number of insect pests. Among them bollworms are very destructive and' have become the most difficult to control. The bollworm control depends largely on application of chemical insecticides. Van Steenwyk *et al.* (1975) reported that season long application of insecticides in cotton fields, resulted in destruction of the beneficial insects thus accelerating the emergence of secondary pests. Therefore, there is a mounting need to develop alternate, economical and environment friendly methods to suppress the infestation of cotton bollworms. Among non-polluting insect management methods, biological control through parasitoids alone (Suh *et al.,* 2000, Orr *et al.,* 2000) or as an adjunct to other management tactics has been successfully used (Ahmad *et aI.,* 2001). The use of *Trichogramma* as a bio-control agent is a recognized alternative to insecticides and has been applied successfully for the management of many insect pests (Suh *et aI.,* 2000). Lizarruga (1980) reported that weekly releases of 5000 *Trichogramma* in cotton field resulted an average average of 20.9 to 26.2% parasitism of *Heliothis* eggs whereas weekly releases of 15000 *Trichogramma* resulted an average of 47.6 to 58.2% parasitism of *H. armigera* eggs in the field. They recommended that releases of parasitoids should begin while the cotton plants are still small. Whereas, Patil *et aI.,* (1991) managed the *H. armigera* and *Earias vittella* in cotton crop through the integration of pesticides and egg parasitoid *Trichogramma* successfully. They reported that the integration also resulted fewer pesticide sprays and higher cost benefit ratio. For the control of cotton bollworms in Pakistan, it has been observed that single component strategies did not prove successful and that supplemental measures are required (Ahmad *et al.,* 2001). Application of pheromones is also a very compatible component of bio-control technology. Integration of biological and behavioural control through pheromones may prove effective for the management of cotton bollworms. Therefore, the present studies were designed to develop an effective environment friendly technique for the management of cotton bollworms using behavioural and biological control methods.

MATERIALS AND METHODS

Experiments were conducted at farmer's field on 16 hectares of cotton during 2000-2001 and 2001-2002 seasons. The area was divided in four

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different blocks of 4 hectares each, and each block was given a separate treatment. One block was treated with egg parasitoid,. *Trichogramma chilon is.* It was reared on eggs of Angoumois grain moth, *Sitotroga cerealella* in the laboratory maintained at 25±2°C and 60-70 % relative humidity. The eggs of Angoumois grain moths were glued on white paper cards and exposed to the parasitoids for 24 hours. The parasitized eggs, prior to adult emergence were released by attaching the cards on the lower side of the cotton leaves at fortnightly intervals at the rate of approximately 20,000 parasites per hectare. The parasitoids released were of good quality having adult emergence percentage above 80 percent in the laboratory. Approximately two thousand parasitoids per card per spot were released at ten uniformly distributed locations per hectare. The spots were selected at about twenty five feet inside the field from each corner of an acre. A second block was treated with both pheromones and parasitoids. The pheromones were applied once in a season at the start of square formation stage of the crop at the rate of 1000 ropes per hectare. The parasitoids were applied at the same rate and interval mentioned earlier starting from the square formation stage of the crop.

The pheromones formulation used was the experimental product of the Shin-Etsu Chemical Company, Japan and supplied by the Karachi office of the Mitsubishi Corporation, which contained the pink bollworm pheromone, gossyplure, a 1: 1 mixture of (Z,Z)- and (Z,E) 7, ll-hexadecadienyl acetate and a 10: 1 mixture of the (E,E)-10,12-hexadecadienal and(Z)-11 hexadecenal components for the two *Earias* spp. The formulation is named as PB/SB-ROPE. This 'twist-tie' PB/SB-ROPE, consisted of a wire-reinforced hollow polyethylene tube, 20 cm in length, sealed at both ends, containing normally, 38.5 mg a.i. of gossyplure plus 40 mg of *Earias* pheromones. The pheromones were applied once in a season at the start of square formation stage of cotton crop. The third cotton block was treated with conventional insecticides. The farmer applied a total of four sprays of insecticides during the whole cotton season. The farmer applied organophosphate (Monocrotophos 40 EC) and Pyrethroid (Polytrin-C) groups of insecticides in two sprays of each. The fourth block was treated with pheromones alone at the same rate and time as mentioned above. The infestation of pink bollworm and *Earias* spp. was recorded at weekly intervals. The establishment of the parasitoids was determined by placing Angoumois grain moth eggs (two cards per hectare having 2000 eggs) in the field. These cards were brought into the laboratory after 24 hours exposure in the differently treated blocks and parasitoid emergence was recorded. For the control of sucking pests, an insecticide (Confidor) was sprayed uniformly in all the treatments in the third week of June during both years of the experiments. The cost of the treatments was recorded and the cost benefit ratio for each treatment was calculated.

RESULTS AND DISCUSSION

The infestation percentage of pink bollworm and the two *Earias* spp. are presented in Tables I and II, respectively. The infestation was minimum in blocks treated with pheromones PB/SB-ROPE in conjunction with egg parasitoids, *T. chilonis.* The

Table I.- Mean infestation percentage of pink bollworm in cotton treated with different environment friendly treatments.

Treatments	Flowers	Green bolls
Trichogramma chilonis + Pheromone (PB/SB-ROPE)	4.91^{a}	4.05^{a}
Pheromone (PB/SB-ROPE)	9.23^{cb}	6.85^{b}
Trichogramma chilonis	10.51^{c}	8.57^{c}
Insecticides (Control)	6.79^{b}	7.73^{cb}

Means followed by similar letters are not significantly different ($P \leq 0.05$).

Table II.- Mean infestation percentage of *Earias* spp. in cotton treated with different environment friendly treatments.

Treatments	Flowers	Green bolls
Trichogramma chilonis + Pheromone (PB/SB-ROPE)	6.44^{a}	5.29^{a}
Pheromone (PB/SB-ROPE)	12.01^{c}	10.20^{bc}
Trichogramma chilonis	11.33^{bc}	11.33^{c}
Insecticides (Control)	10.75^{b}	8.85^{b}

Means followed by similar letters are not significantly different ($P \leq 0.05$).

Table III.- Mean percentage parasitization of Angoumois grain moth eggs exposed to *T. chilonis* in the field during different cotton growing months.

Months	No. of eggs exposed	Parasitism percentage	Mean Temp. (°C)	Mean R.H. (%)
June	2000	0.25e	33.60	63.0
July	2000	0.26e	31.87	74.8
August	2000	1.57d	30.65	74.1
September	2000	10.89c	30.10	74.3
October	2000	23.50b	27.10	66.5
November	2000	38.51 a	20.90	62.8

Means followed by similar letters are not significantly different (P≤0.05).

Table IV.- Mean percentage parasitization of Angoumois grain moth eggs exposed to *T. chilonis* in the field during different cotton growing months.

	Treatments			
	***T. chilonis* + pheromones**	**Pheromones**	***T. chilonis***	**Insecticides (control)**
Cost of treatment/ ha (Rs.)	4550	4000	550	2920
Application charges/ha (Rs.)	65	50	15	850
Total cost (Rs.)	4615	4050	565	3770
Seed cotton yield/ ha (Kg)	2855	1842	1470	2485
Total income/ha* (Rs.)	66022	42596	33994	57466
Net income/ha (Rs.)	61407	38546	33429	53696
Benefit over insecticides (Rs.)	+ 7711	- 15150	- 20267	-
Cost economic ratio over insecticides	1:1.14	1:0.72	1:0.62	-

*Rate of seed cotton Rs. 925 / 40 Kg.

infestation was higher in blocks treated with pheromone~ and egg parasitoids separately as compared to insecticide treated blocks. Infestation of the three-bollworm species remained low in the pheromones and parasitoids treatments throughout the cotton season. However, the establishment of parasitoids was low during the hot cotton growing months.

Population of the parasitoids started increasing in the cotton field during the month of August as the temperature and relative humidity became favourable (Table III) and peak population of the parasitoid and parasitism percentage in the field was recorded during the month of November. The maximum parasitism percentage recorded in the month of November may be attributed to the successive generations produced by the parasitoid, favourable environmental conditions and presence of comparatively more number of the host eggs in the field. Qureshi *et al.* (1985, 1989) observed the peak population of pink and spiny bollworms in the field during the month of October. Jones *et a/.* (1979) observed that crop microclimate is also influenced by the plant size, density and architecture. This has been shown to have a substantial effect on *Trichogramma* (Kot, 1979; Orr *et aI.,* 1997). Our studies revealed that when the cotton plants were small in the field, establishment of the parasitoid was low but it started increasing as the development stages of cotton plants advances and more favourable micro climatic conditions in the cotton field prevailed.

The management of cotton bollworms through pheromones in the present studies is not in conformity with the results of Henneberry *et al.* (1981). They reported that the infestation of pink

bollworm was significantly less in pheromone treated areas as compared to insecticides on large isolated areas in the United States of America. This discrepancy in the results may be due to the non-isolation of cotton blocks and consequently there may be some inter treatment effects. The other reason could be that the pheromones dispenser applied only once on the young plants may lose their effectiveness because they would be below the plant canopy. Shorey *et al*. (1976) observed that dispensers of hexalure placed at the top of cotton plants gave respectively 82 and 97 % better disruption of pink bollworm communication than dispensers placed mid-way down the cotton plant or on the ground. However, the amount of pheromones used in the present studies may have been sufficient to reach the upper canopy and achieve mating disruption of the bollworms. Henneberry *et al.* (1981) observed that the amount of gossyplure was more important in reducing trap catches and the disrupting mating of the pink bollworm than the number of point sources dispensing the pheromones. On the basis of these results, placement of the dispensers does not seem to be critical for disruption, if sufficient quantity of the pheromones is used.

Beneficial insects have long been recognized as an important tool and in many cases they have controlled the pests well enough to eliminate the need for further treatment. However, besides such success this classical management strategy has not always provided adequate control (Caltagione, 1981), because of the need for periodical releases and environmental management, such as providing food or hosts during time of low prey density. Present studies revealed that applying them together increased the potential of management techniques of pheromones and biocontrol strategies against cotton bollworms.

More yields were achieved from the pheromones and parasitoids treated block as compared to the separate treatments and the insecticides treatment (Table IV). The management cost was higher in the combine treatment of pheromones and the parasitoids, but the benefit achieved was also higher. The application costs of pheromones and parasitoids were very low as compared to the insecticides. Pheromones are much costly than insecticides but these are applied once in a season and their application costs only Rs. 50/- per ha. Whereas, the application cost of the parasitoid is Rs. 12.5 per ha. On an aggregate basis, higher return was achieved with the integrated treatments of pheromones and the parasitoids. Moreover, integration of these environment friendly techniques is species-specific, non-hazardous and did not disturb the natural equilibrium.

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