AUGMENTATION OF *TRICHOGRAMMATOIDEA BACTRAE* NAGARAJA IN THE IPM PROGRAMME FOR CONTROL OF PINK BOLLWORM, *PECTINOPHORA GOSSYPIELLA* (SAUND.) IN EGYPT

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Abstract

Studies were carried out to estimate fundamental bases needed for handling *Trichogrammatoidea bactrae* Nagaraja against pink bollworm, *Pectinophora gossypiella* (Saund.) eggs under field conditions; i.e., the device of release, the suitable distances between *T. bactrae* release points and the effect of some climatic factors (temperature and % relative humidity) on the emergence of the parasitoid from parasitized eggs and it's capability to parasitize new pink bollworm eggs. Also, studies were conducted to determine the role of augmenting *T. bactrae* in the IPM program for controlling pink bollworm. Field experiments were conducted during three successive cotton seasons from 1995 to 1997 under recommended cotton pests control program practices at El-Ebrahemea region, Sharkia Governorate cultivated with Giza 85 cotton variety.

Introduction

The indiscriminate use of insecticides has caused a number of problems to various ecological niches around the world including Egypt. Hence there is a growing necessity and interest in the use of biological agents for management of insect pests. Biological control of insects that feed on crops has become more practical in recent years by mass release of egg parasitoids. Practical uses of trichogrammatid egg parasites occur worldwide against many lepidopterous pests on several key crops (Smith 1986; Tuhan *et al*. 1987; Newton 1993; Hassan 1993; Smith 1994 and Zandigacome & Greatti 1997). However, before a biological organism can be released as a population regulator, preliminary tests are needed to determine the feasibility of certain necessary manipulations. Hence, the following experiments were conducted to establish the best methods for handling the parasitoid, *Trichogrammatoidea bactrae* Nagaraja for controlling pink bollworm, *Pectinophora gossypiella* (Saund.) under field conditions and to evaluate it's role in IPM control program.

Trichogrammatoidea bactrae Nagaraja, a newly egg parasitoid of pink bollworm (introduced to Egypt from USA in 1992) was reared on eggs of pink bollworm *P. gossypiella*, spiny bollworm Earias insulana and black cutworm Agrotis ipsilon (Hufn.) in theLaboratory at Bollworms Department, Plant Protection Research Institute. For efficient mass rearing, host egg sheets (containing 2000 - 2500 eggs) were exposed to adults (100-150 adults) in a 0.4-liter glass jars. Jars were provided with 10% sucrose solution as a nutrition source. Jars were covered with wrapped cotton cloth. Host eggs were replaced every 24 hr. to avoid superparasitism. Parasitized eggs were kept in clean jars.

Pink and spiny bollworm eggs were obtained from a colony maintained at the formerly mentioned laboratory where reared on a modified semi-artificial diet previously described by Abd El-Hafez *et al.,* (1982). Black cutworm A. ipsilon was reared on castor been leaves (Fahmy *et al*. 1973) in order to satisfy the demand of host eggs needed for T. bactrae release at low rearing cost. Rearing took place at constant temperature of 27 ± 1˚C and 80 ± 5 %R.H. The mean developmental time of T. bactrae oviposited eggs to adult was about 8 days at these conditions (Abd El-Hafez 1995). Our laboratory studies indicated good efficacy results of T. bactrae in parasitizing A. ipsilon and *E. insulana* eggs. Thus, these eggs were used as suitable hosts for about 1-2 generations before release. Newly deposited host eggs and parasitized host eggs at different stages of development were stored at 8 ± 1 ˚C up to 10 days to collect the required numbers of parasitized eggs.

Field Experiments were conducted from 1995 to 1997 at El-Ebrahemea region, Sharkia Governorate cultivated with Giza 85 cotton variety. Releases of parasites as pupae in parasitized host eggs were applied into the field using a device that protects them from predators and unfavorable weather. The first type was an ice cream plastic container (5-cm diam.) including card of parasitized pink bollworm eggs (3 x 3 cm.) and covered with bored paper. The device was hanged on the cotton plant (which was chosen as a release point) by small filament. This device was used during 1995 cotton season The second device was modified to lower the labor and cost, as it consists of a strip of paper (4 X 10 cm). The length of the strip paper (10cm) was marked to 3 sections A (4cm), B (4cm) and C (2cm). Then section A was folded on section B to make a closed container of 4 x 4 cm, while a card of parasitized host eggs (3 x 3 cm) was glued between the two sections. Section C was used as an edge (2cm) for hanging manually on the plant by small pins. Five replicates of ten devices from each type were fixed on the cotton plants at different dates, while another similar numbers were maintained under laboratory conditions until parasitoids emergence. . The two types of devices were tested in 1996 cotton season. Five days after fixing, the devices were collected, transfers to laboratory whereas the inside parasitized egg cards were examined and the percentage of parasitoids emergence was calculated.

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The locomotion of *T. bactrae* on cotton plants was determined by estimating the ability of emerged parasitoid females to move and search after host eggs under field conditions in 1995 cotton season. Cards of non parasitized pink bollworm eggs were fixed on cotton plants (in an area of 0.2 hectare) at different distances from the release points (i. e.; 0, 1, 2, 3, 5 and 7m). Twelve replicates per each point were used. About 200 *T. bactrae* pupae (one day before emergence) in parasitized eggs were placed at each release point. Two days later, pink bollworm egg cards were collected, maintained at laboratory until hatching or evidence of parasitization showed up. Percentage of parasitism was calculated.

Lack of success in biological control programs is doubtless often caused by high mortality of natural enemies due to climatic extremes. Field experiment was carried out during 1995 cotton season to determine the emergence of wasps from parasitized host eggs under field conditions and the capability of the emerged females to parasitize a new host eggs. During the period of study, maximum & minimum temperature and relative humidity were recorded under field conditions during the two days followed the release of parasitoids. Sixty device containers (ice cream cups), each including a card of 200 full grown pupae of *T. bactrae* (one day before adult emergence) in parasitized pink bollworm eggs were placed in an area of 0.2 hectare. The emerged *T. bactrae* females were allowed to parasitize new pink bollworm eggs on cards, which were placed at a distance of 5m from the release points. Two days later (after placing the unparasitized eggs), the parasite containers and pink bollworm egg cards were collected and held at the laboratory. The percentages of parasitoid's emergence and parasitized pink bollworm eggs were calculated. The correlation between these percentages and each of the recorded temperature & relative humidity (maximum and minimum) was estimated. The experiment was replicated 6 times at different dates through the period from June 14 to August 31.

Field studies were conducted to determine the efficiency of augmenting T. bactrae in suppressing the population of pink bollworm (PBW) during three successive cotton seasons from 1995 to 1997 under recommended cotton pests control program practices. The experimental area was 10 hectares. The cotton was planted and cultivated under the same conditions. The parasitoid was released as pupae in parasitized host eggs at a rate of 20000, 30000 and 60000 parasites/ 0.4 hectare in 1995, 1996 and 1997 seasons, respectively. Treatments using *P. gossypiella*, *E. insulana* and *A. ipsilon* eggs that contains *T. bactrae* pupae in a uniform stage of development (mature pupal stage) were tried in 1995. While, parasitized host eggs at three different stages of development (1, 2, 3 days before emergence) were applied in 1996 and 1997 seasons. A laboratory estimation for normal emergence of *T. bactrae* from parasitized host eggs recorded more than 90% and about 70% female ratio. In the three seasons, host eggs were exposed to female parasitoids for oviposition prior to release and the parasitized eggs were subjected to various temperature regimes to program adult emergence (Abd El- Hafez 1995). The intention in programming was to obtain a high percentage of emergence from the parasitized eggs within a given period of time after they were exposed to normal temperature. The dates of *Trichogramma* / insecticide treatments of the three seasons are presented in Table (1).

In 1995 cotton season 3.6 hectares were divided in a randomized block design into 9 plots (each of 0.4 hectare). *T. bactrae* was released into 6 plots, while three plots were left without release as control. The distance between the release points was 5m. Another plot of 6.4 hectares at 400-500m to the north of the test plots was used as control. Four *T. bactrae* releases were carried out between July 15 and Aug 31.

The distance between the release points was reduced to 3½ m in 1996 and 1997 seasons based on the obtained data of *T. bactrae* female locomotion on cotton plants in 1995 cotton season. Two experiments were conducted in 1996 cotton season to study the possibility of using *T. bactrae* instead of one (8 hectares) or two (0.4 hectares) pesticide applications for control PBW infestation in green cotton bolls. (Table, 1).

At 1997 cotton season, *T. bactrae* was used in a combination with insecticides. Experiments were done late in the season and were coincided with the evidence of high density of pink bollworm population. Treatments started by releasing *T. bactrae* for two times by sequence with three insecticide treatments comparing with three applications with pesticides only. This sequence aimed to give *T. bactrae* the chance to parasitize most PBW eggs, and insecticides to kill newly hatched larvae & moths. Based on a previous laboratory study (Abd El- Hafez 1995) *T. bactrae* adults lived about 2 days, by programming *Trichogramma* to emerge at three waves, parasitoids will be active seeking hosts over a continuous period of 5 days. Thus, the period between *T. bactrae* release and insecticide treatment was determined by 6 days.

The sequential sampling method was used to evaluate the infestation of green cotton bolls with pink bollworm and to determine the duration for the release of *T. bactrae* and pesticide spraying. Therefore, 100 green bolls were collected randomly from each plot at 3-7 days intervals, dissected and the number of pink bollworm larvae was recorded. Efficiency of treatment with *T. bactrae* was calculated along with the influence of pesticides to justify the role of *T. bactrae* in the IPM program. Analyses of variance were conducted on all data (ANOVA) and when statistical differences existed within a data set, Duncan's multiple range test was used to separate the means.

Results and Discussion

The Release Device

Data in Table (2) show similar percentages of T. *bactrae* emergence from parasitized pink bollworm eggs under laboratory or field conditions. These percentages ranged between 94.23 – 97.04 % and 94.54 – 98.00% with an average of 95.74 and 95.90% when the ice cream (1st device) and the strip paper container (2nd device) were used as release containers under laboratory conditions, respectively. While these percentages ranged between 93.64 – 97.42 %and 94.94 – 98.59% with an average of 95.87 and 96.65% when the two aforementioned devices were used under field conditions, respectively. Thus, the 2nd device was used at 1996 and 1997 seasons as it was cheaper, required less time for preparation and at the same time gave similar result.

Locomotion of Trichogramma Female on Cotton Plants

Table (3) summarized the results of the capability of female wasps locomotion on cotton plants which determined by fixing cards of non parasitized pink bollworm eggs at different distances from parasitoid release points. Results indicated that increasing the distance between the release point and the target eggs significantly decreased the efficacy of the emerged female of *T. bactrae* to move and parasitize pink bollworm eggs in the field (correlation value = -0.9295). The highest percentage of parasitized pink bollworm eggs (93.50%) was recorded when pink bollworm egg cards were fixed at the same release point and the lowest percentage (23.76%) was recorded when those cards were fixed at a distance of 7 meter from the release point. Percentage of parasitism varied insignificantly between the release points of 1 and 2 m (85.94 and 82.63%) or between 2 and 3m (82.63and 78.80%). When the distance between pink bollworm egg cards and the release point was increased to 5 or 7m, percentage of parasitized eggs decreased to 32.30 and 23.79%%, respectively. The present results are in agreement with those finding by Kiku and Teshler (1994) who mentioned that the effective application of the capsuled release method in the vineyard against grape leafrollers is possible when capsules are placed directly on the plants with an interval of no more than 3 m and rate of 300 – 400 thousand females/ ha. However, Neuffer (1982) indicated that *Trichogramma* must be released at 80 point (10 m x10 m) per hectare instead of 50 point (14 m x 14 m). In addition Smith (1994) indicated that *Trichogramma* disperse short distances from the point of release, usually less than 20 m.

Effect of Some Climatic Factors on the Emergence and Parasitism of *T. bactrae* Under Field Conditions

Data in Table (4) clearly showed that the wasps emergence from parasitized eggs in the field and their searching capability were significantly affected by the climatic condition (temperature and relative humidity). There was a significant negative correlation between the percentages of emergence and the maximum temperature of the two days which followed the incidence of release (r = -0.9674). On the other hand, there was significant positive correlation between the percentages of emergence and the minimum temperature of those two days (r = 0.8669). During 1995 season, the maximum temperature reached 36.6 and 38.3˚C in June, 14 and 15, respectively, and this caused mortality to about half of the released *T. bactrae* inside the parasitized eggs; the percent of emergence averaged 49.33%. *T. bactrae* emergence recorded higher percentages at the other dates of release (ranged from 94.54 % and 97.77%). Statistically, the percentages of parasitized eggs correlated insignificantly with temperature.

As for the relative humidity (% R.H.), it could be noted that the lowest percentages of R.H. (26.50 & 33.50%) were recorded at the two days followed the first release (i.e.; June 14 and 15). The averages of minimum and maximum % R.H. of those two days were 44.5 and 15.5 30%, respectively. Consequently, the reduction of % R.H. caused a great reduction in the emergence of *T. bactrae* from parasitized eggs. In the contrary, the increased of % R.H. during July and August was followed by higher percentages of parasitoids emergence (94.54 – 97.77%). The emergence of parasites under field conditions was more close with R.H. than temperature (Table, 4). There was highly positive correlation between the percentages of parasitoid's emergence and the averages of maximum, minimum or mean R.H. of the two days which followed parasitoid's release (r = 0.9497, 0.9635 and 0.9607, respectively). Percentages of parasitized pink bollworm eggs correlated significantly with maximum, minimum and mean R.H.; r values were 0.8206, 0.8119 and 0.8200, respectively. These results agree with those mentioned by Calvin *et al.* (1984) who found that *T. pretiosum* development was prolonged and adult fecundity was reduced at relative humidities as law as 20%. While, Smith (1994) suggested that improved parasitoid efficacy could be achieved in field releases during inclement weather (particularly temperature). It could be recommended that, in field where temperature is relatively high during the day, releases of *T. bactrae* should be conducted on the late evening or in early morning.

Efficiency of *T. bactrae* in Control Pink Bollworm Under the Recommended Cotton Pests Program Practices

1995 Season. At 1995 cotton season, four *T. bactrae* treatments, were carried out between July 15 and August 31, however, one insecticide (Baythroid) application against pink bollworm was applied at July 29 according to the recommended control program (Table, 1). In addition, three insecticide applications were applied against cotton leafworm (CLW). The infestation of green cotton bolls with PBW larvae is presented in Table (5) and Fig. (1). Pink bollworm infestation in the study field plots averaged 3, 6, 4 and 3 % at the first four boll inspections (July 4, 7, 10 and 14 , respectively). After the first release, percentage of infestations declined to 0% at July 21& 28 in the release field, 1 & 5% in the 1st control (near the release field), and to 1 & 3% in the 2nd control (400-500m north the release field), respectively. In the last 5 inspections, percentages of infestation ranged between 0 – 1, 2 – 6 and 7 - 26 % in the three aforementioned fields, respectively.

Although PBW density was relatively low, the mean infestation in the inspection dates, was significantly higher in the nonrelease fields than in the release one, where the overall percentages of infestation averaged 1.64, 3.45 and 7.18% in release, 1st control and 2nd control, respectively. It could be noted that the percent of infestation was comparatively low in the near control than the far one, this may due to the migration of *T. bactrae* from the released field. In addition, the reduction on the percentage of pink bollworm infestation in the release field in comparison with the two control fields reached 52.46 and 77.16%, respectively. The significantly lower numbers of pink bollworm in the release fields would indicate that *T. bactrae*, was an effective agent on control PBW larvae in the field.

1996 season. Data of the first set are present in Table (6) and illustrated in Fig. (2). The same pesticide treatments against PBW and CLW were applied at the two study plots between July 6 and August 11 (Table 1), so the percentages of infestation through this period averaged approximately the same values (2.44 and 2.55% for the release and non-release fields, respectively). *T. bactrae* was released at August 19 in the second plots instead of Larvine which was applied in the first plots. Percentages of infestation at the day of release reached 4 and 5% in the non-release and release study plots, respectively. *T. bactrae* seemed to be more effective than Larvine as the percentages of infestation averaged 6 and 5% at the third and eighth day of parasite release, however it increased to 7 and 10% in the non-release study plots at the same dates, respectively. At Sep., 3 the percentage of infestation reached 22% in the non-release plots, however it still relatively low at the release plots (20%).

At the second set, four pesticide applications (according to the recommended control program) were tried against PBW and CLW in the first plot. While in the second plot, the first and the fourth applications were changed by releasing *T. bactrae* at rate of 30, 000 parasitoids/ 0.4 hectare. Percentages of PBW infestation at the day of the first treatment (July 21), averaged 4 and 3% in the first (non-release) and second (release) plots, respectively. Four days after treatment (July 25), the infestation with PBW decreased to 3 and 2%, respectively, while it increased again to 5 and 4% at the third inspection (July 25).

At August 2, PBW infestation recorded about twice its values (11 and 8%) and then decreased gradually at the two following inspections (August 6 and 10) to reach 9 & 5% in the insecticide plot and 7& 6% in *Trichogramma* release plot, respectively. More increase in PBW (15 and 13%) and CLW infestations was achieved in the two study plots at August 14, where the third application was applied by using Curacron. Pink bollworm infestation decreased at the two following inspections to 7 & 6% in the non release plots and to 8 & 6% in the release plots, respectively.

The fourth treatment was applied at August 26 by using Larvine at the non release plots and *T. bactrae* (30 000/ Fed.) in the release plots, however, higher percentages of PBW infestation were recorded in the two plots at this date (16 and 12%, respectively). After the fourth treatment, the percentage of PBW infestation recorded 6 & 13% and 5 & 9 % at the last two inspections (August 30 and Sep. 3, respectively). The whole percentages of PBW infestation averaged 8.33 and 6.92% in the non-release and release plots, respectively. Regarding the present results it could be noted that *T. bactrae* was so effective as or more than Delfos and Larvine when introduced in the recommended program of control cotton pests. It could be indicated that *T. bactrae* was capable to reduce the PBW infestation in cotton bolls as insecticides and can be used safely in the IPM program.

1997 season. In this season, field studies were done to determine the possibility of using *T. bactrae* in sequence with insecticides to suppress the high population of PBW in green cotton bolls. The first release of *T. bactrae* (60 000 parasite / 0.4 hectare) started at August 5 in plots with high levels of PBW infestation averaged 52% opposite to 23% in the non-release plots. Five days after release, the percentages decreased to 37 and 19% in the release and non-release plots, respectively. At August 11 (6 days after the first release), the first insecticide treatment was tried by using Kendo in the two study plots. The combination effect of *T. bactrae* and insecticide treatment was more evident as it caused a great reduction in the PBW infestation comparing with insecticide treatment (Table, 8 and Fig., 4).

The second release of *T. bactrae* (60 000 parasite / fed.) was done at August 27 whereas the PBW infestation averaged 4 and 8% in the release and nonrelease plots. At Sept.1 inspection the percentage of PBW infestation increased to 20% in the nonrelease plots opposite to 9% in the release plots, however the second insecticide application (Cypermethrin) was done at the next day (Sept. 2). At Sept. 8, the percentages of PBW infestations were at the same level (14 %).

The third release of *T. bactrae* (60 000 parasite / fed.) occurred at Sept. 10 while the percentages of PBW infestation averaged 19 and 18% in the release and nonrelease plots, respectively. Five days after the third treatment, percentage of PBW infestation decreased to 13% in *T. bactrae* release plots however it increased to 24% in the nonrelease plots (insecticide treatments) and then the third insecticide treatment (Larvine) was applied (Sept. 15). Lower percentages of PBW infestation in the release plots were recorded at the two last inspections (15 and 14%) compared to those recorded in the nonrelease plots (19 and 21%).

Releases of *T. bactrae* in combination with sprays of Kendo, Cypermethrin, and Larvine significantly reduced the infestation of pink bollworm. Furthermore, although percentage of PBW infestation in the *T. bactrae* release plots (52%) was more twice than those in the nonrelease plots (23%) at the beginning of the experiment, *T. bactrae* was efficient to suppress PBW population and subsequently decreased the percentage of infestation to became approximately at the same level (18.25 and 17.08%, respectively). Similar results were obtained by Tuhan *et al.* (1987) who found that release of *Trichogramma brasiliense* at a rate of 20, 000 newly emerged adults/acre per week in combination with sprays of carbaryl, dimethoate and monocrotophos significantly reduced the damage caused to cotton by *Earias insulana, E. vittella and P. gossypiella*. Also, Dhandapani *et al.* (1992) revealed that three releases of biocontrol agents., *T. chilonis* and *Brinckochrysa sceletes* on 90, 105 and 120 days after sowing could effectively check the population of *Heliothis armigera* and *Bemisia tabaci* which was equal to that of insecticides.

Summary

Results indicated that increasing the distance between the release point and the target host (pink bollworm eggs), significantly, decreased the capability of parasitism by the emerged parasitoid females. There was significant negative and positive correlation between the percentages of parasitoid emergence and the maximum and minimum temperature of the two days that followed the incidence of release, respectively. Also, the emergence of parasites from parasitized eggs and their capability to parasitize new pink bollworm eggs under field conditions were positively correlated with maximum or minimum R. H. of the two days which followed parasitoid's release. The present results revealed also that *T. bactrae* was effective in reducing pink bollworm infestation either when introduced in the IPM program of controlling cotton pests or when used in combination with insecticides to control pink bollworm. Thus it could be used safely in the IPM program.

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Table 1. The program of treatment the studying plots with T. bactrae and insecticides during 1995- 1997 cotton seasons.

Date of treatment	Release field		Non-release field	
	Treatment	Target pest	Treatment	Target pest
1995 cotton season				
June, 28	Delfos	CLW	Delfos	CLW
July, 15	T. bactrae	PBW	-	-
July, 19	Curacron	CLW	Curacron	CLW
July, 29	Bythroid	PBW	Bythroid	PBW
August, 7	T. bactrae	PBW	-	-
August, 11	Dursbane	CLW	Dursbane	CLW
August, 15	T. bactrae	PBW	-	-
August, 31	T. bactrae	PBW	-	-
1996 cotton season				
First experiment				
July, 6	Delfos	PBW & CLW	Delfos	PBW & CLW
18	Curacron	CLW	Curacron	CLW
30	Bythroid	PBW	Bythroid	PBW
August, 11	Delfos	CLW	Delfos	CLW
19	T. bactrae	PBW	Larvine	PBW
Second experiment				
July, 21	T. bactrae	PBW	Delfos	PBW
August, 2	Bythroid	PBW	Bythroid	PBW
14	Curacron	PBW & CLW	Curacron	PBW & CLW
26	T. bactrae	PBW	Larvine	PBW
First experiment				
July, 6	Delfos	PBW & CLW	Delfos	PBW & CLW
18	Curacron	CLW	Curacron	CLW
30	Bythroid	PBW	Bythroid	PBW
August, 11	Delfos	CLW	Delfos	CLW
19	T. bactrae	PBW	Larvine	PBW
Second experiment				
July, 21	T. bactrae	PBW	Delfos	PBW
August, 2	Bythroid	PBW	Bythroid	PBW
14	Curacron	PBW & CLW	Curacron	PBW & CLW
26	T. bactrae	PBW	Larvine	PBW
1997 cotton season				
August, 5	T. bactrae	PBW	-	-
11	Kendo	PBW	Kendo	PBW
27	T. bactrae	PBW	-	-
Sep., 2	Cypermethrin	PBW	Cypermethrin	PBW
10	T. bactrae	PBW	-	-
15	Larvine	PBW	Larvine	PBW

Table 2. Percentage of emergenceof *Trichogramma bactrae* from two different devices under laboratory and field conditions.

Replicates	Ice cream container		Strip paper container	
	Laboratory	Field	Laboratory	Field
1	97.04	97.42	96.49	94.94
2	95.00	96.93	98.00	98.59
3	95.97	93.64	95.45	95.59
4	96.34	94.25	94.54	95.71
5	94.23	97.13	95.00	98.41
Average	95.738	95.874	95.896	96.648

Table 3. Effect of the distance between release points on the percentage of parasitized PBW eggs by *T. bactrae* female under field conditions.

Distances in meters from the release point	% Parasitized pink bollworm eggs (% ± SE)	Range
0	$93.50^{a} \pm 2.02$	80.85 - 100
1	$85.94^{b} \pm 2.38$	76.00 - 100
2	$82.633^{bc} \pm 2.52$	71.43 - 95.29
3	$78.80^{c} \pm 1.64$	68.75 - 85.00
5	$32.30^{d} \pm 2.08$	22.95 - 42.86
7	$23.79^{e} \pm 1.60$	16.67 - 35.00
Mean	66.19 ± 3.36	16.67 – 100
Regression equation (y = a + bx)	99.269 + (-11,0361*x)	
R^2	0.86395***	

Table 4. Effect of temperature and relative humidity on the emergence of *T. bactrae* from parasitized eggs and capability of the emerged female to parasitize new PBW eggs under field conditions during 1995 cotton season.

Date	% emergence	% Parasitized Eggs	Temperature (˚C)		Relative Humidity R.H.	
			Max.	Min.	Max.	Min.
June, 14	49.33	0.028	36.6	19.90	39.00	14.00
15			38.3	22.20	50.00	17.00
July, 15	97.24	8.08	33.50	23.40	72.00	42.00
16			34.00	23.40	70.00	41.00
Aug., 7	97.39	26.67	33.40	23.20	72.00	48.00
8			32.80	22.00	79.00	53.00
Aug., 15	97.77	31.01	33.20	22.70	82.00	50.00
16			34.30	21.00	82.00	48.00
Aug., 19	95.33	32.98	34.60	22.00	81.00	48.00
20			34.00	22.80	79.00	50.00
Aug., 19	95.33	32.98	34.60	22.00	81.00	48.00
20			34.00	22.80	79.00	50.00
Aug., 25	94.54	16.84	33.20	22.20	79.00	52.00
26			35.60	22.70	82.00	48.00
Correlation (probability)						
Max. Temp.	- 0.9674	-0.6857				
	(0.0016)**	$(0.1326)^{ns}$				
Min. Temp.	0.8669	0.3096				
	(0.02539)*	$(0.55045)^{ns}$				
Max. R.H.	0.9497	0.8206				
	(0.003738) **	(0.04540)*				
Min. R.H.	0.9635	0.8119				
	(0.00198)**	(0.04976)*				

Table 5. Effect of *T. bactrae* in control pink bollworm *P. gossypiella* under the recommended practices pest program of 1995 cotton season.

Samples' date	% infestation by pink bollworm		
	Release Plots	Control	
		Near the Release plots	500 m north the release plots
July, 4	3	3	3
7	6	6	6
10	4	4	4
14	3	3	3
21	0	1	1
28	0	5	3
Aug., 5	1	6	26
12	0	2	9
19	0	2	8
24	0	2	9
31	1	5	7
Mean	1.64	3.45	7.18
% reduction		52.46	77.16

Table 6. Efficiency of releasing *T. bactrae* for one time instead of one insecticide application on suppressing infestation pink bollworm, in 1996 cotton season.

Date of inspections	% infestation	
	Release plots	Control plots
July, 6	3	2
12	3	0
18	0	0
24	0	8
30	5	1
Aug., 5	0	1
11	2	2
17	5	4
19	4	5
23	6	7
27	5	10
31	20	22
Mean	4.42	5.2
% reduction		15.0

Table 7. Efficiency of releasing *T. bactrae* for two times instead of two insecticide applications on suppressing infestation with pink bollworm, in 1996 cotton season.

Date of inspections	% infestation	
	Release plots	Control plots
July, 21	3	4
25	2	3
29	4	5
August, 2	8	11
6	7	9
10	6	5
14	13	15
18	8	7
22	6	6
26	12	16
30	5	6
September, 3	9	13
Mean	6.92	8.33
% reduction than control	16.93	

Table 8. Efficiency of treatment with *T. bactrae* along with insecticides on suppressing infestation with pink bollwormin 1997 cotton season.

Date of inspections	% infestation	
	Release plots	Control plots
July, 30	13	12
August, 5	52	23
10	37	19
14	18	19
20	11	8
27	4	8
September, 1	9	20
8	14	14
10	19	18
15	13	24
19	15	19
25	14	21
Mean	18.25	17.08

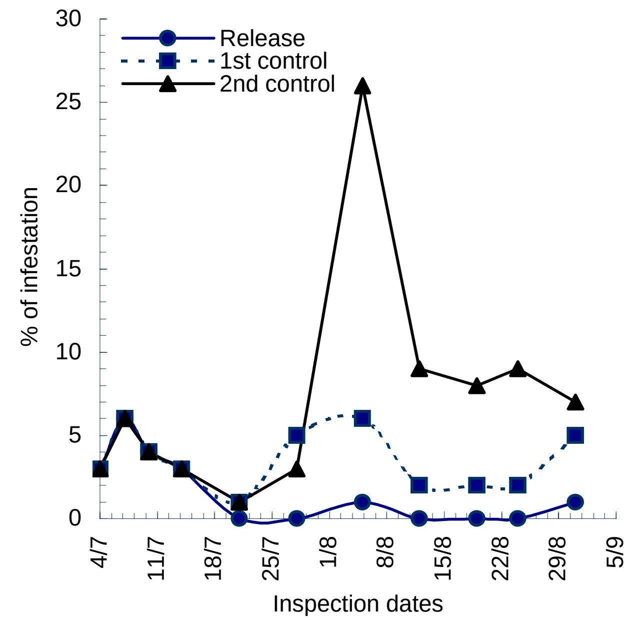

Figure 1. Percentages of infestation with pink bollworm larvae in *T. bactrae* release and non-release fields during 1995 cotton season.

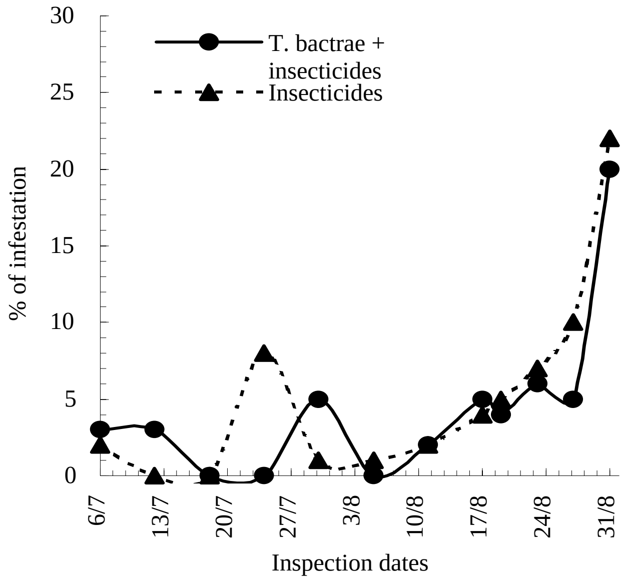

Figure 2. Percentages of infestation with pink bollworm larvae in green cotton bolls under 5 insecticide applications or 4 insecticide applications + one release of *T. bactrae* during 1996 cotton season.

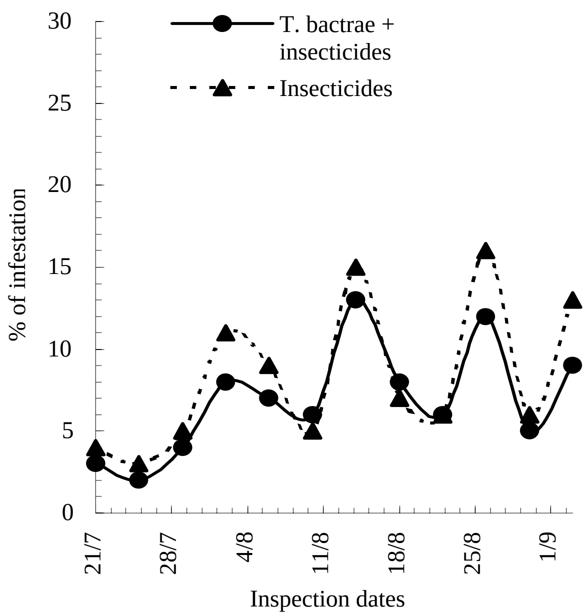

Figure 3. Percentages of infestation with pink bollworm larvae in green cotton bolls under 4 insecticide applications or 2 insecticide applications + 2 releases of *T. bactrae* during 1996 cotton season.

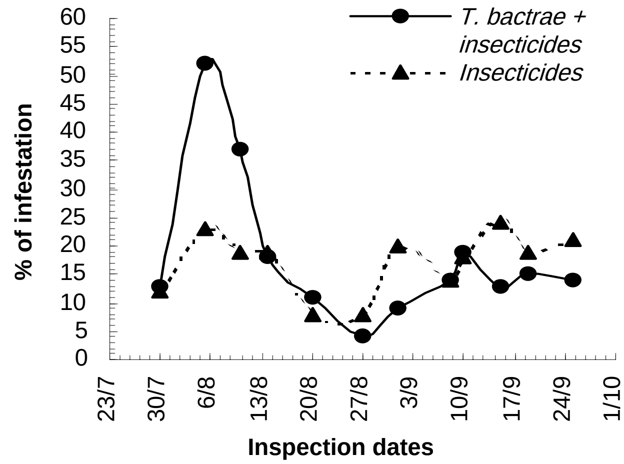

Figure 4. Efficiency of treatment with *T. bactrae* along with insecticides or with insecticides only on suppressing the high infestation with pink bollworm larvae during 1997 cotton season.