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Management of *Plutella xylostella* (Linnaeus) (Lepidoptera: Plutellidae) with *Trichogrammatoidea bactrae* Nagaraja and *Bacillus thuringiensis* Berliner on cabbage

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ABSTRAT: **Laboratory studies on parasitizing efficiency of *Trichogrammatoidea bactrae* Nagaraja and bioassay of *Bacillus thuringiensis* Berliner, and field evaluation of these bioagaents alone and in combination were carried out against diamondback moth, *Plutella xylostella* (Linnaeus) on cabbage. The results indicated that the parasitism of *T. bactrae* was higher in the eggs of *Corcyra cephalonica* Stainton (91.36%) than *P. xylostella* (82.46%) while the adult emergence was more from parasitized eggs of *P. xylostella* (92.16%) than *C. cephalonica* (91.40%). The estimated LC_{50} value of *B. thuringiensis* formulation Dipel 8L was 0.043 per cent. Field studies revealed that inundative releases of *T. bactrae* @50,000 adults/ha/release five times at weekly interval with two intermittent sprays of *B. thuringiensis* @ 1 litre/ha at 10 days interval commencing from 30 days after transplanting of cabbage resulted in minimum of 0.45 mean surviving larvae of DBM with 84.16 per cent reduction in larval number and maximum yield of 380.2 q/ha marketable cabbage heads, and proved to be the most effective.**

KEY WORDS: *Bacillus thuringiensis*, cabbage, *Corcyra cephalonica*, *Plutella xylostella*, *Trichogrammatoidea bactrae*

INTRODUCTION

Use of pesticides has brought adverse changes in the biotic balance, which leads to the development of resurgence and resistance in *Plutella xylostella* (Linnaeus) (Deshmukh and Saramma, 1973; Chawla and Kalra, 1976). It is, therefore, most desirable to formulate a Biointensive Pest Management (BIPM) system for minimizing the use of chemical pesticides and promoting the application of bioagents like parasitoids and microbial insecticides to keep the pest population below economic injury level. The naturally occurring egg parasitoids, *Trichogramma* spp. are most widely used for biological suppression of lepidopterous pests. The test species of the parasitoid *Trichogrammatoidea bactrae* Nagaraja is being mass reared on factitious host, *Corcyra cephalonica* Stainton for several generations under laboratory conditions. Hence, it was felt necessary to study its parasitizing efficiency in the target host diamondback moth (DBM). Besides, *Bacillus thuringiensis* Berliner gave encouraging results in curbing the population of *P. xylostella* in Cole crops. In order to exploit these promising bioagents, a BIPM module was formulated and evaluated against DBM in cabbage crop.

MATERIALS AND METHODS

The present investigations on parasitizing efficiency of *T. bactrae* and bioassay of *B. thuringiensis* were carried out in the Biological Control Laboratory and field evaluation of these bioagents against DBM on cabbage was undertaken at the research farm of Entomology Section, College of Agriculture, Pune during 2001-2002.

Parasitization of *T. bactrae* in *P. xylostella*

The eggs of *P. xylostella* and *C. cephalonica* were glued on separate paper card with 5 per cent gum. Each egg strip containing 100 eggs and 10 pairs of adults of *T. bactrae* were introduced into glass vials (7x3 cm) and plugged with cotton. Such fifteen vials for each host were kept for parasitization and adult emergence after 8-9 days. The per cent parasitism and per cent emergence of the parasitoid were worked out.

Bioassay of *B. thuringiensis* against *P. xylostella*

The leaf residue bioassay method was employed for assessing the toxicity of *B. thuringiensis* (Dipel 8L) to *P. xylostella* larvae (Tabashnik *et al.*, 1990; Shelton *et al.*, 1993). Seven serial dilutions with 0.5, 0.25, 0.125, 0.0627, 0.03125, 0.0156 and 0.0078 per cent concentrations were prepared in distilled water containing Sandovit 0.1 per cent as surfactant. The water with 0.1 per cent Sandovit served as control. Leaf discs of 6 cm diameter obtained from the untreated plots were treated individually by dipping them in various concentrations for one minute and then allowed to dry. These were then placed in plastic vials and ten third instar larvae were released in each vial with plugged cotton. Such thirty larvae starved for 4 hours were exposed to each concentrations and control treatment. Observations on larval mortality were recorded at 6 to 36 hours after treatment. Corrected per cent mortality was worked out by using Abbott's formula. The data were subjected to Probit analysis and LC_{50} value was worked out.

Field management of *P. xylostella* with *T. bactrae* and *B. thuringiensis* on cabbage

Healthy cabbage seedlings of *var.* Golden acre were transplanted in flat bed plots (5x3m^2) and application of treatments was started 30 days after transplanting. Inundative releases of *T. bactrae* five times at weekly interval were carried out by stapling the bits of tricho-card on the under surface of leaves. Whereas, three sprays of *B. thuringiensis* (Dipel 8L) were given at 10 days interval with high volume sprayer. The intermittent applications of *B. thuringiensis* at 10 days interval were given in the *T. bactrae* commencing the first spray five days after first release of the parasitoid. Similarly, three sprays of endosulfsan (Endocel 35EC) were given at 10 days interval as standard check. Inclusive of untreated control, seven treatments were replicated three times in the experiment. The detail application schedule of these treatments is given below:

T1 - *T. bactrae* @ 1 lakh adults/ ha/ release, 5 releases at weekly interval

T2 - *T. bactrae* @ 50,000 adults/ ha/ release, 5 releases at weekly interval

T3 - *B. thuringiensis* @ 1 Kg/ha – 3 sprays at 10 days interval

T4 - *T. bactrae* @ 50,000 adults/ha/release, 5 releases at weekly interval + *B. thuringiensis* @ 1 Kg/ha, 2 sprays at 10 days interval starting from 5 days after first release of the parasitoid

T5 - *T. bactrae* @ 50,000 adults/ha/release, 5 releases at weekly interval + *B. thuringiensis* @ 1 Kg/ha, one need based application

T6 - Endosulfan (0.07%), 3 sprays at 10 days interval

T7 - Untreated Control

The observations on pre and post-treatment population counts of the surviving larval population of *P. xylostella* were recorded on 10 randomly selected plants at weekly interval in each treatment plot. The pooled mean of surviving larvae, per cent reduction in larval population and yield of marketable cabbage heads (q/ha) were worked out.

RESULTS AND DISCUSSION

Parasitizing efficiency of egg parasitoid, *T. bactrae* in *P. xylostella*

Laboratory studies revealed that the parasitism of *T. bactrae* was significantly higher in the eggs of *C. cephalonica* (91.36%) than *P. xylostella* (82.46%). Whereas, adult emergence of the parasitoid was more in *P. xylostella* (92.16%) than in *C. cephalonica*(Table 1). These results are in agreement with the findings of Klemm *et al.* (1990) who recorded as high as 67 per cent parasitism of *T. bactrae* in *P. xylostella*. Paul *et al.* (1981) recorded highest percentage parasitism and adult emergence from the eggs of *C. cephalonica* in case of *T. chilonis* and *T. exiguum*. Higher parasitisation of *T. bactrae* in *C. cephalonica* in the present study may be due to its adaptability for its prolonged rearing on this host. The parasitoid could be reared and mass cultured satisfactorily on *C. cephalonica* eggs. Pak *et al.* (1990) opined that the rate of parasitism was low in *P. xylostella* due to its smaller egg size.

Table 1. Parasitizing efficiency of *T. bactrae* in *P. xylostella* and *C. cephalonica*

Host	Parasitism (%)	Emergence (%)
Plutella xylostella	82.46 (65.27)	92.16 (73.78)
Corcyra cephalonica	91.36 (72.95)	91.40 (72.95)
SEM ±	(0.63)	((0.22)
CD (P=0.05)	(1.93)	((0.63)

*Mean of 15 observations
Figures in parentheses are arcsine values.

Bioassay of *B. thuringiensis* against *P. xylostella*

The larval mortality recorded at 36 hours after treatment ranged from to 99.33 per cent for the concentrations from 0.0078 to 0.5 per cent (Table 2). The estimated LC_{50} was 0.043 per cent with upper and lower fiducial limits as 0.060 and 0.030, respectively. The Probit regression equation was Y=2.8413+1.323x. Pawar and Patil (1997) worked out LC_{50} and LC_{95} values of *B. thuringiensis* subsp. *kurstaki* (formulation Wock-01 Halt WP) as 0.069 and 0.1929 per cent, respectively. Pokharkar *et al.* (2002) determined the LC_{50} values of the five *B. t.* formulations, *viz.* Delfin WG, Dipel 8L, Halt WP, Biobit HPWP and Biolep WP against third instar larvae of *P. xylostella* and the values for corresponding formulations were 0.01, 0.011, 0.0173,

Table 2. Dosage-mortality responses of third instar larvae of *P. xylostella* due to Dipel 8L

Concentration (%)	Log con. x 1000	Larval mortality (%)	Corrected mortality (%)	Expected probit
0.5	2.6989	99.33	98.89	7.50
0.25	2.3979	93.33	92.59	5.90
0.125	2.0969	73.33	70.37	5.71
0.0625	1.7959	56.66	51.84	5.17
0.03125	1.4949	43.33	37.03	4.78
0.0156	1.1931	26.66	18.51	4.38
0.0078	0.8921	16.66	7.03	4.02

Regression equation: Y = 2.8413 + 1.3231 x Wherein, Y = Probit kill, x = log concentration
LC_{50}: 0.043 %
Fiducial limits: upper = 0.060 %, lower = 0.030%
Heterogeneity (χ^2): 2.4821

0.0125 and 0.0169 per cent. Thus, these observations supported the present findings in this respect. It is evident from the results that the *B. thuringiensis* formulation Dipel 8L was highly toxic to the third instar larvae of *P. xylostella* and could be employed for the control of DBM under field conditions.

Field management of *P. xylostella* with *T. bactrae* and *B. thuringiensis* in cabbage

The results indicated that five releases of *T. bactrae* @ 50,000 adults/ ha/ release at weekly interval with two intermittent sprays of *B. thuringiensis* (Dipel 8L) @ 1kg/ha at 10 days interval resulted in minimum of 0.45 mean surviving larva of DBM/ plant with 84.16 per cent reduction in larval population and maximum marketable yield of 380.2 q/ha cabbage heads and proved to be the most effective (Table 3). It was, however, favourably compared with the treatments like five releases of *T. bactrae* @ 50,000 adults/ha/release at weekly interval with the need based one spray of *B. thuringiensis* @ 1kg/ha, and 3 sprays of endosulfan 0.07 per cent at 10 days interval. Hadapad (2000) reported that inundative releases of *T. bactrae* @ one lakh adults/ ha/ release at weekly interval and spraying of *B. thurinigensis* formulation like Delfin WG were statistically comparable with endosulfan 0.07 per cent in respect of surviving larval population as well as yield of marketable cabbage heads. Kandoria *et al.* (2000) observed that Dipel 8L at 1.5 lit/ha gave maximum of 72.42 per cent mortality of DBM larvae after 10 days. Thus, the efficacy of *T.*

Table 3. Management of DBM with *T. bactrae* and *B. thuringiensis* in cabbage

Treatment	Pre-treatment count (larvae/Plant)	Post-treatment count (larvae/ plant)						Percent reduction in larval population	Yield (q/ha)
		I week	II week	III week	IV week	V week	Pooled mean		
T. bactarae @ 1 lakh adults ha/ release	2.06 (1.60)	1.20 (1.30)	0.80 (1.14)	0.60 (1.40)	0.30 (0.89)	0.20 (0.83)	0.62 (1.05)	73.59	358.2
T. bactrae @50,000 adults/ ha/ release	2.40 (1.70)	2.20 (1.64)	1.80 (1.51)	1.50 (1.41)	1.10 (1.26)	0.90 (1.18)	1.80 (1.41)	34.00	343.7
B. thuringiensis @ 1lit/ha	2.43 (1.71)	1.06 (1.24)	1.00 (1.22)	1.13 (1.27)	0.60 (1.04)	0.76 (1.13)	0.91 (1.18)	67.05	360.8
T. bactrae @50,000 adults/ ha/ release + 2 sprays of *B. t.* @ 1 lit/ ha	2.50 (1.73)	1.06 (1.24)	0.60 (1.04)	0.30 (0.89)	0.20 (0.83)	0.10 (0.77)	0.45 (0.97)	84.16	380.2
T. bactrae @50,000 adults/ ha/ release+1 spray of *B. t.* @ 1 lit/ha	2.33 (1.68)	1.40 (1.37)	0.60 (1.04)	0.50 (1.00)	0.30 (0.89)	0.20 (0.83)	0.60 (1.04)	77.33	374.8
Endosulfan 0.07%	2.63 (1.76)	1.03 (1.23)	0.80 (1.14)	0.40 (0.94)	0.30 (0.89)	0.20 (0.83)	0.54 (1.01)	81.93	377.8
Untreated Control	2.50 (1.73)	2.70 (1.78)	2.90 (1.84)	3.20 (1.92)	3.00 (1.87)	2.40 (1.70)	2.84 (1.83)	-	196.3
SEM ±	(0.140)	(0.15)	(0.10)	0.06	(0.06)	(0.03)	(0.02)	-	(41.32)
CD (P=0.05)	(N.S.)	(0.46)	(0.32)	(0.17)	(0.17)	(0.09)	(0.06)		(127.35)

bactrae and *B. thuringensis* in the biosuppression of DBM as documented by these earlier research workers could support the present findings.

It is evident from the studies that combined applications of bioagents *T. bactrae* @ 50,000 adults/ ha/ release five times at weekly interval with two intermittent sprays of *B. thuringiensis* @1.0 lit/ ha at 10 days interval could be the effective BIPM module for the biosuppression of DBM, and increase in yield of cabbage.

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