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EFFECT OF *BACILLUS THURINGIENSIS* BERLINER SUSPENSION ON RICE LEAF FOLDER *CNAPHALOCROCIS MEDINALIS* GUENEE (PYRALIDAE : LEPIDOPTERA) AND THE PREDATORY COCCINELLID BEETLE, *MENOCHILUS SEXMACULATUS* FAB.

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Efficacy of *Bacillus thuringiensis* Berliner (*Bt*) and malathion 50 EC on leaf folder and the predatory coccinellid beetle *Menochilus sexmaculatus* was assessed in paddy field cultivar on *Swarna mashuri* during 2005-2008 at Raiganj, Uttar Dinajpur, West Bengal. *Bt* and malathion were applied at vegetative and early tillering stage. Control field was treated with the same volume of water. Malathion was found superior in suppressing leaf folder population at first application than the second. Numerically, at post application counting, maximum leaf folder population (122.21 moths/trap and 13.09 larva / 4m^2) with lowest grain yield (19.72 q/ha) was noted in control. Least pest incidence (62.87 moths/trap and 1.02 larval individuals/4m^2) with maximum grain yield (34.27 q/ha) was noted when malathion was applied @ 1.0kg/ha. This result was statistically at par with the application of *Bt* formulation @ 3.0 kg/ha. Overall impact of malathion on predatory coccinellid population was found detrimental in suppressing the population to an extent of 59.36-83.82% and 54.42-74.22% during first and second phase of applications, respectively. *Bt* formulation had no significant repression effect on beetle population recording 0.49-3.48% and 0.38-1.86% in the first and second round, respectively. *Bt* formulation @ 3.0 kg/ha was found economical and environmentally prudent.

Key words : *Bt*, leaf folder, predatory beetle, yield loss.

INTRODUCTION

Rice leaf folder, *Cnaphalocrocis medinalis* Guenee is a major rice pest (Pathak, 1975; Kaul *et al.*, 1999; Patnaik, 2001). The larvae fold paddy leaves and scrape the green tissues resulting in complete foliage deterioration. Loss incurred by the larvae is insurmountable (Bautista *et al.*, 1984). A single larva can destroy many paddy leaves (Upadhyay *et al.*, 1975). Sellamal *et al.* (1983) reported that larval damage to10 per cent flag leaf reduces grain yield by 0.13 g /tiller and filled grain number by 4.5 per cent / tiller, respectively. Control of larva by insecticides, in many cases, was found less practical (Pradhan, 1964; Kushwaha, 1995); Predatory coccinellid *Menochilus sexmaculatus* Fab. is a generalized predator on leaf folder larva. Bio-pesticides due to their non toxicity to non-target organisms and humans are imperative in this regard (Nele, 1997). *Bacillus thuringiensis* (*Bt*) is considered as an important bio-pesticide (Gill *et al.*, 1992). Application of *Bt* formulation suppresses the pest population leaving no harmful impact (Singh *et al.*, 2000). Pest caterpillars infected by *Bt* immediately show physiological abnormalities (Gill *et al.*, 1992). But even preliminary experiment was not carried out to assess the efficacy of the bio-pesticide on the incidence of paddy leaf folder and its natural enemies especially predatory coccinellid beetles in West Bengal.

MATERIALS AND METHODS

Field experiments were conducted with transplanted 35-day old seedlings of *Swarna mashuri* (MTU 7029) during 2005-2008 at Raiganj [26°35′15′′(N) - 87°48′37′′(W)], Uttar Dinajpur, West Bengal. The soil of the experimental field was sandy loam with P^H 3386.7 and EC value 0.29 mm hs / cm. Available N, P_2O_5 and K_2O was 309,55 and 358 kg/ha, respectively. Experiment was conducted in random block design and at 15x15 cm. Each plot was 15 x 7 m separated from the adjacent plot by at least 2m. There were three replications.

Two types of pesticides were applied, *Bacillus thuringiensis* formulation (*Bt*) and malathion as. *Bt* formulation was added with required amount of water to make appropriate conidial suspension. For each treatment, optimum irrigation was done 2-3 days before pesticide application. Five solution grades of each of the two pesticides were prepared. The grades of *Bt* formulations were 1.0, 1.5, 2.0, 2.5, 3.0 and 3.5 kg/ha. While that for malathion it was 0.15, 0.25, 0.50, 0.75 and 1.00 kg /ha. Application was manifested in relation to days of seedling transplantation (DAT). Each formulation was applied in separate plot by high volume sprayer @ 500ml/ha at two specific times *viz.* vegetative (35-40 DAT) and tillering stages (70-75 DAT). Control field was treated with only water of same volume and at the same time like the treated fields. Incidence of pest and abundance of predatory beetles was recorded 2-day before and 10-days after each spray application (DAS).

Light trapping : Two modified Chinchura light traps (200 watt) were equidistantly placed in each field, 6 meter above the ground level, with a collection pan (r=30cm.) below the light trap in two occasions; 2-day before application (DBA) and 10-day after field application (DAA). Adult leaf folder moths so collected were counted next morning.

Quadrate estimation : Quadrate was flat metallic square (2 x 2m or $4m^2$) to allow paddy plants to be more easily grasped by hands and facilitated counting of both the leaf folder larvae and beetles.

Adult leaf folders were recorded by light trapping. Average of two light traps from before and after each treatment was represented separately. Larva of leaf folder and the adult beetle, numbers were assessed only by $4m^2$. In both the cases DBA and DAA was compared and extent of pest suppression in percentage was calculated after conducting the experiment three times for each of the four experiment years. The pooled data was statistically analyzed by INDOSTAT- ANOVA and CD values were determined for all the data sets.

RESULTS AND DISCUSSION

Leaf folder population : In the vegetative phase, first application of different concentrations of Bt and malathion had no significant effect of the leaf folder *C. medinlis*. But all the insecticidal treatments were found superior in suppressing the larval numbers of the leaf folder than control. Best performance in consideration of larval population reduction was noted in malathion applied @ 1.0 kg/ha and the registered days before application and days after application were 13.39 and 1.32 Individuals/$4m^2$, respectively. The highest larval numbers was recorded when *Bt* formulation was applied @ 1.0 kg/ ha.

The corresponding DBA and DAA in first application were 11.31 and 6.84 larvae, respectively. Though the DAA larval numbers differed with the application of *Bt* @ 3.0 kg/ha (2.09 individuals/4m^2) and malathion @ 1.0 kg/ha (1.32 individuals/4m^2), it was statistically non significant. Higher the dose of the formulation, lesser was the larval abundance. Numerical abundance of larval numbers under the application of *Bt* formulation at 1.0ml/ha (DBA-11.31, DAA-6.84), 1.5ml/ha (DBA-12.47, DAA-6.96), 2.0ml/ha (DBA-13.37, DAA-6.17) 2.5ml/ha (DBA-12.53, DAA-4.36) and 3.0 ml/ha (DBA-10.98, DAA-2.09) ranked in descending order.

Table I : Coccinellid numbers in vegetative and reproductive phases of paddy under different concentrations of *Bt.*

(A) Vegetative phase

Treatment	Dose Kg/ha	1st application*				2nd application			
		DBA		DAA		DBA		DAA	
		A	L	A	L	A	L	A	L
Bacillus thuringiensis	1.0	112.09	11.31	104.12	6.84	94.14	29.56	88.12	22.84
	1.5	95.12	12.47	87.31	6.96	91.02	22.44	84.31	15.96
	2.0	97.02	13.37	85.14	6.17	86.17	23.87	79.14	15.07
	2.5	86.21	12.53	72.09	4.36	82.09	22.33	75.09	11.96
	3.0	99.07	10.98	81.13	2.09	79.03	21.98	72.13	9.58
Malathion	0.1	104.03	11.87	89.13	5.76	95.07	21.67	85.13	12.79
	0.25	95.07	12.47	79.21	4.56	85.05	22.47	77.21	10.42
	0.50	103.12	12.69	89.33	3.56	93.11	22.61	85.33	9.96
	0.75	97.03	13.76	78.14	2.86	87.14	23.76	81.14	9.86
	1.00	118.06	13.39	92.87	1.32	98.13	23.34	92.87	9.12
Water	500 L	128.11	14.71	122.21	13.09	128.11	24.71	119.21	22.89
CD		22.27	0.89	23.89	1.09	18.21	1.02	11.07	1.21

(B) Reproductive phase

Treatment	Dose Kg/ha	1st application*		2nd application	
		DBA	DAA	DBA	DAA
Bacillus thuringiensis	1.0	10.14	10.09	13.14	13.09
	1.5	10.45	10.27	14.43	14.32
	2.0	11.24	10.98	14.78	14.61
	2.5	16.45	15.97	14.21	14.01
	3.0	12.34	11.91	15.04	14.76
Malathion	0.15	13.41	5.45	15.62	7.12
	0.25	11.62	4.21	15.32	6.45
	0.50	11.8	3.78	15.43	5.63
	0.75	11.95	3.45	14.98	4.77
	1.00	12.42	2.01	16.02	4.45
Water	500 L	11.63	10.23	15.22	13.85
CD		0.12	0.09	0.07	0.11

A: adult, L : larvae numbers, DBA : Date before application, DAA : Date after application;
* : Mean of 2005-2008 data.

When formulations applied second time at 70-75 days after transplantation, substantially reduced both larvae and adults. For all the treated plots the DBA of adult was significantly lower than at the vegetative phase. Further DAA of all the plots was higher showing that the extent of population suppression in tillering phase was considerably lesser than at vegetative phase. However, like the first phase application, the least number of leaf folder adults (92.87) and larvae (1.32 individuals/4m^2) was noted when the field was treated with 1.0 kg malathion/ha. Least population repression efficacy with highest number of adults (104.12 adult catch number) and larvae (6.84 individuals/4m^2) was noted when *Bt* formulation was applied @ 1.0 kg/ha. First application of all the doses was found more efficacious than second application (Table 1). During the first application the relative larval numbers suppression efficacy of malathion for the dose 0.15,0.25,0.50,0.75 and 1.00 kg/ha was 51.47%,63.43%,71.95% and 79.22%, respectively. For the second application of the same dose corresponding values were 40.98%, 53.63%, 55.95%, 58.50% and 60.93%, respectively. When *Bt* formulation was applied for the first time at 1.0, 1.5, 2.0, 2.5 and 3.0 kg/ha, respectively the consequent pest suppression values were 39.52%, 44.19%, 53.85% and 65.20%, 80.97%, respectively. During the second application of the same dose the recorded range were 22.73%, 28.88%, 36.87% and 46.44% and 56.41%, respectively (Table II).

Beetle population : Before insecticide application for the vegetative phase *M. sexmaculatus* numbers was on an average 12.67 adults/4m^2. Both formulations suppressed the beetle population. Reduction was comparatively higher for malathion than *Bt* formulation. Application of all the doses of *Bt* formulation imparted negligible lethality on beetle population. But, higher the dose of malathion, lesser was beetle abundance. In the pre-treated field the average number of beetles during the second application was comparatively higher than first application. But different doses of all the formulations exerted less lethality on the beetles.

Table II : Population suppression of leaf folder different populations in relation to control.

Treatment	Dose Kg/ha	Population suppression (%)*						Yield (q/ha)
		Leaf folder				Beetles		
		1st application		2nd application		1st application	2nd application	
		A	L	A	L			
Bacillus thuringiensis	1.0	7.11	39.52	6.39	22.73	0.49	0.38	21.65
	1.5	8.21	44.19	7.37	28.88	1.72	0.76	24.24
	2.0	12.24	53.85	8.16	36.87	2.31	1.15	26.43
	2.5	16.38	65.20	8.53	46.44	2.92	1.41	29.02
	3.0	18.11	80.97	8.73	56.41	3.48	1.86	32.87
Malathion	0.15	14.32	51.47	10.46	40.98	59.36	54.42	24.66
	0.25	16.68	63.43	9.22	53.63	63.77	57.90	26.82
	0.50	13.37	71.95	8.36	55.95	67.97	63.51	28.16
	0.75	19.47	79.22	6.89	58.50	71.13	68.16	30.18
	1.00	21.34	90.14	5.36	60.93	83.82	72.22	33.27
Water	500 L	4.61	11.01	6.95	7.37	12.04	9.00	19..72

A : Adult; L : Larvae numbers; * : Mean : 2005-2008 data.

For the first application, suppression by *Bt* formulation was 0.49% for 1.0, 1.72% for 1.50, 2.31% for 2.0%, 2.92% for 2.5 kg/ha and 3.48% for 3.0ml. For the second phase, *Bt* population suppression was 0.38% for 1.0kg, 0.76% for 1.50kg, 1.15% for 2.0kg, 1.41% for 2.5 kg and 1.86% for 3.0kg. Average population reduction in the field treated with malathion was 59.36% for 0.15kg, 63.77% for 0.25kg, 67.97% for 0.75kg, 71.13% for 0.75kg and 83.82% for 1.00kg, respectively. For the second application, the values were 54.42% for 0.15kg, 57.90% for 0.25kg, 63.51% for 0.50kg, 68.16% for 0.75kg and 72.22% for 1.00kg, respectively.

Rice yields : Maximum (33.27 q/ha) and minimum (19.72 q/ha) yield was registered from field treated with malathion1.0 kg/ha and control, respectively. Yield obtained (32.87 q/ha) from Bt. formulation @3.0 kg/ha differed nonsignificantly from malathion of @ 1.0 kg/ha. There is no reported post application toxicity effect of *Bt* formulation. So it can be opted as an alternative of malathion application (Table II).

Pest-natural enemy equation : A series of equations have been generated to visualize the field dynamics of both leaf folder adult and larvae and beetle population. Equation elaborates that after pesticide application the equilibrium changed to a great extent. Effect was more profound during the first phase of application than the second phase. In all the cases both leaf folder and beetle population was reduced after spray application. All the equations were elaborated with a negative constant and a variable value. Constant value remains unchanged in consideration of a particular relation and indicates the minimum impact when individuals were zero during post application counting. As the damage to the paddy plant is mainly due to the larval attack, a relation between the larval numbers and the grain loss was generated. Equation elaborates that per unit increase of larval number/4m^2 causes grain loss by 0.8710 factor.

During first application:

$LF(A_a) = -15.614+0.9994\,LF(A_b)$ — r^2: 58.97

$LF(L_a) = -9.665+1.9562\,LF(L_b)$ — r^2: 84.21

$LBB(A_a) = -7.559+3.7906\,LBB(A_b)$ — r^2: 89.12

During second application:

$LF(A_a) = -13.048+0.6418\,LF(A_b)$ — r^2: 59.60

$LF(L_a) = -6.428+1.548\,LF(L_b)$ — r^2: 64.21

$LBB(L_a) = -2.343-2.488\,LBB(A_b)$ — r^2: 89.12

Extent of loss = 3.865 + 0.8710 [number of larval individuals/4m^2], r^2: 93.92

LF: leaf folder, LBB: lady bird beetle, (A_b): adult population before application, (A_a): adult population after application.

Observations on the effect of bio-pesticide formulation on both larvae and adults of paddy leaf folder in relation to natural enemy population in the northern parts of West Bengal are not documented. During the first phase of pesticide application at about 55 DAT, the paddy plant was at early growth stage with low tiller number. The larvae were exposed to spray formulation resulting in high mortality. As *Bt* has little or no effect on the adult population, so no noteworthy impact of early light trapping was noted. Little variation of moth number before and after trapping was probably due to the mechanical disturbance to the canopy during spray application. During second application the plant was at more advanced growth stage which endures compact canopy structure. Applied formulation was mostly restricted to the upper part of the canopy. So the larvae can easily get rid of from the pesticide contact. Further, 'pesticide shocked' larvae can easily hide within the canopy disallowing predation. Thus the efficacy of application in tillering phase was comparatively low. Low number of adults during tillering phase was perhaps due to the destruction of the early larval brood by pesticides.

No significant effect of *Bt* formulation on beetle population was noted at both the vegetative and tilering phases of paddy growth. Coccinellid beetle population was prey density dependent (Thomson, 1951) and was also highly prey specific (Obata, 1986). The beetle populations in paddy field gradually build up in synchrony with the leaf folder abundance. In first pesticide application the beetle number was low as the leaf folder population was meager. During second application, on an average, beetle was much lower than the earlier phase. High number of beetle population was noted in the nearby paddy field. This may be due to the dispersal of the beetle population to the adjoining field area as leaf folder population declined in the plots under observation. In the control plot, the pest population persisted in the field for four months and a flush of leaves appeared on the plants in-between the larval phases of the two successive generations. The plants in control plot dried about 25-45 days earlier than those in the treated plot.

In the southern parts of India, Kandibane (2010) experimented with four specific concentrations of *Bt* formulation and obtained some what similar results. The present results are comparable with the findings of Singh *et al.* (2000) who elucidated that high concentration of *B. thuringiensis* reduced food consumption by lepidopteran larvae and enhanced significantly its mortality. Singh *et al.* (2000) noted that in laboratory formulation of *B.thuringiensis* Berliner based bio-pesticides against the diamondback moth, *Plutella xylostella* (Linnaeus). Upadhyay *et al* .(1975) stated that the varietal susceptibility of rice leaf folder, *C. medinalis* in Gujarat and documented that extent of damage corroborates to the pest abundance. Ghosh (1999) documented that *Bt* was effective against lepipdopteran pest on of brinjal in *terai* region of West Bengal. Zaz *et al.* (1983) also noted that *Bt* formulation was effective against *Spodoptera litura* (Bosid) causing more than 80% mortality, both in laboratory and field when applied with endosulfan.

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