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RESEARCH ARTICLE

COMPARATIVE EFFICACY OF SOME NEWER INSECTICIDES AGAINST RICE LEAF FOLDER (*CNAPHALOCROSIS MEDINALIS* GUEN.) AND THEIR EFFECTS ON NATURAL ENEMIES IN RICE ECOSYSTEMSanjida Shaki^a, Md. Niaz Morshed^b, Naznin Sultana^a, Gopal Das^{a*}^aDepartment of Entomology, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh.^bAdaptive Research Division, Bangladesh Rice Research Institute (BRRI), Gazipur-1701, Bangladesh.*Corresponding author email: gopal_entom@yahoo.com

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ABSTRACT

In the present study, some new generation insecticides were evaluated against rice leaf folder (RFL) infestation and their toxic effects were also observed on some natural enemies in the rice ecosystem. Data were collected on percent hill infestation, percent leaf infestation, number of moths/sweep, grain yield (t/ha) and abundances of natural enemies/m². Results clearly showed that Serput (Bifenthrin) 2.5EC @ 2.0 ml/L water resulted in the greatest reduction of RFL and increased the grain yield compared to the untreated control which was followed by Envoy (Fipronil) 50SC @ 1.0 ml/L, Libsen (Spinosad) 45SC @ 0.40 ml/L, Acemida (Acephate + Imidacloprid) 51.8WDG @ 1.0 g/L, Suspend (Emamectin benzoate) 5SG @ 1.0 g/L, Combi-DT (Deltamethrin + Triazophos) 36EC @ 0.50 ml/L and Altima plus (Thiamethoxam + Emamectin benzoate) 40WG @ 0.20 g/L respectively. To know the toxic effect of selected insecticides, abundances (number/m²) of some natural enemies were counted at 7 days after given each spray. It was found that the highest numbers of natural enemies (m²) were recorded in the untreated control plot. In all field trials, the harmful effects of the seven insecticides were in the following rank order (least harmful to most harmful): Suspend 5SG, Serput 2.5EC, Envoy 50SC, Libsen 45SC, Acemida 51.8WDG, Altima plus 40WG and Combi-DT 36EC. Based on the reduction in rice leaf folder infestation, increase in grain yield and compatibility with natural enemies, Serput 2.5EC @ 2.0 ml/L proved to be the best among all the selected insecticides.

KEYWORDS

Insecticide, infestation, rice leaf folder, natural enemy, grain yield

1. INTRODUCTION

Rice (*Oryza sativa* L.) is one of the world's most important grain crop, providing staple food for nearly half of the global population (Heinrichs et al., 2017). Bangladesh with its topography, fertile soil, abundant water and subtropical climate constitutes a favorable environment for the rice plant (Morshed et al., 2020). Among the leading rice growing countries, Bangladesh occupies the third position in acreage and the fourth position in production (BRRI, 2018). About 84.67% of the total cropping area of Bangladesh is used for rice production, with an annual production of 36.27 million metric tons from 11.62 million hectares of land (BBS, 2019). The per capita consumption of rice is more than 150 kg per annum places it among the highest of the rice consuming Nations (BBS, 2009). It's occupying about 70 percent of the cultivated area, 78 percent of the irrigated area, 71 percent of the caloric intake as dominates Bangladesh agriculture and the economy (Hassan and Bakshi, 2005). Demand for rice is increasing with the increase in population and is expected to remain high in Bangladesh in the future (Virmani et al., 1997).

The rice crop can be attacked by more than 100 species of insects and 20 of them can cause serious economic loss (Heinrichs et al., 2017). In Bangladesh, 175 species of insect pests have been recorded on rice (Mustafiz et al., 2007). The pest problem is one of the major constraints

for achieving higher production in agriculture crops. Bangladesh loses about 30% of its crops due to pests and diseases each year (BBS, 2019). In producing more rice, farmers are using modern varieties, fertilizers, pesticides, water and other technologies intensively which have eventually changed the ecology and escalated pest proliferation (Parvin, 2010). Among various constraints for good rice production, the infestation of different insect species is very important. During the last four decades, rice production have been transformed from a low input, traditional system to an intensive, high-yielding system relying on high inputs which has strongly influenced the incidence and abundance of rice pests. Insect-pests are the major constraints in enhancing rice productivity, besides diseases and weeds (Behura et al., 2011). Rice crop is highly sensitive for several insect pests and rice leaf folder or rice leaf roller (RLF), *Cnaphalocrossis medinalis* (Guen.) has been evolved as a serious constraint for rice production in Bangladesh (Singh et al., 2017).

Earlier it was considered as a minor pest and currently has gained the status of a major pest with the wide spread of high-yielding rice varieties and the accompanying changes in cultural practices (Shah et al., 2008; Nanda et al., 2000). It is an important pest in almost all of the rice growing countries of Asia. Reports show that severe infestation of this pest leads to as high as 23.3% leaf damage and yield loss caused by leaf folder reported to the extent of 5 to 25 Percent (Kulagad et al., 2011). RLF is a lepidopteran insect pest and caterpillar is the only damaging stage. The

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young larvae feed on open leaves but later feed inside the rolled leaf formed by folding the leaf longitudinally with a sticky substance. The larvae scrape the green tissues of the leaves and cause scorching and leaf drying. Each larva is capable of destroying several leaves by its feeding.

This activity disturbs the photosynthesis and plant growth and ultimately yield is reduced. Insecticides offer a practical method of insect control. Use of insecticides has a positive impact on rice yields and insecticides are often highly effective, fast-acting, convenient and economical, making them the most powerful tools in pest management (Iqbal et al., 2000; Wakil et al., 2001; Misra and Panda, 2004; Dhuyo and Soomro, 2007; Bhutto and Soomro, 2010; Chakraborty, 2012; Abro et al., 2013). But injudicious and indiscriminate use of insecticides in many cases causes or accelerates insecticide resistance, pest resurgence, secondary pest outbreak, environmental contamination, persistent residual toxicity and destruction of populations of beneficial insects. In addition to pests, many beneficial insects are present in rice fields (Satpathi et al., 2005; Wakil et al., 2001).

These beneficial faunas, collectively known as natural enemies, are categorized as predators or parasites. Conservation of natural enemies in the rice-ecosystem should be of the prime strategy for sustainable control of rice leaf folder. Predators, parasitoids and entomopathogens conservation is an important component of modern integrated pest management (IPM). Pesticides that are less harmful to natural enemies can also be effective tools for IPM. The use of selective insecticides that are effective against RLF and less toxic to beneficial fauna is of prime importance for managing the pest. Keeping these points in view the following experiment is mainly aimed to evaluate the efficacy of different newer insecticides against rice leaf folder and their toxic effects on the population densities of beneficial fauna in the rice field.

2. MATERIALS AND METHODS

2.1 Soil and climate

The study was conducted at the Entomology Field Laboratory, Bangladesh Agricultural University (BAU), Mymensingh, Bangladesh during Aman season from July to December 2016. The site of the study located at 24.75° N latitude and 90.5° E longitudes at a mean elevation of 7.9 to 9.1 m above the sea level. The soil of the experimental area was silty loam in texture belonging to the old Brahmaputra Flood Plain under the Agro-ecological zone 9. The climate is subtropical, characterized by heavy rainfall during the month of April to September and scanty rainfall from October to March.

2.2 Raisings of seedlings

Seedling nurseries were prepared by puddling the soil. Weeds and stubbles were removed from the field by hand. Seeds of rice variety BR11 were soaked in water in a bucket for 24 h and then taken out of the water and kept in gunny bags. After 72 hours, sprouted seeds were sown in the wet nursery bed by hand.

2.3 Experimental field preparation

Experimental plots were prepared by puddling, cleaning and then applied recommended doses N-P-K fertilizers (120:60:60 kg/ha) in the form of urea, triple super phosphate and muriate of potash. After that 30-35 days, old seedlings were transplanted in the prepared experimental plots in the mid-August. The experiment was laid out in a randomized complete block design (RCBD) with eight treatments and three replications for each treatment. The entire experimental area was measured as 13.2 m × 22.7 m which was divided into three equal blocks. Each block was divided into eight plots. Thus, there were 24 experimental plots and finally, treatments were allotted in the experimental plots. Each plot size was 10.0 m² (4.0 m × 2.5 m). Borders between plots were 0.3 m to facilitate cultural operations and insecticide applications.

2.4 Treatments specification and application

Eight treatments are given in table-1 with their doses and other specifications. Calculated quantities of selected insecticides and combinations were measured with the help of micropipettes and mixed with required quantities of water to get the desired dilution and sprayed with a hand compression knapsack sprayer. After every application of each of the treatments, the sprayer was thoroughly washed and rinsed twice with water and used for further application. All the selected insecticides were applied with their recommended doses. A total of three sprays were given at 7 days interval and data were collected at 1, 3 and 7 days after treatment (DAT) application.

2.5 Data collection

Data were collected on percent hill infestation, leaf infestation, number of moths/sweep, grain yield (t/ha) and abundances of natural enemies/m². To get percent hill infestation, a total number of infested hills were counted per plot and then divided by total number of hills and finally multiplied by 100. In the case of leaf infestation, a total number of rolled or infested leaves per plant were counted and then divided by total number of leaves and finally multiplied by 100. To know the severity of the infestation, moth were counted in experimental plots. In this case, five sweepings were done consecutively at a single point using the sweeping net. This procedure was continued in 10 different points of the experimental plots. After that the total number of moths were counted from 50 sweepings (5 × 10).

Finally, the total number of moths were divided by total number of sweeps and expressed as moths/sweep. Moreover, after full ripen, rice grains were harvested from the experimental plots. Then harvested grains were sun-dried and then cleaned carefully to remove the straw and other debris. Freshly harvested grains contained approximately 22 to 23% moisture whereas normally dry grains have moisture content of 12% to 14%, therefore, the yield was adjusted to 14% moisture. Abundances of natural enemies were observed at 7 days after spraying each insecticide. Natural enemies like ladybird beetle, carabid beetle and lynx spiders were counted visually from the whole 10 m² plot and then finally expressed as number/m². Proper care was taken to not disturb natural enemies while observations were being made. The natural enemies observed in experimental plots are listed in table 2.

2.6 Statistical analysis

The recorded data were compiled and tabulated for statistical analysis. Analysis of variance was done with the help of computer package Statistics 10. The mean differences among the treatments were adjudged as per tested with Duncan's Multiple Range Test (DMRT) and Least Significant Difference (LSD) test, when necessary.

Table 1: List of insecticides used in this experiment during Aman, 2016

Treatment	Trade name	Active ingredient	Doses
T ₁	Suspend SSG	Emamectin Benzoate	1.0 g/L
T ₂	Libsen 45SC	Spinosad	0.40 ml/L
T ₃	Altima plus 40WG	Thiamethoxa+ Emamectin Benzoate	0.20 g/L
T ₄	Acemida 51.8WDG	Acephate +Emidacloprid	1.0 g/L
T ₅	Combi DT 36EC	Deltramethrin + Triazophos	0.50 ml/L
T ₆	Serput 2. 5EC	Bifenthrin	2 ml/L
T ₇	Envoy 50SC	Fipronil	1 ml/L
T ₈	Untreated Control	-	-

Table 2: List of natural enemies recorded in rice field.

Category	Common name	Scientific name	Family	Order
Predator	Lady bird beetle	<i>Micraspis discolor</i>	Coccinellidae	Coleoptera
	Lynx spider	<i>Oxyopes salticus</i>	Oxyopidae	Araneae
	Carabid beetle	<i>Ophionea indica</i>	Carabidae	Coleoptera

3. RESULTS

3.1 Effects of different insecticides on hill infestation (%) at different DAT after 1st, 2nd and 3rd spray

Effect of different selected insecticides on the reduction of hill infestation at different days after treatment (DAT) has shown in table 3. The result clearly showed that the selected insecticides had significant effect on the reduction of hill infestation compared to untreated control ($P < 0.05$). The highest hill infestation was recorded from untreated control plot and that was 8.14%. Data clearly showed that all the selected insecticides had

significant effect on the reduction of hill infestation. Significant reduction of hill infestation was found at 7 days after given 1st spray and this infestation level was gradually reduced with increasing time and the lowest infestation was found at 7 DAT after given 3rd spray. Among the insecticides, Serput 2.5EC showed the best efficacy which reduced hill infestation at the level of 3.97% at 7 DAT after 1st spray. This result was followed by Envoy 50EC (4.55%), Libsen 45SC (4.82%), Acemida 51.8WDG (4.89%), Suspend 5SG (4.95%), Altima plus 40WG (6.09%), and Combi-DT 36EC (7.05%) respectively. Only 1.14% infested hill was found in Serput 2.5EC treated plot after given 3rd spray (at 7 DAT) while 22.97% infested hill was recorded when plants were kept untreated. The 2nd best insecticide was Envoy 50EC that reduced hill infestation to 1.51% after given 3rd spray (7 DAT).

3.2 Effects of different insecticides on leaf infestation (%) at different DAT after 1st, 2nd and 3rd spray

Effect of different selected insecticides on the reduction of leaf infestation

Table 3: Effects of different insecticides on hill infestation (%) at different DAT after 1 st , 2 nd and 3 rd spray during Aman season at BAU, 2016										
Treatments	BTA	% Hill infestation at different DAT after 1 st spray			% Hill infestation at different DAT after 2 nd spray			% Hill infestation at different DAT after 3 rd spray		
		1DAT	3DAT	7DAT	1DAT	3DAT	7DAT	1DAT	3DAT	7DAT
T ₁	5.59	5.67	5.90 bc	4.95 de	4.53 cd	4.19 c	4.08 c	3.76 c	3.52 d	3.18 d
T ₂	5.86	6.15	6.63 ab	4.82 de	3.6 de	3.37 c	2.45 de	2.14 c	1.77 f	1.76 de
T ₃	5.81	6.31	6.39 ab	6.09 c	5.97bc	7.75 b	11.74 b	11.74 b	12.11 b	13.40 b
T ₄	5.37	5.77	5.37 c	4.89 d	4.58 cd	4.04 c	3.45 cd	3.56 c	3.25 de	2.70 dc
T ₅	6.15	6.53	6.57 ab	7.05 b	7.14 b	8.30 b	11.49b	11.48 b	8.30 c	11.48 c
T ₆	6.02	6.28	6.49 ab	3.97 e	2.89 e	1.96 d	1.89 e	1.78 c	1.26 f	1.14 e
T ₇	5.48	5.98	6.15 ab	4.55 de	3.63 de	3.15 cd	2.40de	2.14 c	1.89 ef	1.51 e
T ₈	5.85	6.76	6.99 a	8.14 a	10.41 a	13.41 a	15.79 a	18.49 a	20.37 a	22.97 a
LSD _{0.05}	0.87	1.09	0.94	0.70	1.48	1.34	1.27	2.02	1.40	1.58
CV (%)	8.69	10.11	8.51	7.28	15.84	13.26	10.91	16.77	12.25	12.44

[T₁: Suspend 5SG @ 1.0 g/L, T₂: Libsen 45SC @ 0.40 ml/L, T₃: Altima plus 40WG @ 0.20 g/L, T₄:Acemida 51.8WDG @ 1.0 g/L, T₅:Combi DT 36EC @ 0.50 ml/L, T₆:Serput 2.5EC @ 2.0 ml/L, T₇:Envoy 50SC@ 1.0 ml/L, T₈: Control. BTA: Before Treatment Application, LS: Level of Significance].

Table 4: Effects of different insecticides on leaf infestation (%) at different DAT after 1 st , 2 nd and 3 rd spray during Aman season at BAU, 2016.										
Treatments	BTA	% Hill infestation at different DAT after 1 st spray			% Hill infestation at different DAT after 2 nd spray			% Hill infestation at different DAT after 3 rd spray		
		1DAT	3DAT	7DAT	1DAT	3DAT	7DAT	1DAT	3DAT	7DAT
T ₁	4.98	5.35 c	6.99 d	6.79 d	3.95d	5.77 d	4.38 c	2.81 c	2.84 c	3.37 d
T ₂	5.21	5.58 c	5.96 d	4.57 d	4.14 d	4.00 d	3.31 c	2.62 c	2.19c	2.29 d
T ₃	5.78	6.16 ab	7.02bc	7.71 c	7.07 c	9.44 c	11.59 b	11.82 b	12.84 b	14.77 c
T ₄	5.03	5.57 c	6.07 bc	6.70 b	4.03 d	4.56 d	3.79 c	3.09 c	2.96 c	2.70 d
T ₅	6.13	6.53ab	6.57 b	7.02 b	8.11 b	10.63 b	10.81 b	15.81 a	16.78 a	13.11 b
T ₆	6.36	6.14 ab	4.63 cd	4.40 d	3.89 d	3.24 d	2.85 c	2.54 c	2.18 c	1.90 d
T ₇	5.48	5.81 bc	5.10 cd	4.52 d	4.49 d	3.85 d	3.00 c	2.83 c	2.36 c	2.28 d
T ₈	5.67	6.82 a	7.52 a	10.23 a	9.25 a	13.03 a	14.77 a	14.77 a	17.10 a	24.97 a
LSD _{0.05}	0.69	0.89	0.77	0.96	0.96	1.316	1.85	1.75	1.47	1.42
CV (%)	7.08	8.56	7.55	9.64	9.81	12.06	15.57	14.27	11.40	9.57

[T₁: Suspend 5SG @ 1.0 g/L, T₂: Libsen 45SC @ 0.40 ml/L, T₃: Altima plus 40WG @ 0.20 g/L, T₄:Acemida 51.8WDG @ 1.0 g/L, T₅:Combi DT 36EC @ 0.50 ml/L, T₆:Serput 2.5EC @ 2.0 ml/L, T₇:Envoy 50SC@ 1.0 ml/L, T₈: Control. BTA: Before Treatment Application, LS: Level of Significance].

3.3 Effect of different insecticides on grain yield (t/ha) of rice

All the selected insecticides significantly increased the grain yield (t/ha) compared to untreated control (Figure 1). In case of control condition, the grain yield was 3.1 t/ha. This yield was increased to 4.67 t/ha when rice plants were treated with Serput 2.5EC and this is the highest yield among the treatments. It was also observed that the application of Serput 2.5EC has increased 50.64% grain yield over control (Fig. 2). This result was closely followed by Envoy 50 SC (4.61 t/ha), Libsen 45SC (4.55 t/ha) and Acemida 51.8WDG (4.5 t/ha) which was statistically similar with Serput 2.5EC. On the other hand, 48.70, 46.77 and 45.16% grain yield can be increased if rice plants are treated with Envoy 50 SC, Libsen 45SC and Acemida 51.8WDG respectively (Figure 2). Suspend 5SG had moderate effect on the grain yield (4.00 t/ha). Combi-DT 36EC (3.5a t/ha) and Altima plus (3.45 t/ha) showed the non-significant effect on grain yield compared to control (3.1 t/ha).

at different days after treatment (DAT) application has shown in table 4. The result showed that the selected insecticides had significant effect on the reduction of leaf infestation compared to untreated control (P<0.05). In case of control condition, leaf infestations were gradually increased to 10.23%, 14.77% and 24.97% after 1st, 2nd and 3rd week of observations respectively. But this infestation level significantly reduced when rice plants were treated with different new generation insecticides. Among the insecticides, Serput 2.5EC showed the best efficacy which reduced leaf infestation at the level of 4.40% at 7 DAT after 1st spray. This result was followed by Envoy 50EC (4.52%), Libsen 45SC (4.57%), Acemida 51.8WDG (6.70%), Suspend 5SG (6.79%), Combi-DT 36EC (7.02%) and Altima plus 40WG (7.71%) respectively after 1st spray. For all insecticides, this reduction trend further seen after given 2nd spray and least reduction was found after 3rd spray. Like as hill infestation data, Serput 2.5EC was found best that was closely followed by Envoy 50EC for the reduction of leaf infestation.

3.4 Effects of different insecticides on the abundances (number/m²) natural enemies in rice eco-system

Toxic effects of selected insecticides were evaluated by counting the abundances of different natural enemies like ladybird beetle, carabid beetle, lynx spiders etc. in the rice field and results were shown in table 5. In all cases, the highest numbers of natural enemies (m²) were recorded in the untreated control plot. But these numbers were significantly varied when rice plants were treated with different newer insecticides except Suspend 5 SG (P<0.05). Suspend 5SG (a bacterial fermented biopesticide) was found to be safe for all the natural enemies as abundances were not varied significantly. Among other treatments, Envoy 50SC, Serput 2.5EC, Combi-DT 36EC etc. were found to be moderately toxic for ladybird beetle, carabid beetle and lynx spiders as their numbers were varied significantly compared to control.

Table 5: Effects of different insecticides on the abundances (number/m²) of natural enemies in rice eco-system during Aman season at BAU, 2016

Treatments	Abundance of ladybird beetle/m ²			Abundance of Carabid beetle/m ²			Abundance of lynx spider /m ²		
	7 Days after 1 st spray	7 Days after 2 nd spray	7 Days after 3 rd spray	7 Days after 1 st spray	7 Days after 2 nd spray	7 Days after 3 rd spray	7 Days after 1 st spray	7 Days after 2 nd spray	7 Days after 3 rd spray
T ₁	9.33 a	12.67 b	11.60 a	10.67 b	11.00 b	13.11a	4.67 ab	4.67 ab	6.67 a
T ₂	9.33 a	7.67 b	7.00 b	7.67 bc	6.33 de	10.67 d	4.67 ab	4.33 b	5.33 c
T ₃	7.67 bc	6.33 bc	8.00 b	7.33 d	9.67 c	10.67 d	4.67 ab	3.33 b	5.67 c
T ₄	7.33 c	6.00 bc	7.67 b	8.00 cd	7.00 de	8.00 c	5.33 ab	4.33 b	4.62 c
T ₅	7.67 bc	4.67 c	7.33 bc	8.33 cd	7.33 cde	8.03 c	4.67 ab	3.67 b	4.33 c
T ₆	7.00 c	6.67 c	7.67 c	8.33 cd	8.33 c	7.69 c	4.33 b	3.67 b	4.33 bc
T ₇	7.00 c	6.00 bc	6.69 bc	9.33 bc	7.67 cd	8.33 c	5.33 ab	4.33 b	3.67 c
T ₈	9.00 ab	11.33 a	11.67 a	13.33 a	12.00 a	14.03a	5.67 a	6.00 a	7.00 a
LSD _{0.05}	1.53	2.26	1.73	1.93	2.00	1.89	1.05	1.45	1.90
CV (%)	10.90	17.44	14.73	12.05	13.57	14.95	12.15	19.28	25.12

[T₁: Suspend 5SG @ 1.0 g/L, T₂: Libsen 45SC @ 0.40 ml/L, T₃: Altima plus 40WG @ 0.20 g/L, T₄:Acemida 51.8WDG @ 1.0 g/L, T₅:Combi-DT 36EC @ 0.50 ml/L, T₆:Serput 2.5EC @ 2.0 ml/L, T₇:Envoy 50SC@ 1.0 ml/L, T₈: Control. LS: Level of Significance].

Figure 1: Grain yield (t/ha) of BR11 rice variety following treated with different insecticides. Similar letters on each bar indicates insignificant difference among each treatment at 5% level of probability.

[T₁:Serput 2.5EC @ 2.0 ml/L, T₂: Envoy 50SC@ 1.0 ml/L, T₃:Libsen 45SC @ 0.40 ml/L,T₄:Acemida 51.8WDG @ 1.0 g/L, T₅:Suspend 5SG @ 1.0 g/L, T₆:Combi-DT 36EC @ 0.50 ml/L, T₇: Altima plus 40WG @ 0.20 g/L, T₈: Control. Level of Significance, P<0.05].

Figure 2: Yield increase (%) over control following treated with different insecticides.

[T₁:Serput 2.5EC @ 2.0 ml/L, T₂: Envoy 50SC@ 1.0 ml/L, T₃:Libsen 45SC @ 0.40 ml/L,T₄:Acemida 51.8WDG @ 1.0 g/L, T₅: Suspend 5SG @ 1.0 g/L, T₆:Combi DT 36EC @ 0.50 ml/L, T₇: Altima plus 40WG @ 0.20 g/L].

4. DISCUSSION

Among the seven insecticides, Serput 2.5EC found to be the best considering all the parameters studied viz. leaf and hill infestation, abundances of rice leaf folder moths, grain yield (t/ha) etc. This result was closely followed by Envoy 50SC, Libsen 45SC and Acemida 51.8WDG but differences were insignificant with Serput 2.5EC. Combi-DT 36EC and Altima plus 40WG showed the least efficacy compared to other

insecticides. Except Suspend 5SG, all the insecticides were found to be moderate to highly toxic to different natural enemies like ladybird beetle, carabid beetle and lynx spiders. The present findings of newer insecticides against rice leaf folder is in conformity with the results of Panda *et al.* (2004) and Sara *et al.* (2006) who reported that Fipronil 50SC @1000ml/ha was found best among several insecticides in reducing rice leaf folder infestation followed by Triazophos @750 ml/ha. In our present study, Serput 2.5EC (Bifenthrin) showed the best efficacy among seven new insecticides that was closely followed by Envoy 50SC (Fipronil) and had an insignificant difference with Bifenthrin.

Similar results were also found from the studies reported that the infestation of rice leaf folder was effectively checked by Deltamethrin and Acephate (Sharma *et al.*, 2018; Rao *et al.*, 1999). Our present findings clearly showed that the application of Combi DT 36EC (Deltamethrin) and Acemida 51.8WDG (Acephate) significantly reduced the hill and leaf infestation compared to untreated control. Grain yield (t/ha) was significantly increased when rice plants were treated with different new insecticides but the highest was found from Bifenthrin treated plot that was closely and insignificantly followed by Fipronil, Spinosad and Acephate treated plots respectively. These findings are in agreement with the findings reported that Fipronil, Spinosad and Acephate provided the highest grain yield compared to untreated control (Mahal *et al.*, 2008; Kakde *et al.*, 2019). A study reported that Suspend 5SG is comparatively safe for natural enemies while Spinosad (Libsen 45SC) provided moderate toxicity to natural enemies and similar results were found from our current study (Islam and Das, 2017).

5. CONCLUSION

Considering the efficacy of selected insecticides against the infestation caused by rice leaf folder as well as grain yield, the insecticides can be categorized as follows: Serput 2.5EC>Envoy 50SC>Libsen 45SC>Acemida 51.8WDG> Suspend 5SG>Combi-DT 36EC> Altima plus. In contrast with good efficacy in reducing infestation as well as increasing grain yield, Serput 2.5EC, Envoy 50SC, Libsen 45SC and Acemida 51.8WDG had moderate toxic effects on natural enemies. On the other hand, Suspend 5SG (Emamectin Benzoate) was found to be the most safe among the tested insecticides in terms of conservation of natural enemies in rice-ecosystem but almost 20% less yield was found from Suspend treated plots compared to Serput 2.5EC or Envoy 50SC. Finally, it can be concluded that on the basis of reduction in rice leaf folder infestation, increase in grain yield and compatibility with natural enemies, Serput 2.5EC @ 2.0 ml/L or Envoy 50SC may be recommended in controlling rice leaf folder in field condition.

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