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Relative efficacy of selected insecticides to check rice yellow stem borer *Scirpophaga incertulas* (Walker) (Lepidoptera, Crambidae) at Hooghly, West Bengal, India

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ABSTRACT: Rice yellow stem borer (YSB), *Scirpophaga incertulas* Walker is one of the major destructive insect pests rendering huge crop damage. Nine insecticide formulations, either solely or in combinations were applied in the rice (*var*. *Lalat*) field for two consecutive seasons during 2019-2021 to assess their efficacy to suppress YSB population and to stabilize yield. The combination of flubendiamide (480 SC) @80 g a.s.ha^{-1} on 45 DAT and deltamethrin (1%) + triazophos (35%) @300 g a.i.ha^{-1} on 80 DAT, treated the rice crop, recorded minimum YSB incidence (4.14 egg clutches, 4.78 larvae and adults 3.17/5 hills) and damage (2.12% dead hearts (DH) and 1.47 white ear (WE). This treatment gave significantly higher grain yield (3.63 t ha^{-1}), an increase of 45.78 per cent over control. The incidence (12.21 egg clutches, 14.12 larvae and adults 11.76/5 hills) and crop damage (14.83 DH and 11.10% WE) was maximum in the treatment, neem seed kernel extract (5%) @50 ml L^{-1} at 15- day intervals after transplanting and neem leaf extract (5%) @7 ml a.s. L^{-1} on 35, 50, 65 and 80 DAT, resulting in minimum yield (2.88 t ha^{-1}). Other combinations of insecticide application gave variable results. © 2022 Association for Advancement of Entomology

KEY WORDS: Grain, yield, damage, population, flubendiamide, deltamethrin, triazophos

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important cereal crop and primary energy source for two third of the world's population (Khan *et al.*, 2015). India ranks first in area of cultivation and second in rice production in the world (DES, Govt. of India, 2016). Annually, about 30 per cent pre-harvest crop loss was noted in India (FAO, 2018). Out of that, insect pests cause, in average, 25-41 per cent rice crop damage, globally (Savary *et al.,* 2019). Rice yellow stem borer (YSB), *Scirpophaga incertulas* Walker is the most dominating and destructive insect pest that ravages the rice field globally. To check insect pest induced crop damage, Indian farmers apply insecticides of different newer brands in high quantum without any concern to the environment and also to the farmer's health (Horrigan *et al.*, 2002). Under modern IPM practice, the best way to reduce pesticide 'tread-mill' is to rely on phyto-formulation based pest control methods (Watts, 2010). Relative efficacy of nine selected insecticide formulations was evaluated against YSB.

MATERIALS AND METHODS

The experiment was carried out at paddy field area of Tarakeswar, Hooghly (22.8958° N; 88.0159°E) in two consecutive *kharif* seasons during 2019-2021. The rice cultivar *Lalat* (IET-9947), a most widely grown popular rice variety was used for the experiment. Parentage of this cultivar were

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Obs.677×IR-207×Vikram rice varieties.

The seedbeds measuring 20 m×1 m were prepared at about 26 standard meteorological weeks (SMW) in each year. Pre-germinated rice seeds of the cultivar *Lalat* (IET-9947) were sown at 28 SMW in the main land that was prepared following conventional management practice. Nine plots each measuring about 25 m×20 m were prepared. All of the plots were separated by a clear space of 5m from the nearby plot. Triple super phosphate, muriate of potash, gypsum and zinc sulphate fertilizers were applied at the rate of 220 kg ha^{-1} in each plot in three equal splits at 15, 30 and 50 days after seedling transplantation (DAT) respectively. Forty day-old seedlings of *Lalat* rice were transplanted at 20 cm × 20 cm spacing in all of the nine plots at about 28 SMW. Conventional cultural practices were accomplished for all of the plots. Seedling was transplanted equidistantly with fixed row-row and hill-hill spacing. Both organic (6.5 t decomposed cow dung ha^{-1}) and inorganic N (120 urea kg ha^{-1}) fertilizer were applied; inorganic fertilizer to rice field was given in two equal splits *i,e.* during vegetative and early reproductive growth stage, fortnightly light trapping of adult YSB population, alternation wetting and drying at 7-day interval from 60 days after seedling transplantation (DAT) was adopted. Periodic field scouting for the dead and old leaves for all treatments including the check (control) was followed.

Preparation of bio-formulations:

i. 150 g of 3 months old neem kernel is finely smashed and subsequently pounded in 1 litre of hot water (1:1 w/v) to prepare neem seed kernel extract (NSKE) formulation.

ii. Neem oil obtained through pressing or crushing of the dry seed kernel. Neem oil 15-30 ml is added to 1 litre of water and stirred well. To this emulsifier stearyl amine ethoxylates is added (1ml L^{-1}).

iii. Similarly, 1 kg green neem leaves were soaked overnight in 5 litre of water, then grinded and the leaf extract was filtered to prepare neem leaf extract (NLE) formulation. Extract solution was kept in the shade for a day and subsequently sieved to get a clear extract of stock solution. From the stock solution workable solution grade was prepared.

Preparation of synthetic insecticide-formulations: During the selection of synthetic insecticides, broad-spectrum hazardous insecticides were generally avoided. But selection was done aiming to replace the conventionally applied highly toxic insecticide by relatively less toxic and eco-friendly formulation. There were seven synthetic insecticides and three neem formulations in the experimental evaluation. Nine treatments were formulated with synthetic insecticides and neem formulations along with an untreated check (Table1). Four replications for each treatment were done. The treatments were applied as in the Table 1. YSB damage was recorded in terms of per cent of dead hearts (DH) and per cent white ears (WE) produced during vegetative and reproductive growth stages of rice plant respectively in each plot. The percentage of DH and WE of individual plot was calculated by using the following formula -

$$DH / WE \% = \frac{\text{Number of DH or WE/hill}}{\text{Total number of tillers/hill}} \times 100$$

The population of egg clutches, larvae and adults of YSB was recorded on 20 randomly selected hills from each plot were at seven day intervals after seedling transplantation. Grains from each plot were dried and weighed. Collected data were subjected to pooled analysis of variance, with square root transformed and compared on the basis of Duncan's Multiple Range Test (DMRT) using SPSS-ANOVA software.

RESULTS AND DISCUSSION

All the insecticide formulations were effective in suppressing the YSB infestation significantly compared to untreated control. But considerable variation in the relative efficacy among the insecticidal treatments was noted.

Assessment based on YSB egg clutches: YSB eggs are laid in groups and each group is called

Table 1. Dose of insecticide and time of application under different treatments

No.	Treatments with dose and time of application
T1	Flubendiamide (480 SC) @80 g a.s./ha on 45 DAT and deltamethrin (1%) + triazophos (35%) @300 g a.i. ha L^{-1} on 80 DAT
T2	Rynaxypyr (0.4% G) @ 50g a.s. ha L^{-1} on 45 DAT and chlorpyriphos (50%) @0.5 kg a.i ha L^{-1} on 75 DAT
T3	Chlorpyriphos (50%)+ organophosphate+ cypermethrin (5%) @ 2 ml a.s. L^{-1} on 35 DAT and carbofuran (35 G) @ 5 g a.s./plant on 50 DAT
T4	Carbofuran (35G) @ 12 g a.s. ha L^{-1} on 35 DAT and NLE (5%) @7 ml a.s. L^{-1} on 45 and 65 DAT
T5	Neem oil @50 ml L^{-1} on 20 DAT and chlorpyriphos (50%)+ organophosphate + cypermethrin (5%) @2 ml a.s. L^{-1} on 35 DAT
T6	NSKE (5%) @7 ml a.s. L^{-1} on 20 DAT and flubendiamide (480 SC)@ 80 g a.s. ha^{-1} on 45 DAT
T7	NSKE (5%) @7 ml a.s. L^{-1} on 20 DAT and neem oil @50 ml L^{-1} on 30, 45, 65 and 75 DAT
T8	Neem oil @50 ml L^{-1}on 20 DAT and NLE (5%) @7 ml a.s. L^{-1} on 35, 50, 65 and 80 DAT
T9	NSKE (5%) @50 ml L^{-1} at 15 day intervals after transplanting and NLE (5%) @7 ml a.s. L^{-1} on 35, 50, 65 and 80 DAT
T10	Untreated (Control)

DAT- Days after seedling transplantation; a.s.- active substance; a.i.- active ingredient

egg clutch. A mixture of flubendiamide (480 SC), deltamethrin (1%) and triazophos (35%) (T1) treatment showed 4.14 YSB egg clutches/5 hills, whereas in the rynaxypyr (0.4% G) and chlorpyriphos (50%) (T2) application there were 5.20 egg clutches. In the neem oil, chlorpyriphos (50%), organophosphate and cypermethrin (5%) (T5) treated plots, 5.93 egg clutches were noted. The treatment of a mixture of carbofuran (35 G), chlorpyriphos (50%), organophosphate and cypermethrin (5%) (T3) recorded 6.12 egg clutches. Carbofuran (35G) and NLE (5%) (T4) when applied jointly, 6.92 egg clutches were noted. Flubendiamide (480 SC) and NSKE (5%) (T6) resulted in 7.10 egg clutches. Combination of NSKE (5%) and neem oil (T7) had 10.12 egg clutches. In neem oil and NLE (5%) (T8) applied plots 11.29 egg clutches were noted. There were 12.21 egg clutches in the NSKE (5%), NLE (5%) (T9) treated plots. Whereas, untreated control field (T10) has registered highest 16.31 egg clutches (Table2).

Assessment based on YSB incidence (individuals/5 hills): A mixture application of flubendiamide (480 SC), deltamethrin (1%) and triazophos (35%) (T1) recorded 4.78 larvae and 3.17 adult YSB/5 hills. This was followed by (T2) rynaxypyr (0.4% G) and chlorpyriphos (50%) application with 5.62 larvae and 3.67 adults. In the treatment T5 (neem oil, chlorpyriphos (50%), organophosphate and cypermethrin (5%) combination) the incidence was 5.93 larvae and 4.06 adults. This was followed by T3 (6.74 and 4.55), T4 (7.09 and 4.95), T6 (7.89 and 5.10), T7 (12.29 and 9.29), T8 (13.34 and 10.38) and T9 (14.12 and 11.76) in ascending order. Whereas, untreated control field has registered 18.42 larvae and 15.89 adults (Fig. 1, Table 2).

DH and WE (%): There were significant variations in the DH and WE among the treatments. The treatment T1 showed a minimum damage of 2.12 per cent DH and 1.47 per cent WE and the

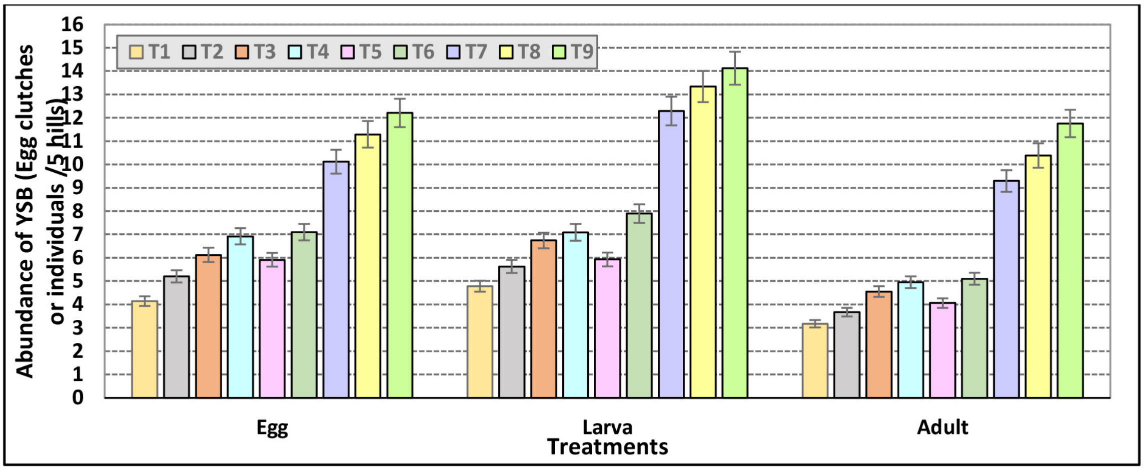

Fig. 1 Effect of different treatments on the incidence of *S.incertulas*

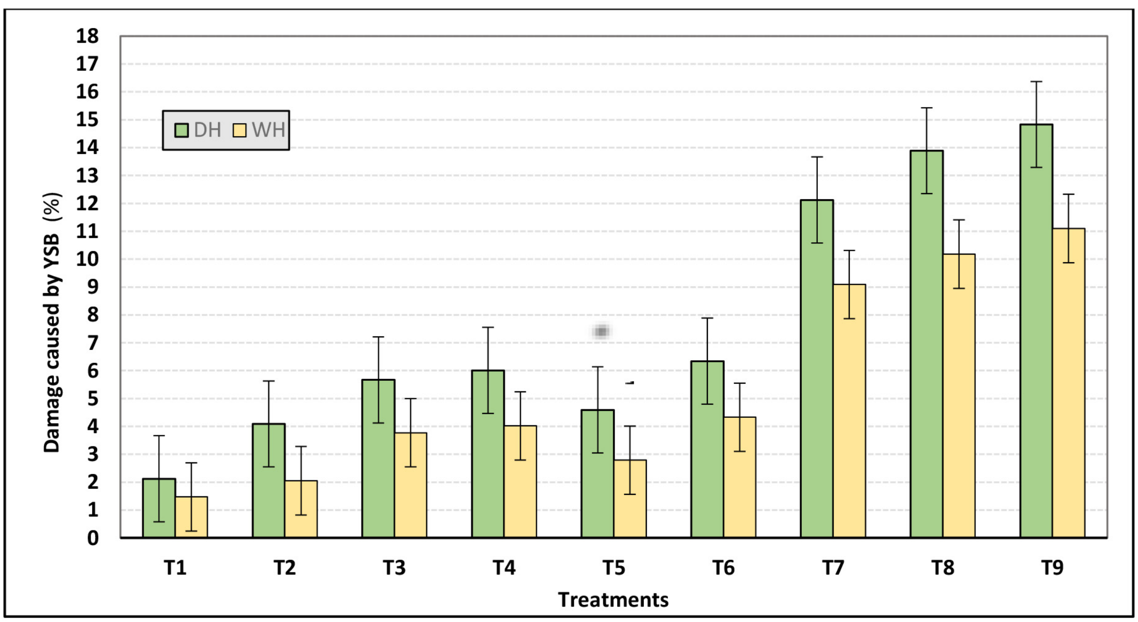

Fig. 2 Effect of different treatments on the extent of damage by *S.incertulas*

maximum was noted in T9 (14.83 DH; 11.10 WE). DH and WE in rest of the treatments were intermediate in nature and the values are T2 (4.09 DH; 2.05 WE), T3 (5.67 DH; 3.77 WE), T4 (6.01 DH; 4.02 WE), T5 (4.59 DH; 2.79 WE), T6 (6.34 DH; 4.33 WE), T7 (12.12 DH; 9.09 WE) and T8 (13.89 DH; 10.18 WE); whereas the control field showed highest damage with 18.74 per cent DH and16.79 per cent WE (Fig. 2, Table 2).

Effect of treatments on yield: Maximum yield benefit with least YSB damage was noted in T1 and was significantly higher than other treatments. Application of flubendiamide (480 SC), deltamethrin (1%) and triazophos (35%) (T1) recorded significantly higher yield (3.63 t ha^{-1}). This was followed by the treatments - T2 (3.55 t ha^{-1}), T5 (3.49 t ha^{-1}), T3 (3.37 t ha^{-1}), T4 (3.32 t ha^{-1}), T6 (3.20 t ha^{-1}), T7 (3.08 t ha^{-1}), T8 (2.99 t ha^{-1}) and T9 (2.88 t ha^{-1}). In untreated control (T10) the grain yield was 2.49 t ha^{-1}. Extent of yield generation over the check was highest in T1 (45.78%) that was followed by T2 (42.25%), T5 (40.04%), T3 (35.27%), T4 (33.11%), T6 (28.56%), T7 (23.44%), T8 (19.86%) and T9 (15.62%) respectively in descending order (Table 2).

In the present study all the insecticide formulations were found effective to suppress YSB population in consideration of untreated control. But considering all aspects of the treatment, a mixture application of flubendiamide (480 SC), deltamethrin (1%) and triazophos (35%) (T1) showed minimum YSB population and damage with maximum yield in comparison to the other treatments. This was followed by the mixture of rynaxypyr (0.4% G) and chlorpyriphos (50%) (T2), neem oil, chlorpyriphos (50%), organophosphate and cypermethrin (5%) (T5), a mixture of carbofuran (35 G), chlorpyriphos (50%), a mixture of organophosphate and cypermethrin (5%) (T3), combination of carbofuran (35G) and NLE (5%) (T4), a mixture of flubendiamide (480 SC) and NSKE (5%) (T6), combination of NSKE (5%) and neem oil (T7), neem oil and NLE (5%) (T8) and NSKE (5%), NLE (5%) (T9) respectively. There was no significant difference between the efficacy of a mixture of organophosphate and cypermethrin (5%) (T5) with a combined application of flubendiamide (480 SC), deltamethrin (1%) and triazophos (35%) (T1). Application of rynaxypyr (0.4% G) and chlorpyriphos (50%) (T2) had somewhat similar result. Combination of organophosphate and cypermethrin (5%) (T5) has less effect. Whereas combination of NSKE (5%) and neem oil (T7) , neem oil and NLE (5%) (T8) and NSKE (5%), NLE (5%) (T9) were purely botanical in nature, but their effectiveness against YSB and in crop

Table 2. Effect of the treatments on the incidence, infestation and damage of *Scirpophaga incertulas*

Treatment	*S. incertulas* population/5 hills			Extent of damage (%)		Yield (t ha^{-1})	Increase (%)
	Egg clutches	Larvae	Adult	DH	WE		
T1	(2.03) 4.14^{b}	(2.18) 4.78^{b}	(1.78) 3.17^{ab}	(1.62 2.12^{a}	(1.40) 1.47^{a}	3.63^{e}	45.78
T2	5.20^{b} (2.28)	5.62^{b} (2.37)	3.67^{ab} (1.91)	4.09^{b} (2.14)	2.05^{a} (1.60)	3.55^{d}	42.25
T3	6.12^{c} (2.47)	6.74^{c} (2.59)	4.55^{b} (2.13)	5.67^{b} (2.48)	3.77^{ab} (2.07)	3.37^{c}	35.27
T4	6.92^{c} (2.63)	7.09^{c} (2.66)	4.95^{bc} (2.22)	6.01^{c} (2.55)	4.02^{b} (2.13)	3.32^{c}	33.11
T5	5.91^{b} (2.43)	5.93^{b} (2.43)	4.06^{b} (2.01)	4.59^{b} (2.26)	2.79^{a} (1.81)	3.49^{a}	40.04
T6	7.10^{d} (2.66)	7.89^{d} (2.80)	5.10^{c} (2.25)	6.34^{c} (2.62)	4.33^{b} (2.20)	3.20^{c}	28.56
T7	10.12^{de} (3.18)	12.29^{ef} (3.50)	9.29^{de} (3.04)	12.12^{ef} (3.48)	9.09^{de} (3.01)	3.08^{b}	23.44
T8	11.29^{de} (3.36)	13.34^{f} (3.65)	10.38^{de} (3.22)	13.89^{f} (3.72)	10.18^{de} (3.19)	2.99^{ab}	19.86
T9	12.21^{ef} (3.49)	14.12^{f} (3.75)	11.76^{de} (3.42)	14.83^{f} (3.85)	11.10^{de} (3.33)	2.88^{ab}	15.62
T10 (control)	16.31^{h} (4.03)	18.42^{i} (4.29)	15.89^{g} (3.98)	18.74^{i} (4.32)	16.79^{h} (4.09)	2.49^{a}	------

Figures in parentheses are the square root transformed values; Means followed by same letters in the column do not differ significantly by DMRT (p=0.05) yielding was not significant in comparison to the other treatments. While a mixture of carbofuran (35 G), chlorpyriphos (50%), organophosphate and cypermethrin (5%) (T3), carbofuran (35G) and NLE (5%) (T4) and flubendiamide (480 SC) and NSKE (5%) (T6) showed average effect in comparison to the others.

In consonance to the present observation Jagginavar *et al*. (2009) have reported that fluben diamide was highly effective against lepidopteran insect pests of rice. It has also been documented that flubendiamide was comparatively safe to natural enemies but suppressed lepidopteran pests population effectively (Hall *et al.,* 2007). Rynaxypyr 0.4G @ 40 and 50 g a.i. ha^{-1} could effectively control stem borer complex and increasing rice grain yield (Kandasamy *et al.,* 1986). In parity to the present observation Ho and Kibuka (1983) reported that neem oil can control borer menace at vegetative stage. Application of 3 per cent neem oil could effectively suppress YSB as suggested by Nanda *et al.* (1996) and Murugabharathi *et al.* (1999). In parity to the earlier observation by Nanda *et al.* (1996), in the present experiment it was found that NSKE moderately effectively suppressed rice borer. Ahmed *et al.* (2002) has stated that neem formulations were economically prudent to suppress stem borer menace like the present experiment. Sasmal *et al.* (2010) reported that neem formulation moderately suppressed white head in the rice cultivar Jaya in Orissa.

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