J. Soils and Crops 33 (2) 353-360, December 2023

ISSN 0971-2836 (Print)
ISSN 2582-2756 (Online)

EFFECT OF PHEROMONE LURE AND BIO-RATIONAL INSECTICIDES TO CHECK *Scirpophaga incertulas* IN RICE FIELD AT HOOGHLY, WEST BENGAL

E. Mondal[1] and K. Chakraborty[2]

ABSTRACT

Rice yellow stem borer (YSB), *Scirpophaga incertulas,* Walker, a major destructive insect pest, renders huge yield damage in field condition. Pheromone trapping in combination of different insecticides can effectively check YSB infestation with low toxic input, judiciously. Experiment was conducted during three consecutive crop years 2019-2021, to observe the relative superiority of application of pheromone lure and bio-rational insecticides in the rice (var. Lalat) fields. There were collectively ten treatments (T1 to T10). In T1, pheromone trapping was followed by the application Neem oil (2%), whereas T2 and T3 included pheromone trapping followed by the application of NLE 2% and DLE 2% respectively. Besides, pheromone trapping was followed by the application of TLE 2% in T4. But in T5 only pheromone trapping was done. In T6, Neem oil 2% and in T7, T8, T9, NLE 2%, DLE 2% and TLE 2% were given respectively. Whereas in T10 (control field) no pheromone trapping and insecticide was done. Apart from control, application of neem leaf extract (NLE 2%) as post pheromone treatment showed minimum incidence of Dead Heart (DH ; 3.16%) and White Head (WH ; 1.36%). Maximum amount of DH (7.09%) and WH (4.67%) incidence was noted when only pheromone trapping was done. Field without installation of pheromone trap and insecticide application (control) showed 8.86% DH and 5.88% WH incidence respectively. Grossly, in consideration of all of the treatments, application of neem leaf extract (NLE 2%) as post pheromone treatment caused a reduction of 64.33% DH and 76.87% WH incidence over control and proved as best control strategy out of the all applications.

(Key words: Yellow stem borer, pheromone trap, insecticide, dead heart, white head)

INTRODUCTION

Rice (*Oryza sativa* L.) under family-Poaceae is the most important food crop around the world and the staple food for approximately more than two billion people in Asia (Hien *et al.,* 2006). Globally, India ranks second in terms of area and production. The state West Bengal ranks second in area and first in production of rice in India (Anonymous, 2019). Increase production of rice is an important requirement to meet the needs of over increasing population in World. With limited cultivated area it is necessary to increase the productivity unit^{-1} area (Shrirame *et al.,*2000). But a number of constrains are found to subsume rice production (Yarasi *et al.,* 2008). Insect-pest constrains in field condition underscore rice production considerably (Chatterjee *et al*., 2016). Stem borers (SBs) are key group of insect pests. Out of that yellow stem borer (YSB), *Scirpophaga incertulas* Walker, accounts about 10-60 % yield loss (Chatterjee *et al.,* 2014). Mature YSB larvae causes deep circular stem feeding and subsequently accommodate within the stem for pupation (Satpathi *et al.,* 2016). Most of the synthetic pesticides used to check YSB population are expensive culminating potential threat to consumer's health (Sasmal *et al.,* 2007). Mumin *et al.* (2018) stated that using of chemical insecticides has become the cornerstone of modern crop production process. Over reliance on chemical insecticides to check borer population results in persistent environmental hazards against which choice for pheromone traps for mass destruction of male YSB is an effective eco-friendly approach (Cork *et al.,* 2005).

Single applications of slow-release pheromone lure as 'eco-friendly approach' can be adopted to control YSB by mating disruption (Katti *et al*., 2001). Pheromone lure are environment friendly, non-hazardous and fully compatible with other methods of YSB control programme (Daryaei, 2005 and Sithanantham *et al.,*2019). Pheromone lure can thus safely be used for both sampling and monitoring YSB population (Krishnaiah *et al.*, 2000). Cork *et al*. (2005) had commented that mating disruption of YSB by mass trapping is highly appraisable and demandable under modern integrated pest management (IPM) programme. But sudden withdrawal of chemical insecticides may cause a sharp decline of rice production (Khan and Khaliq, 1989). In this conjecture, therefore, in order to improve efficiency of rice

1. Ph.D Scholar, Laboratory of Entomology, Dept. of Zoology, Raiganj University, Raiganj, Uttar Dinajpur,West Bengal
2. Professor, Laboratory of Entomology, Dept. of Zoology, Raiganj University, Raiganj, Uttar Dinajpur, West Bengal

crop production and to reduce food crisis in a sustainable manner, while preserving consumer's health, a compromise between low toxic insecticide input and eco-friendly non-insecticidal method is admirable (Sasmal *et al.,* 2007).

In consideration of bio-products, neem formulations can be applied in rice-IPM programme (Juan *et al*., 2000 and Calvo and Malina., 2003). Tobacco is used effectively against field and storage pests in some parts of Tanzania (Isman 2000 and Dahlin, 2009). Jacob and Sheila (1993) had noted that leaf powders of *Datura* sp. and *Azadirachta* sp. at 2.5% and 5% respectively can be applied to control rice lesser grain borer, *Rhyzopertha* sp.

However, to optimise, at field level, the most reliable, cost-effective and simple techniques for monitoring YSB population, a critical field experiment on the pheromone traps and bio-pesticides are essential. In view of this a study was undertaken to evaluate the relative superiority of the combination application of pheromone lure and bio-rational insecticides after checking male YSB population in rice field at Hooghly, West Bengal.

MATERIALS AND METHODS

Place of observation

The experiment in rice field was carried out at Tarakeswar, Hooghly, West Bengal (Latitude: 22.8958° N and Longitude: 88.0159°E) during three consecutive *kharif* crop season (2019-2021) (Fig.1).

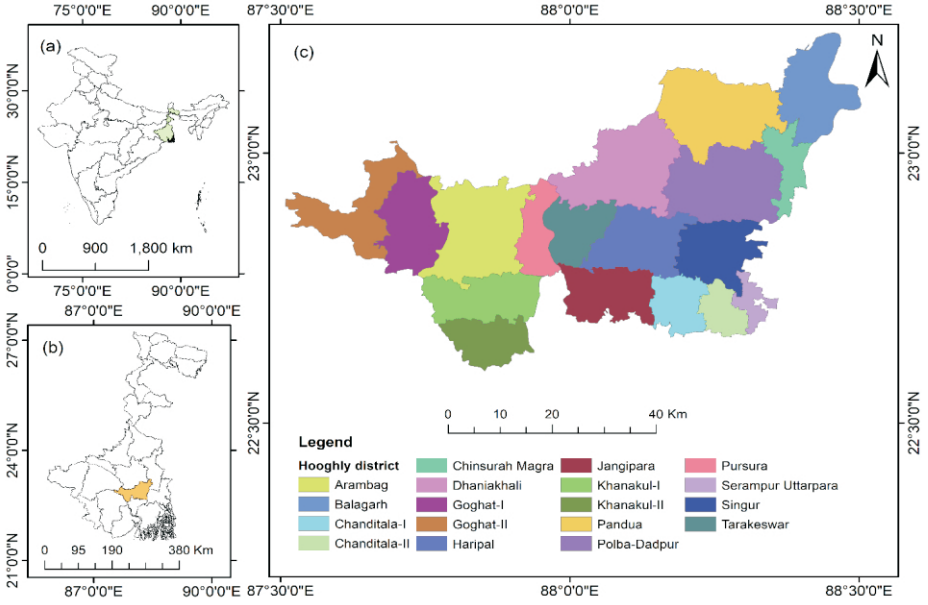

Fig.1 Location of the experimental rice field at Tarakeswar, Hooghly, WB, India

The rice cultivar

Lalat (IET-9947), a most widely grown popular rice variety was considered for the experiment. Parentage of this cultivar were Obs.677×IR-207×Vikram rice varieties.

The pest

Rice yellow stem borer (YSB) , *Scirpophaga incertulas* (Walker) is one of the most notorious insect pests belonging to order Lepidoptera and family Pyralidae. It is holometabolous in nature, but out of the four stages (egg, larva, pupa and adult), larvae are injurious to the rice crops. YSB larvae causes the characteristic symptoms of 'dead hearts' (DH) at vegetative growth stage or 'white head' (WH) at late tillering.

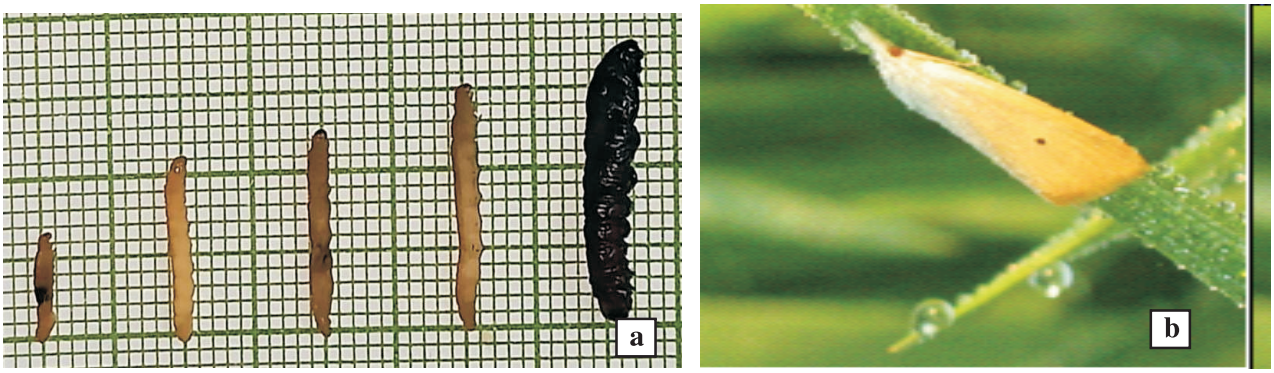

Fig. 2 Rice yellow stem borer (a) Larval instars (1st-5th) (b) adult form

Crop establishment and management

There were ten treatments each with three replications for each year. Each plot was 25 m x 25 m in size and separated from the nearby plot by a distance of 20 m×20 m to avoid any inference of the experiment of the nearby fields.

Field experiment was conducted with transplanted 35-day old Lalat seedlings. The soil of the experimental field was sandy loam with pH value of 6.7. In the field N, P_2O_5 and K_2O were added in the ratio of 385:55:329 kg ha^{-1} respectively. Experiment was conducted in randomized block design. Seedlings were transplanted at 15 cm x10 cm spacing.

Fertilizer inputs and other necessary field management were done in due course of time following the national protocol with befitting modifications.

Establishment of pheromone trap

The selected funnel traps were lured with pheromone containing 3 mg of 1:3 blend of 2-(Z)-9 and 2-(Z)-11 hexadecenal loaded in polythene vials and that were placed in the experimental rice fields after 30 days after transplanting of rice seedlings. Each trap was stranded with a bamboo stick at the height of 90 cm lure are designed to release pheromones at constant or near constant rate during the course of experiment. Both the funnel traps and the lure (Scirpolure) were purchased from manufacturer Green Revolution, Kolhapur, Maharashtra India.

Release rate depend on the molecules, physical and chemical properties of the lure matrix and environmental conditions such as temperature and local weather. Traps were checked and YSB were recorded over time, usually in a week.

Fig.3 The pheromone trap (a) installation of single trap (b) multiple traps in the paddy field

Preparation of pesticide formulation

Four different types of conventional bio-pesticide formulations were prepared 2 days prior to the schedule application date.

Neem oil : 1 kg sundried neem leaves were crushed properly for getting neem powder, then it was steamed on boiling water for extracting oil, out of 100 ml Neem oil 50 ml was taken and mixed with 1 litre of water.

Neem leaf extract (NLE) : 1 kg green neem leaves were soaked overnight in 5 litre water, grinded and the leaf extract was filtered to prepare neem leaf extract (NLE) formulation.

Datura leaf extract (DLE) : 2.5 kg green datura leaves were soaked overnight in 5 litre water, grinded and the leaf extract was filtered to prepare datura leaf extract (DLE) formulation**.**

Tobacco leaf extract (TLE) : 1 kg tobacco leaves were soaked overnight in 5 litre water; grinded and the leaf extract was filtered to prepare tobacco leaf extract (TLE) formulation**.**

Experimental treatments

There were collectively ten treatments (T1 to T10). Out of that, four treatments (T1 to T4) were based on the introduction of pheromone trapping followed by bio rational insecticidal applications. In T1, pheromone trapping was followed by the application Neem oil 2%, whereas T2 and T3 included pheromone trapping followed by the application of NLE 2% and DLE 2% respectively. Besides, pheromone trapping was followed by the application of TLE 2% in T4. But in T5 only pheromone trapping was done.

Whereas, in the remaining four treatments (T6 to T9) bio-rational insecticides were only applied. In T6, Neem oil 2%, whereas in T7 and T8 NLE 2% and DLE 2% were given respectively. On the other hand, TLE 2% was applied in T9. Whereas in T10 (control field) no pheromone trapping and insecticide was done.

Table1. Pheromone and bio-rational insecticides for field experiment

Types of Treatment	Formulations	Source/ Manufacturer	Dose	Time of application(Days after seedling transplantation DAT)
Pheromone trapping	Pheromone lure (Scirpolure)	Green Revolution, Kolhapur, Maharashtra	3 mg lure^{-1}	30
Insecticidal application	Neem oil	Lila Agrotech Pvt. Ltd. Kolkata, West Bengal	1ml 20ml^{-1}	45
	Neem leaf extract (NLE)	From about 4-years old neem tree (3.5 m in height) with 20–40 cm long opposite pinnate leaves and with 20 to 30 media to dark green leaflets about 3–8 cm long	1g 5ml^{-1}	45
	Datura leaf extract (DLE)	From mature datura plant (2 m in height) with 10–20 cm. long and 5–18 cm. broad leaves	1g 2ml^{-1}	45
	Tobacco leaf extract (TLE)	From about 50-years old tobacco leaves	1g 5ml^{-1}	45

Assessment on pest incidence

Efficacy of each treatment was assessed in terms of rice-hill damage. The infestation by YSB was recorded in terms of number of Dead Heart (DH) and White Head (WH). The extent of damage was estimated 7 days after each treatment. The percentage of DH and WH of individual plot was calculated by using the following formula described by Singha and Pandey (1997).

$$\text{DH and WH \%} = \frac{\text{Number of DH / WH}}{\text{Total number of tillers}} \times 100$$

Figure 4. Damage symptoms caused by YSB larvae (a) the dead heart (DH) (b) the white head (WH)

Statistical analysis

Data obtained from field experiment was statistically analyzed by INDOSTAT- ANOVA and accordingly CD value was determined (Chandel, 1984).

RESULTS AND DISCUSSION

Efficacy of different treatments were determined in consideration of DH and WH formation.

DH symptoms (5 hills^{-1})

Considering the data, it was seen that application of all the treatments significantly reduced the percentage of DH in comparison to the control. The incidence of DH caused by YSB larvae, post pheromone trapping application of NLE 2% (T2) showed 3.18%, 3.05% and 3.27% of DH incidence in three consecutive crop years (2019, 2020 and 2021) respectively followed by the post pheromone trapping effect of TLE 2% (T2) with 3.16%, 3.86% and 3.29% of DH incidence in three consecutive crop years respectively. When pheromone trapping was followed by the application neem oil 2% (T1), 3.98%, 3.49% and 3.56% of DH incidence were noted in three consecutive crop years respectively. Post pheromone trapping treatment with DLE 5% (T3) caused 4.12%, 4.36% and 3.98% of DH incidence in three consecutive crop years respectively. Whereas, NLE 2% (T7) when applied singly, 4.53%, 4.78% and 4.65% of DH incidence were noted and TLE 2% (T9) resulted 5.03%, 5.17% and 5.46% of DH incidence in three consecutive crop years respectively. 5.89%, 5.63% and 5.49% of DH incidence were noted when Neem oil 2% (T6) were applied and 6.12%, 6.07% and 6.23% of DH incidence were noted when DLE 5% (T8)

was given during the aforesaid time period. In addition, applications resulted 6.94, 7.32 and 7.03 DH incidence per cent in three consecutive crop years respectively. Whereas, untreated control field (T10) registered 8.86%, 8.52% and 9.21% of DH incidence respectively in the said period (Figure 2 and Table 1).

Decrease of DH incidence over control (%)

Considering the data, it was seen that application of all the treatments significantly reduced the percentage of DH in comparison to the control. The post pheromone trapping application of NLE 2% (T2) showed 64.33% decrease in DH incidence over control. This was followed by the post pheromone effect of TLE 2% (T4) application with 61.28% decreased over control. Whereas post pheromone trapping application of neem oil 2% (T1) decrease in DH incidence over control. 30.69% decrease in DH incidence over control was noted when DLE 5% (T8) was applied. But only 19.97 % decrease in DH incidence over control was noted when only pheromone trapping (T5) was done (Table 1).

WH symptoms (5 hills^{-1})

Considering the data, it was seen that application of all the treatments significantly reduced the percentage of WH in comparison to the control. The incidence of WH caused by YSB larvae, post pheromone trapping application of NLE 2% (T2) showed 1.46%, 1.23% and 1.39% of WH incidence in three consecutive crop years (2019, 2020 and 2021) respectively. This was followed by the post-pheromone trapping effect of TLE 2% (T4) application with 1.89%, 1.62% and 1.77% of WH incidence respectively in three consecutive crop years. When pheromone trapping was followed by the application neem oil 2% (T1), 2.07%, 2.18% and 2.22% of WH incidence were noted in three consecutive crop years respectively. Post pheromone trapping treatment with DLE 5% (T3) caused 2.53%, 2.47% and 2.31% of WH incidence in three consecutive crop years respectively. Whereas, NLE 2% (T7) when applied singly, 2.96%, 2.84% and 2.72% of WH incidence were noted and TLE 2% (T9) resulted 3.03%, 3.17% and 3.21% of WH incidence in three consecutive crop years respectively. 3.74%, 3.69% and 3.51% of WH incidence were noted when Neem oil 2% (T6) was applied and 4.27%, 4.09% and 3.97% of WH incidence were noted when DLE 5% (T8) was given during the aforesaid time period. In addition to these treatments, only pheromone trapping (T5) without any insecticidal applications resulted 4.79%, 4.68% and 4.55% of WH incidence in three consecutive crop years respectively. Whereas, untreated control field (T10) registered 5.84%, 6.19% and 5.62% of WH incidence respectively in the said period (Figure 5 and Table 2).

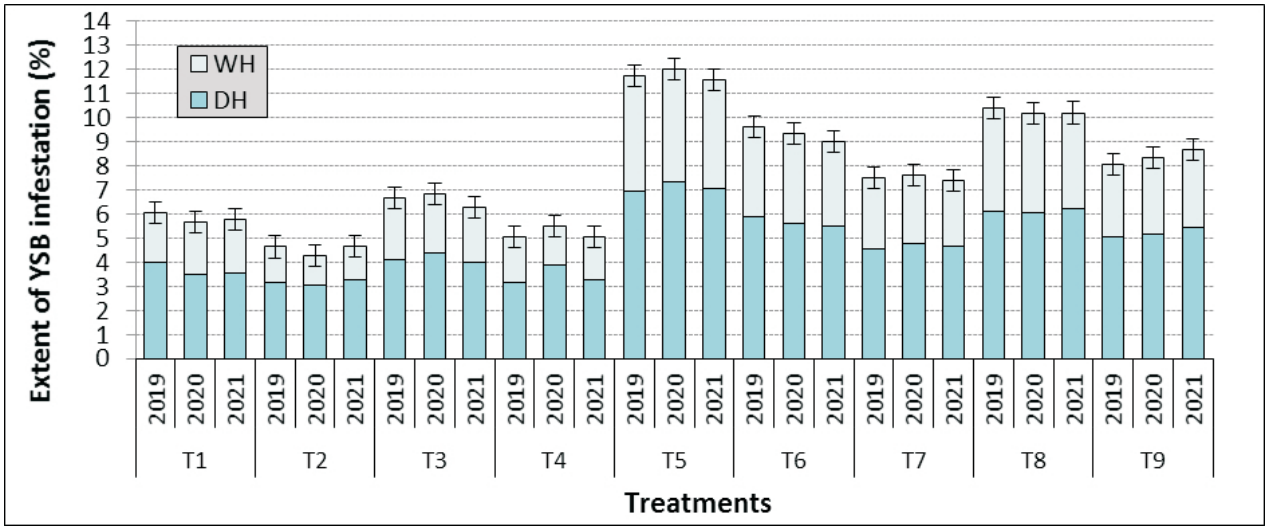

Figure 5. Impact of pheromone trapping and different bio rational insecticide formulations on the incidence of DH and WH (%) during three consecutive years (2019-2021)

Decrease of WH incidence over control (%)

Considering the data, it was seen that application of all the treatments significantly reduced the percentage of WH in comparison to the control. The post pheromone trapping application of NLE 2% (T2) showed 76.87% decrease in WH incidence over control. This was followed by the effect of post pheromone trapping application of TLE 2% (T4) application with 70.06 % decrease in WH incidence over control. Post pheromone trapping application of neem oil 2% (T1) showed 63.43% decrease in WH incidence over control. Post pheromone trapping treatment with DLE 5% (T3) caused 58.67% decrease in WH incidence over control. NLE 2% (T7) and TLE 2% (T9) when applied singly, 51.70% and 46.76% decrease in WH incidence over control was noted respectively. Whereas neem oil 2% (T6) resulted 38.09% decrease in WH incidence over control. 30.10% decrease in WH incidence over control was noted when DLE 5% (T8) was applied. 20.57% decrease in WH incidence over control was noted when only pheromone trapping T5 was done (Table 1).

Post pheromone trapping followed by the application of bio rational insecticides showed highest

Table 2. Impact of pheromone trapping and different bio rational insecticide formulations on the incidence of DH (%) and WH (%)

Types of Treatment	Treatments	Insecticidal formulations	Extent of YSB infestation (%)									
			DH (%)				Decrease of incidence over control (%)	WH (%)				Decrease of incidence over Control (%)
			2019	2020	2021	Mean		2019	2020	2021	Mean	
Pheromone trapping + Insecticidal application	T1	Neem oil (2%)	3.98 (2.12)	3.49 (2.00)	3.56 (2.01)	3.67 (2.04)	58.57	2.07 (1.60)	2.18 (1.64)	2.22 (1.65)	2.15 (1.63)	63.43
	T2	NLE (2%)	3.18 (1.92)	3.05 (1.88)	3.27 (1.94)	3.16 (1.91)	64.33	1.46 (1.40)	1.23 (1.32)	1.39 (1.37)	1.36 (1.36)	76.87
	T3	DLE (5%)	4.12 (2.15)	4.36 (2.20)	3.98 (2.12)	4.15 (2.16)	53.16	2.53 (1.74)	2.47 (1.72)	2.31 (1.68)	2.43 (1.71)	58.67
	T4	TLE (2%)	3.16 (1.91)	3.86 (2.09)	3.29 (1.95)	3.43 (1.98)	61.28	1.89 (1.55)	1.62 (1.46)	1.77 (1.51)	1.76 (1.50)	70.06
Only by Pheromone trapping	T5	---	6.94 (2.73)	7.32 (2.80)	7.03 (2.74)	7.09 (2.75)	19.97	4.79 (2.30)	4.68 (2.28)	4.55 (2.25)	4.67 (2.27)	20.57
Only by Insecticidal application	T6	Neem oil (2%)	5.89 (2.53)	5.63 (2.48)	5.49 (2.45)	5.67 (2.48)	36.00	3.74 (2.06)	3.69 (2.05)	3.51 (2.00)	3.64 (2.03)	38.09
	T7	NLE (2%)	4.53 (2.24)	4.78 (2.30)	4.65 (2.27)	4.65 (2.27)	47.51	2.96 (1.86)	2.84 (1.83)	2.72 (1.79)	2.84 (1.83)	51.70
	T8	DLE (5%)	6.12 (2.57)	6.07 (2.56)	6.23 (2.59)	6.14 (2.58)	30.69	4.27 (2.18)	4.09 (2.14)	3.97 (2.11)	4.11 (2.15)	30.10
	T9	TLE (2%)	5.03 (2.35)	5.17 (2.38)	5.46 (2.44)	5.22 (2.39)	41.08	3.03 (1.88)	3.17 (1.92)	3.21 (1.93)	3.13 (1.91)	46.76
Control (no application)	T10	---	8.86 (3.06)	8.52 (3.00)	9.21 (3.12)	8.86 (3.06)	-	5.84 (2.52)	6.19 (2.59)	5.62 (2.47)	5.88 (2.53)	-
SE(m)±			**0.010**	**0.023**	**0.021**	**0.015**		**0.018**	**0.017**	**0.014**	**0.034**	
CD at 5%			**0.030**	**0.068**	**0.062**	**0.045**		**0.053**	**0.050**	**0.041**	**0.102**	

efficacy against YSB infestation with least DH and WH percentage. Insignificant variation was noted when neem oil 2%, NLE 2%, DLE 5% and TLE 2% were applied individually. In parity to the present experiment, Ho and Kibuka (1983) have observed that neem oil can control stem borer menace at vegetative stage. Efficacy of neem oil to suppress yellow stem borer has also been reported by Dhaliwal *et al*. (2015). Application of 3% neem oil could effectively suppress rice yellow stem borers as suggested by Murugabharathi and Balasubramanian (1999). Ahmed *et al.* (2002) stated that neem formulations were economically feasible to control YSB incidence like the present experiment. From Orissa, Sasmal *et al.* (2010) had observed that neem formulation moderately suppressed white head in the rice cultivar Jaya. Application of bio-pesticides during the first phase at 35 DAT brings about the mortality of the early YSB larval brood. This might be due to the anti-feedant activity of bio-formulations against larval broods (Ganguli and Ganguli, 1998). Thus, the canopy is protected from larval damage. Consequently, the field symptoms of DH and WH are reduced. Bhanukiran and Panwar. (2000) have noted that in in-vitro condition neem products could effectively control the activity of maize stalk borer, *Chilo partellus* larvae. Ahmed *et al.* (2002) have concluded that neem formulations were economically prudent to suppress stem borer menace. Samrit *et al.* (2020) has stated that neem leaf kernel extract (5%) was effective in controlling rice stem borer. The usefulness of YSB sex pheromone-based traps as monitoring tool in rice ecosystems has been well documented (Shilpa *et al.,* 2018). Cork *et al.* (2005) had reported that some agrochemical industries supported the development of mating disruption and mass trapping of rice stem borer in order to maintain a sustainable level of pesticide use.

Sawant *et al*. (1995) stated that damage by *S. incertulas* larvae were significantly less in the pheromone-treated plots than the farmers' practice plots and crop production was also increased about 60% in Maharashtra. Dani and Jena (2008) had observed that sex pheromone installed plot and control plot recorded 1.6 and 17 per cent YSB damage respectively. Patel and Desai (2004) had noted that the moth catches from pheromones infestation had the significant relation with the lure concentration.

From the present study it can be inferred that all of the treatments were more or less effective to suppress the incidence of DH and WH in consideration of untreated control. But consider-ing all aspects of the treatment, post pheromone trapping application of NLE 2% (T2) showed minimum incidence of DH and WH in comparison to the other treatments. This was followed by the post pheromone trapping application of TLE 2%, post pheromone trapping application of neem oil 2%, post pheromone trapping application of DLE 5%, only by the application of NLE 2%, only by the application of TLE 2% , only by the application of neem oil 2%, only by the application of DLE 5%. Whereas, only pheromone trapping showed maximum incidence of DH (7.09%) and WH (4.67%).

REFERENCES

Ahmed, S., M.A. Saleem and I. Rauf, 2002. Field Efficacy of Some Bio insecticides against Maize and Jowar Stem Borer, *Chilo partellus* (Pyralidae: Lepidoptera). Int. J. Agri.Bio. **3**: 332-334.

Anonymous, 2019. Agricultural Statistics at a Glance.Directorate of Economics and Statistics, Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Government of India. Available at http://agricoop.gov.in/sites/default/files/agristatglance2018.pdf. 76. accessed on 07.19.2020.

Bhanukiran, Y. and V.P.S. Panwar, 2000. In vitro, efficacy of neem products on the larvae of maize stalk borer *Chilo partellus* (Swin.). Ann. Plant Prot. Sci. **8:** 240–246.

Calvo, D. and J.M. Molina, 2003. Effects of a commercial neem (*Azadirachta indica*) extract on *Streblotepanda* larvae. Phytopara. **31**:365-370.

Chandel, S.R.S. 1984. A handbook of Agricultural Statistics. – Achal Prakashan Mandir, Kanpur (U.P.) India. pp. 149-318.

Chatterjee, S. and P. Mondal, 2014. Management of rice yellow stem borer, *Scirpophaga incertulas* Walker using some biorational insecticides. J.Biopest. **7**(supp): 143-147.

Chatterjee, S., M. Ghose and C. Gangopadhyay, 2016. Field screening of different rice entries against different insect-pests of rice during *kharif* season. Inter. J. Agri. Environ. Biotech. **9**(4): 667-71.

Cork, A., M.J. Iles, N.Q. Kamal, J.C.S. Choudhury, M.M. Rahman and M. Islam, 2005. An old pest, a new solution: commercialization rice stem borer pheromone in Bangladesh. Outlook Agri. **34:** 181-187.

Dahlin, A. B. 2009. Botanical pesticides: a part of sustainable agriculture in Babati District Tanzania. Environment and development educational programme. Södertörn University College School College School of Life Sciences Bechlor Thesis. pp. 33.

Dani, R.C. and M. Jena, 2008. Use of sex pheromone in the management of rice yellow stem borer, *Scirpophaga incertulas*. National Seminar on Pheromone Technologies: Strengthening Eco friendly Agriculture in India. pp.19.

Daryaei, M.G. 2005. Assessment of yield loss in rice due to yellow stem borer *Scirpophaga incertulas* using simulation model. Casp. J. Env. Sci. **3**(1): 59-62.

Dhaliwal, G. S., V. Jindal and B. Mohindru, 2015. Crop Losses due to insect pests: Global and Indian Scenario. Ind. J.Entomol. **77**(2):165–175.

Ganguli, R.N. and J. Ganguli, 1998. Residual toxicity of insecticides and neem-based formulations against *Chilo partellus* (Swin.) infestingmaize. Ind. J. Agri. Res.**32**: 227–32.

Ho, D.T. and J.K. Kibuka, 1983. Neem (*Azadirachta indica*) products or Control of rice borers. International Rice Research Institute News. **8**(5):15-16.

Hien, N.L., T. Yoshihashi and W.A. Sarhadi, 2006. Evaluation of aroma in rice using KOH method, molecular markers and measurement of 2-acetyl-1pyrroline concentration. Jap. J. Trop. Agri. **50:**190-198.

Isman, M. B. 2000. Plant essential oils for pest and disease management. Crop Prot. **19**:603–608.

Jacob, S and M.K. Sheila, 1993. A note on the protection of stored rice from lessor grain borer (*Rhizopartha dominica* Fabr.) by indigenous plant products. Ind. J. Entomol. **55** (3):337-339.

Juan, A., A. Sans and M. Riba, 2000. Anti-feedant activity of fruit and seed extracts of *Melia azedarach* and *Azadirachta indica* on larvae of *Sesamia nonagrioides*. Phytopara, **28**:311-319.

Katti, G., I. C. Pasalu, N. R. G. Varma and K. Krishnaiah, 2001. Integration of pheromone mass trapping and biological control for management of yellow stem borer and leaf folder in rice. Ind. J. Entomol. **63**:325-328.

Khan, L. and A. Khaliq, 1989. Field evaluation of some granular insecticides for the control of rice stems borers. Pak. J. Sci. Ind. Res. **32**(12):824.

Krishnaiah, K., R. G. Varma, I.C. Pasalu, S. Zainulabeudin and J. S. Yadav, 2000. Development of mass trapping technique for management of yellow stem borer Innovative pest and disease management in Horticultural and Plantation Crops (Eds., Narasimhan, S., Suresh, G. and Weisley, D.), Allied Publishers, Chennai. 33-40.

Mumin,M.A.A., M.A.Latif, M.M.Rahman,S.O.Nasif and S.A.Shahriar,2018.Species diversity, infestation intensity and management of mango fruit weevil in the Hilly areas of Bangladesh, J. Soils and Crops. **28**(2):265-272.

Murugabharathi, J. and G. Balasubramanian, 1999. Relative efficacy of botanicals against rice stems borer and leaf folders and their safety to natural enemies. Neem News Letter. **16**(3):25.

Patel, K.G. and H.R. Desai, 2004. Monitoring rice yellow stem borer, *Scirpophaga incertulas* (Walker), using sex pheromone/light traps. Insect Env.**10**:51-52.

Samrit, R.M.,B.N. Chaudhari, G.R. Shamkuwar, P.S. Neharkar and H.R.Sawai, 2020. Evaluation of biopesticide,botanicals and plant extracts against rice stem borer *Scirpophaga incertulas* Walker. J. Soils and Crops, **30**(1):124-128.

Sasmal, A., D.K. Bhattacharya and L.R. Nanda, 2007.Eco-friendly management of rice leaf folder and case worm in Odisha. National Symposium on sustainable pest management of safer environment organized by OUAT, Bhubaneswar.pp.33-34.

Sasmal, A., D.K. Bhatachharya and L.R. Nanda, 2010. Management of with Integration of chemicals, botanicals and bio-pesticide. J. Plant Prot. Env. **7**(1):38.

Satpathi, C. R., A. M. Raut and K. Krishnaiah, 2016. Auto confusion technology-An innovative and novel method of use of pheromone for management of rice yellow stem borer *Scirpophaga incertulas* (Walker) in Eastern India. Int. J.Plant, Animal Env. Sci. **7** (1). 1-10.

Sawant, A., K. Krishnaiah, A. Cork, and S. Mehendale, (1995) Control of stem borer through pheromone mediated mass trapping. Proceedings of the Indo-British Workshop on Current Approaches to Pheromone Technology. *eds*. N.S. Narsimhan,S. Narasimhan, G. Suresh and S. Madhavan. SPIC Science Foundation, Madras, India. pp. 44-48.

Shilpa, D., K. L. Naik and B. B. Hosetti, 2018. Population dynamics of yellow stem borer *Scirphophaga incertulas*(Walker) on rice (*Oryza sativa*): Using sex pheromone trap at Shimoga District, Karnataka. Int. J. Sci. Eng. Inv. **7:**17-22.

Shrirame, M.D., H.J. Rajgire and A.H. Rajgire, 2000. Effect of spacing and seedling number per hill on growth attributes and yield of rice hybrids under lowland condition. J. Soils and Crops. **10**(1):109-113.

Singha,S.S. and V. Pandey, 1997. Relative susceptibility of rice germplasm to yellow stem borer, *Scirpophaga incertulus.* Ind. J. Entomol. **59**(3):257-262.

Sithanantham, S., M. Prabakaran, B. Bhavani, K. Jhansi, P. Vijayaprasd, V. Babu, V. V. Punnarao and N. Kannanraja, 2019. Multi-location test of alternative pheromone trap designs for sugarcane early shoot borer in south India. Sugar Tech. **21**: 1-7.

Yarasi, B., V. Sadumpati, C. P. Immanni, D. R. Vudem and V. R. Khareedu, 2008.Transgenic rice expressing *Allium sativum* leaf agglutinin (ASAL) exhibits high-level resistance against major sap-sucking pests. Plant Bio.**8**:102-115

Rec. on 01.05.2023 & Acc. on 17.05.2023