Archives of Agriculture and Environmental Science 8(2): 112-115 (2023)
https://doi.org/10.26832/24566632.2023.080203

e-ISSN: 2456-6632

This content is available online at AESA

Archives of Agriculture and Environmental Science

Journal homepage: journals.aesacademy.org/index.php/aaes

ORIGINAL RESEARCH ARTICLE

Efficacy of eco-friendly insecticides against yellow stem borer under spring rice crop ecosystem of Saptari district, Nepal

Sonam Sah* and Rohit Sharma

Department of Entomology, G.P Koirala College of Agriculture and Research Center, Gothgaun, Morang, NEPAL
*Corresponding author's E-mail: shahsonam748@gmail.com

ARTICLE HISTORY

Received: 25 December 2022
Revised received: 01 June 2023
Accepted: 10 June 2023

Keywords

Bacillus thuringiensis
Eco-friendly insecticides
Neembicide
Scirpophaga incertulas
Yellow stem borer

ABSTRACT

The study aimed to assess the effectiveness of eco-friendly insecticides in controlling yellow stem borer in spring rice crops of Hardinath-1 variety in Saptari district, Nepal. For this experiment, a Randomized Block Design was used with seven different treatments and an untreated control group. The treatments tested included *Bacillus thuringiensis var kurtaski*, *Beauveria bassiana*, *Azadiractin* 2.00%, garlic extract, tobacco extract, larvosin, and an untreated plot. The plots used were 3 × 4 meters in size and the plants were spaced 20 centimeters apart in both rows and between plants. The crop was sprayed twice, once during the vegetative stage and once during the reproductive stage, when the pest population reached a certain level. The incidence of dead heart was observed on ten randomly selected hills from each plot before and after the insecticide application, and observations on yellow stem borer incidence were recorded. Results showed that *B. thuringiensis var kurtaski* had the lowest dead heart infestation (0.4889%) and the minimum white head infestation (0.367%), as well as the highest mean yield (5.755mt/ha). Neembicide and *B. bassiana* also showed promising results.

Citation of this article: Sah, S., & Sharma, R. (2023). Efficacy of eco-friendly insecticides against yellow stem borer under spring rice crop ecosystem of Saptari district, Nepal. *Archives of Agriculture and Environmental Science*, 8(2), 112-115, https://dx.doi.org/10.26832/24566632.2023.080203

INTRODUCTION

Rice (*Oryza sativa* L.) is a crucial food source for over 3.5 billion people worldwide, with China and India being the top producers (Singh *et al*., 2015; Rajput *et al*., 2020). Approximately 165 million hectares of land are dedicated to rice farming worldwide, which results in a total output of 750 MT, according to IRRI (2019). China and India rank as the top two rice-producing countries globally, with 214 MT and 172 MT production, respectively, as reported by USDA (2018) and Pokhrel *et al*. (2021). According to MoALD's report from 2020, Nepal cultivates this crop on 1.46 million hectares of land, resulting in a total production of 5.55 million tons, with an average yield of 3.80 tons per hectare (MoALD, 2020). Nepal's domestic demand for rice is not met by the current level of production, and as a result, the country has to import a substantial quantity of milled rice each year, which costs NRs 25.7 billion (MoALD, 2020; Madhu *et al*., 2020).

Rice production is under constant threat from both biotic and abiotic stress factors, which can cause a decline in both quantity and quality. Kumari *et al*. (2019) reported that although there are approximately 100 insect species that can harm rice, only 20 of them have a notable economic impact. The yellow stem borer (YSB), which is considered the most harmful pest of tropical rice insects, is a biotic stress that can cause yield losses ranging from 10 to 60% reported by Chatterjee and Mondal (2014) and Estiati (2020). The yellow stem borer is a significant pest that primarily affects rice crops grown in low-lying, flood-prone, and rain-fed areas. According to Singh and Chatterjee (2021), this pest is responsible for a global loss in rice production of approximately 10 million tons, and almost half of all insecticides used are for its control. The yellow stem borer insect can result in two types of damage to rice crops: "dead hearts" when it attacks during the tillering stage and "white ear heads" when it attacks during the reproductive stage. Farmers tend to use synthetic pesticides extensively to control this insect due to their broad-spectrum action, cost-effectiveness, and quick action (Singh and Choudhary, 2018; Kumari *et al.*, 2019). However, the excessive use of synthetic chemicals can harm the agroecosystem, human health, and wildlife. Therefore, this study aims to address the negative impacts of synthetic insecticides and develop an environmentally responsible approach to managing the yellow stem borer in rice production.

MATERIALS AND METHODS

A field trial was carried out in a farmer's field located in Rupani bazar, Saptari, Nepal, between the second week of January and the third week of June 2022. The study focused on the Hardinath-1 variety of spring rice, which is commonly cultivated by farmers in the area. A randomized block design was employed, with seven treatment groups and an untreated control group, all replicated three times. The trial was conducted using 3 × 4 m plots, with a spacing of 20 cm between rows and 20 cm between plants. The experiment involved seven different treatment groups: T_1 involved the use of *Bacillus thuringiensis var krustaki* at a rate of 2ml/l, T_2 and T_3 involved the application of garlic and tobacco extracts at a rate of 15ml/l, respectively, T_4 used Larvosin at a rate of 3ml/l, T_5 involved the use of Azadirachtin 2.00% at a rate of 2ml/l, T_6 utilized *Beauveria bassiana* 1.15% W.P. at a rate of 2g/l, while T_7 was an untreated control plot. Two applications of insecticides were administered to the crops: one during the vegetative stage and the other during the reproductive stage, timed with the pest population reaching its economic threshold level. Before the application of insecticides, the incidence of dead heart was observed on ten randomly selected hills from each plot, and the same was observed seven days after the application of insecticides as a post-treatment observation. The incidence of yellow stem borer was also recorded during these observations. The percentage of dead hearts and white heads was calculated, and the mean was determined. The mean values of dead hearts and white heads for each treatment group were compared with those of the untreated control plot, and the Percentage Reduction Over Control (PROC) was calculated. The percent reduction in dead hearts and white heads over the control was calculated using the formula provided by Khosla (1997).

$$PROC = X_2 - X_1 / X_2 \times 100$$

Where, X_1= the mean value of treated plots
X_2= the mean value of untreated plot

The crop was harvested when about 90% of the crops had reached 85% maturity stage, and crop cutting was conducted. Moisture content of the harvested crops was measured using a moisture meter, and the yield was calculated from the 1m^2 sections of each plot. The yield weight was measured and recorded. Test weight was determined when the harvested rice reached a dry moisture content of 12%, and 1000 seeds were counted and weighed using a weighing machine to calculate the test weight.

Test weight = Weight of 1000 seeds
The collected data were analyzed using the statistical software Gen Stat (15th version) through ANOVA. The mean values of dead heart and white head were subjected to statistical analysis after being transformed into square root values, while the percentage of filled and unfilled grains were transformed into arc sign values following the method recommended by Gomez and Gomez (1984). Mean comparisons were made among the significant variables using Fisher-LSD at a significance level of 5%.

RESULTS AND DISCUSSION

Tables 1 and 2 present the outcomes of the experiment on the impact of environmentally friendly insecticides on dead heart and white head caused by the yellow stem borer on spring rice. The findings indicate that *Bacillus thuringiensis var kurtaski* resulted in the lowest dead heart infestation (0.4889%), followed by Neembicide (0.5776%). *B. thuringiensis var kurtaski* also had the lowest white head infestation (0.367%), followed by *Beauveria bassiana* (0.544%). The results demonstrated that the use of *B. thuringiensis var kurtaski* resulted in the highest yield (5.755mt/ha) compared to other treatments, followed by Tobacco extract (4.983mt/ha) (Table 3). *B. thuringiensis ssp. kurstaki* and *aizawai* are known for their strong activity against lepidopteran larval species (Estiati, 2020; Kumari *et al.*, 2019). The toxins produced by *B. thuringiensis* can cause damage to the gut tissues of the larvae, resulting in gut paralysis. This, in turn, leads to a cessation of feeding and ultimately the death of the larvae due to starvation and mid-gut epithelium impairment (Chatterjee and Mondal, 2014). Commercial formulations containing *B. thuringiensis* have been shown to be an effective alternative for controlling other insect pests (Balasubramamiam and Kumar, 2019; Hashemitassuji *et al.*, 2015). Singh *et al.* (2015) found that using nimbecidine at 300 ppm and 3 liters per hectare resulted in lower dead heart and white ears in the reproductive stage, with an increased yield of 5.30 tons per hectare compared to the untreated check. Other studies, conducted by Singh and Choudhary (2018) and Madhu *et al.* (2020) also found that neem oil is an effective treatment against yellow stem borer. The results obtained in this study are consistent with the findings of previous studies by Prasad *et al.* (2004) reported the effectiveness of neem products in controlling the yellow rice stem borer (Ogah *et al.*, 2011). Julien suggested that neem pesticide is effective as it disrupts the metabolism of insects, causing female infertility and disrupting the molting process. It also possesses antifeedant properties (Hashemitassuji *et al.*, 2015).
Several studies have shown the effectiveness of Bt against YSB. For example, in a field trial conducted in the Philippines, the use of Bt significantly reduced YSB infestation and resulted in a 50% increase in yield compared to the control. Another study conducted in China found that Bt application reduced YSB infestation by 60-80% and resulted in a yield increase of 7-12%. Bt is easy to apply and can be used in different forms, such as

Table 1. Effect of treatments on mean dead heart of spring rice at Rupani, Saptari during 2022.

		Dead hearts					
S.N.	Treatment	Day before 1st spray	7 DAS	14DAS	21DAS	Pooled Value	PROC of mean dead heart
1	Garlic extract	1.500 ^{b} (1.402)	0.8333^{ab} (1.154)	0.5333^{bc} (1.015)	0.7333^{b} (1.110)	0.6997 (1.093)	45.71
2	Tobacco extract	1.167 ^{b} (1.270)	0.5000^{b} (0.997)	0.7667abc (1.125)	0.9333^{b} (1.197)	0.733 (1.1063)	43.129
3	*B.thuringiensis var kurtaski*	2.433ab (1.703)	0.5667^{b} (1.023)	0.2667^{c} (0.873)	0.6333^{b} (1.061)	0.4889 (0.98567)	62.068
4	Larvosin	4.200 ^{a} (2.129)	1.0333^{ab} (1.237)	0.3333^{c} (0.906)	0.4333^{b} (0.957)	0.5996 7 (1.033)	53.474
5	DADA Guard plus (Neembicide)	1.600^{b} (1.431)	0.5000^{b} (0.992)	0.6000^{bc} (1.047)	0.6333^{b} (1.056)	0.5776 (1.03167)	55.186
6	*B. bassiana*	2.200ab (1.622)	1.4333^{a} (1.375)	1.3333^{a} (1.348)	0.9333^{b} (1.196)	1.2333 (1.3063)	4.313
7	Control	1.133 ^{b} (1.245)	1.0000^{ab} (1.221)	1.0000^{ab} (1.208)	1.8667^{a} (1.531)	1.2889 (1.32)	-
8	LSD(0.05)	2.044	0.5868	0.5838	0.5463		
9	S.E.M	0.663	0.1904	0.1895	0.1773		
10	F-probability	Ns	*	*	**		
11	CV(%)	21.7	11.7	13.2	11.1		

Figure in the parenthesis are square root transformed value. Values are mean of three replications at different day of observation; PROC: Percentage over control CV: Coefficient of variation; ns: non-significant; **: Significant at 0.05% level of significance; LSD: Least Significant Difference; Values with the same letters in a column are not significantly different at 5% level significance by Fisher-LSD test and figures in the parenthesis indicate square root transformation values.

Table 2. Effect of treatments on white head of spring rice at Rupani, Saptari during 2022.

		White heads				
S.N.	Treatment	7DAS	14DAS	21DAS	Pooled value	PROC of mean white head
1	Garlic extract	0.7667^{bc} (1.122)	0.933bc (1.193)	1.167^{bc} (1.289)	0.956 (1.201)	43.764
2	Tobacco extract	0.4000^{c} (0.942)	0.867^{bc} (1.167)	0.600cd (1.038)	0.623 (1.049)	63.352
3	*B. thuringiensis var kurtaski*	0.3000^{c} (0.887)	0.367^{c} (0.917)	0.433^{d} (0.945)	0.367 (0.916)	78.411
4	Larvosin	1.4000^{a} (1.376)	1.600^{a} (1.445)	1.800^{ab} (1.515)	1.6 (1.445)	5.882
5	DADA Guard plus (Neembicide)	1.1667^{ab} (1.289)	1.367^{ab} (1.365)	1.567^{ab} (1.436)	1.367 (1.364)	19.588
6	*B. bassiana*	0.4000^{c} (0.942)	0.500^{c} (0.994)	0.733cd (1.109)	0.544 (1.015)	68
7	Control	1.5000^{a} (1.407)	1.700^{a} (1.477)	1.900^{a} (1.544)	1.7 (1.476)	
8	LSD(0.05)	0.5708	0.6163	0.6393		
9	S.E.M	0.1852	0.2000	0.2075		
10	F-probability	**	**	**		
11	Cv (%)	12.0	11.6	11.7		

Figure in the parenthesis are square root transformed value. Values are mean of three replications at different day of observation; PROC: Percentage over control CV: Coefficient of variation; ns: non-significant; **: Significant at 0.05% level of significance; LSD: Least Significant Difference; Values with the same letters in a column are not significantly different at 5% level significance by Fisher-LSD test and figures in the parenthesis indicate square root transformation values.

sprayable formulations and granules. However, the efficacy of Bt depends on several factors such as timing of application, dosage, and frequency of application. In addition, the use of Bt may not be effective against YSB populations that have developed resistance to the insecticidal proteins produced by the bacterium. *B. thuringiensis var kurtaski* was found to be the best eco-friendly insecticide against rice yellow stem borer, reducing the incidence of the insect and lowering the occurrence of dead heart and white head in the field, while also producing better yield results compared to other insecticides. However, the efficacy of the insecticides was affected by environmental factors such as temperature, relative humidity, and rainfall, which led to an increase in pest incidence even after the treatments were applied (Hashemitassuji *et al.*, 2015).

Table 3. Effect of treatments on yield and yield attributing characters of spring rice at Rupani, Saptari during 2022.

Treatment	Mean plant height (cm)	Filled grain (%)	Unfilled grain (%)	Test weight (g)	Yield (mt/ha)
Garlic extract	92.83	73.07^{ab} (58.92)	26.93^{ab} (31.08)	20.33	4.240
Tobacco extract	88.30	75.13^{ab} (60.10)	24.87^{ab} (29.90)	20.33	4.983
B. thuringiensis var kurtaski	88.07	77.07^{a} (61.41)	22.93^{b} (28.59)	24.33	5.7553
Larvosin	93.83	67.83^{b} 55.49)	32.17^{a} (34.51)	20.33	4.100
DADA Guard plus (Neembicide)	91.67	74.07^{ab} (59.46)	25.93^{ab} (30.54)	22.33	4.933
B. bassiana	88.90	73.43^{ab} (59.00)	26.57^{ab} (31.00)	21.00	4.037
Control	89.57	73.00^{ab} 58.74)	27.00^{ab} (31.26)	19.67	3.767
LSD(0.05)	10.13	4.977	4.977	7.395	0.2412
S.E.M	3.29	1.615	1.615	2.400	0.0783
F-probability	Ns	ns	ns	ns	Ns
CV (%)	6.4	4.7	9	19.6	29.8

Figures in the parenthesis indicate arcsine transformation values. Values are mean of three replications; CV: Coefficient of variation; ns: non-significant; LSD: Least Significant Difference; Values with the same letters in a column are not significantly different at 5% level significance by Fisher LSD test.

Conclusion

All the used insecticides somehow controlled the pest but *B. thuringiensis var. kurtaski* gave the best result. In conclusion, the use of *Bt* is a promising alternative to chemical pesticides for controlling YSB. It is safe, effective, and environmentally friendly. However, the efficacy of the insecticides was influenced by the environmental factors. The factors like temperature, relative humidity and rainfall had affected in the pest population due which there was increment in the incidence of pest even after the application of the treatments. However, proper management practices and monitoring of YSB populations are necessary to ensure the long-term effectiveness of Bt. Further research is needed to explore the potential of *Bt* in controlling other pests and its integration with other pest management strategies.

REFERENCES

Balasubramamiam, M., & Kumar, K. (2019). Bioefficacy of neem formulations against the rice yellow stem borer, *S. incertulas* (Walk.). *7*(3), 1145–1149.

Chatterjee, S., & Mondal, P. (2014) Management of rice yellow stem borer, *Scirpophaga incertulas* Walker using some biorational insecticides. Management of rice yellow stem borer, *Journal of Biopesticides 7*, 143-147.

Estiati, A. (2020). Development of Bt rice potential for yellow stem borer control. *Journal of Crop Science and Biotechnology*, *23*(5), 395–403, https://doi.org/10.1007/s12892-020-00025-w

Hashemitassuji, A., Safaralizadeh, M. H., Aramideh, S., & Hashemitassuji, Z. (2015). Effects of *Bacillus thuringiensis* var. kurstaki and Spinosad on three larval stages 1st, 2nd and 3rd of tomato borer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) in laboratory conditions. *Archives of Phytopathology and Plant Protection*, *48*(5), 377–384, https://doi.org/10.1080/03235408.2014.893630

IRRI (2019). http://books.irri.org/AR2019_content.pdf

Khosla, R. K. (1977). Techniques for assessment of losses due to pests and diseases of rice. *Indian Journal of Agricultural Sciences*, *47*(4), 171-174.

Kumari, P., Prasad, R., Kumari, S. Yadav, M., D., Prasad, R., & Prasad, D. (2019). Bioefficacy of some botanical and chemical insecticides against yellow stem borer *Scirpophaga incertulas* (Walk.) In rice field at Jharkhand. *Journal of Pharmacognosy and Phytochemistry*, *2*, 200–203.

Madhu, B., Warghat, A. N., & Tayde, A. R. (2020). Comparative effect of bio pesticides and neem commercial products on rice yellow stem borer, *Scirpophaga incertulas* (Walker). *Journal of Entomology and Zoology Studies*, *8*(1), 758–760. http://www.entomoljournal.com

MoALD, (2020). Statistical Information on Nepalese Agriculture 2018/2019. Agri Statistics

Section, Monitoring, Evaluation and Statistics Division. Singha Durbar, Kathmandu, Nepal: Ministry of Agricultural Development.

Ogah, O., Omoloye, A., Nwilene, F., & Nwogbaga, A. (2011). Effect of neem seed kernel extracts in the management of rice stem borers in the field in Nigeria. *Nigerian Journal of Biotechnology*, *23*, 13–21.

Pokhrel, A., Dhakal, S., Kafle, R., & Pokhrel, A. (2021). Adoption status of improved production technology in rice cultivation in Kanchanpur, Nepal. *Archives of Agriculture and Environmental Science*, *6*(2), 178–185, https://doi.org/10.26832/24566632.2021.060209

Prasad, S. S., Gupta, P. K., & Kanaujia, B. L. (2004). Simulation study on yield loss due to *Scirpophaga incertulas* on semi deep water rice. *Annuals of Plant Protection Sciences*, *15*, 491492

Rajput, V. S., Jhala, J., & Acharya, V. (2020). Biopesticides and their mode of action against insect pests: A review. *International Journal of Chemical Studies*, *8* (2), 2856–2862, https:/doi.org/10.22271 chemi.2020.v8.i2ar.9184

Singh, B., & Chatterjee, S. (2021). Relative efficacy of some biorational and microbial insecticides against yellow stem borer and whorl maggot of boro paddy. *Journal of Biopesticides*, *14*(2),90–96.

Singh, P., Dhaka, R. S., Kumar, S. S., Kumar, D., & Kumari, H. (2015). Bioefficacy of insecticides and bio-pesticides against yellow stem borer, *Scirpophaga incertulus* (Walk.) and their effect on spiders in rice crop. *South Asian Journal of Food Technology and Environment*, *1*(2), 179-183.

Singh, P., & Choudhary, P. K. (2018). Efficacy of *Bacillus thuringiensis* against yellow stem borer in rice: A review. *International Journal of Current Microbiology and Applied Sciences*, *7*(4), 2249-2258.