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Field Efficacy of botanical Insecticides against *Scirpophaga incertulas* Walker Infesting Paddy

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ABSTRACT

This study evaluated the field efficacy of various botanical insecticides against the rice yellow stem borer (Scirpophaga incertulas) during the 2016-2017 seasons. Results indicated that Achook (Azadirachtin 0.03% EC) consistently demonstrated the lowest incidence of dead heart (1.91%) and 2.50%) and white ear damage (2.89% and 3.59%) consequently during both the year compared to other insecticides and the untreated control. In both 2016 and 2017, Achook significantly reduced DH incidence to levels statistically comparable to rynaxypyr 20 SC and dinotefuran 20 SG, outperforming other botanicals such as Neem Baan, Neemazal, pongamia oil, and Nimbecidine. Similar trends were observed in WE incidence, with Achook showing the lowest damage, aligning closely with the chemical insecticides. Achook (Aza. 0.03%) provided the highest incremental grain yield (42.08 q/ha) and net profit (Rs 26,133.2/ha), outperforming other treatments such as Rynaxypyr 20 SC and Dinotefuran 20 SG. While Dinotefuran 20 SG showed the lowest cost of protection (Rs 994/ha) and the highest benefit-cost ratio (24.82:1), neem-based products also demonstrated significant yield increases over untreated plots. The pooled data over two years also revealed that all botanical insecticides were significantly more effective in controlling DH and WE compared to untreated plots. Overall, all botanical insecticides were significantly more effective than the untreated control plot.

Keywords: *Botanical insecticides; Efficacy; yellow stem borer; Dead heart; White ear, Scirpophaga incertulas and Economics*

Introduction

Rice is the most important staple food for over half of the world's population, serving as a primary source of calories and protein [13]. It is grown under diverse ecosystems such as flooded, irrigated, rainfed lowland and upland conditions on approximately 167.25 million hectares globally [3 and 17], making it the top food crop in terms of dietary intake worldwide. Asia alone accounts for about 90% of the world's rice cultivation and production. India, with 28% of the global rice cultivation area, has the largest area dedicated to rice but ranks second in production after China [19]. In India, rice is grown on 43.388 million hectares, producing 104.32 million tonnes with an average yield of 2404 kg per hectare [1].

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Major rice-producing states include Uttar Pradesh, West Bengal, Andhra Pradesh, Chhattisgarh, and Bihar. Bihar ranks fifth, cultivating rice on 3.268 million hectares and producing 6.377 million tonnes [5]. Worldwide, around 52 per cent of rice production is lost yearly due to biotic agents, of which 21 per cent is attributed to insect pests [20].

Rice is susceptible to over 100 insect species, with 20 of them posing a significant economic threat. Among the pests that affect rice, the yellow stem borer (YSB) is the most destructive. This pest is active from April to October, while it hibernates from November to March as a fully-grown larva in rice stubble. When rice plants are attacked in the early stages, they produce empty ears without grain. The extent of yield losses in rice due to YSB has been estimated as 20-70 per cent [14 and 18]. In the state of Jharkhand, yield losses from YSB have been reported to range from 10-30% [11]. Various insecticides have been tested for their effectiveness against YSB, with many studies reporting their relative efficacy. However, over-reliance on chemical pesticides and their excessive, unchecked use has raised environmental and health concerns, making alternative pest

control methods essential. Botanical insecticides offer an eco-friendly and effective solution, presenting lower risks to the environment and human health. Therefore, this study aims to evaluate and compare the efficacy of botanical insecticides in controlling yellow stem borer in rice fields.

Materials and Methods

Field trial on efficacy of botanical insecticides against yellow stem borer of rice was conducted at Rice Research Farm, Birsa Agricultural University, Kanke, Ranchi, Jharkhand during *kharif* season in the year 2016 and 2017. The experimental plot was situated at 23°17' North latitude and 82°19' East longitude an altitude of 625 mt (location map 1) in randomised block design with ten treatments (table 1) including untreated check and three replications. Plot size was kept 20 m^2 with row spacing of 15 cm. The rice variety IR-8 was sown in July, 2016 and 2017 and raised as per the recommended package of practices. Each of the nine botanical insecticides was applied twice as a foliar spray over the standing crop of rice starting forty days after the transplanting (40 DAT) for the control of the dead heart and ninety days after transplanting (90 DAT) for the control of white ear. Observations were recorded on total number of dead hearts (DH) and total no. of tillers (DH + healthy tillers) also white ear observation were recorded from the total no. of the white ear (WE) and total no. of panicles (WE+ healthy panicles) from 10 randomly selected hills at 4th, 7th and 10th days after each spray (DAS) of botanical insecticides

The formulae used for calculating per cent dead heart and white ear are given below-

$$\text{Per cent dead heart} = \frac{\text{Total no. of dead hearts (DH) in 10 hills}}{\text{Total no. of tillers (DH + healthy tillers) in 10 hills}} \times 100$$

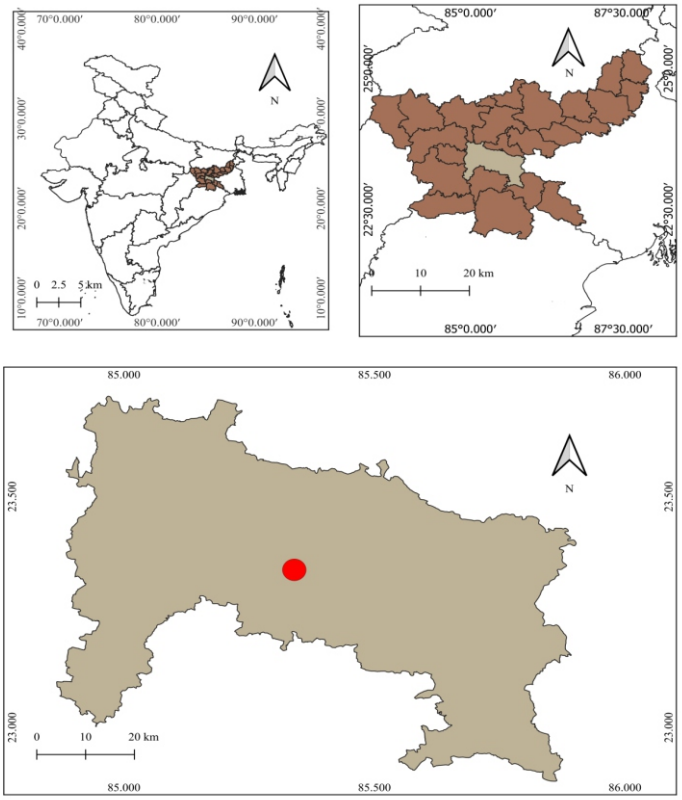
$$\text{Per cent white ear} = \frac{\text{Total no. of white ear (WE) in 10 hills}}{\text{Total no. of panicles (WE+ healthy panicles) in 10 hills}} \times 100$$

The data on yield were also recorded from each plot. Additionally, per cent increase in yield was also calculated.

The benefit-cost ratio was also calculated for each botanical insecticide and bio-pesticide. The formulae used for calculating per cent increase in yield is given below-

$$\text{Per cent increase in yield} = \frac{\text{Increased yield in treatment plot}}{\text{Yield in control plot}} \times 100$$

Data were subjected to analysis of variance after transformation of data as per the procedure suggested by Gomez and Gomez [10] through SPSS software (version 29.0).



Location map : 1

Table: 1 Details of selected commercial formulations of botanical insecticides

Treatments	Botanicals/Insecticides	Formulation	Dose ml or g/l of water
T 1	Neem Baan	1 % EC	2 ml
T 2	Neemazal	1 % EC	2 ml
T 3	Nimbecidine	0.03 % EC	5 ml
T 4	Multineem	0.03 % EC	5 ml
T 5	Neemoil	-	5ml
T 6	Achook	0.03 % EC	5 ml
T 7	Pongamia oil (karanj oil)	-	5ml
T 8	Dinotefuran*	20 SG	0.5 g
T 9	Rynaxypyr*	20SC	0.3 ml
T 10	Untreated Contol	-	-

Results and Discussion

Field efficacies of different botanical insecticides against rice yellow stem borer during 2016-2017

Results on relative field efficacy of different botanical insecticides against rice yellow stem borer during 2016-2017 are presented in Table 2. It had been observed that the overall mean of dead heart (DH) incidence recorded at 4, 7, and 10 days after application (DAA) during 2016 and 2017 showed a significant effect of treatments. In 2016, Achook (Aza. 0.03% EC) exhibited the lowest DH incidence which was found to be 1.91%, performing significantly better than all tested insecticides, although it was statistically at par with rynaxypyr 20 SC (2.49% DH) and dinotefuran 20 SG (2.68% DH), followed by Neem Baan (Aza. 1% EC) at 2.92% DH and Neemazal (Aza. 1% EC) at 3.22% DH. The highest DH incidence of 9.52% was observed in the untreated crop. In 2017, similar trends were observed, with Achook (Aza. 0.03% EC) again recording the lowest DH at 2.50%, comparable to rynaxypyr 20 SC (3.08% DH) and dinotefuran 20 SG (3.26% DH), followed by Neem Baan (Aza. 1% EC) at 3.51% DH, Neemazal (Aza. 1% EC) at 3.83% DH, pongamia oil (4.04% DH), and Nimbecidine (Aza. 0.03% EC) at 4.29% DH.

The unprotected crop recorded the highest DH damage at 9.88%. In both years, all botanical insecticides were significantly more effective than the untreated control. The overall mean incidence of white ear (WE) recorded at the dough and pre-maturity stages during 2016 and 2017 demonstrated a significant impact of botanical insecticides (Table 2). In 2016, rice plants treated with Achook (Aza. 0.03% EC) exhibited the lowest WE incidence at 2.89%, which was superior to all other tested insecticides, although statistically on par with rynaxypyr 20 SC (3.38% WE), dinotefuran 20 SG (3.65% WE), and Neem Baan (Aza. 1% EC) (3.97% WE). The untreated control plot showed the highest WE damage at 11.53%. In 2017, similar results were observed, with Achook (Aza. 0.03% EC) again recording the lowest WE incidence at 3.59%, comparable to rynaxypyr 20 SC (4.09% WE), dinotefuran 20 SG (4.36% WE), and Neem Baan (Aza. 1% EC) (4.67% WE). The highest WE damage was recorded at 12.23% in the untreated control plot. In both years, the botanical insecticides proved significantly more effective in reducing WE incidence compared to the untreated control.

The findings of the present investigation are in close agreement with the findings of [12] who reported that neem formulations viz. Nimbecidine, Neemark, Neem Gold, Econeem, Neemzal and Fortune were statistically at par with chlorpyriphos in terms of suppression in the incidence of stem borer, hispa and leaf folder infesting rice varieties, Kasturi and Basmati. The similar observations were also obtained by [6, 4 and 11].

Field efficacies of different botanical insecticides against rice yellow stem borer for pooled data

The pooled mean incidence of dead heart (DH) caused by yellow stem borer, recorded at 4, 7, and 10 days after application (DAA) during 2016 and 2017, showed a significant effect of botanical and chemical insecticides (Table 3). At 4 DAA, Achook (Aza. 0.03% EC) recorded the lowest DH incidence at 1.28%, which was superior to most of the tested insecticides, followed by rynaxypyr 20 SC (1.82% DH), dinotefuran 20 SG (1.91% DH), and Neem Baan (Aza. 1% EC) (2.13% DH). The untreated crop exhibited the highest DH incidence at 8.28%. At 7 DAA, Achook again showed the lowest DH incidence at 2.20%, followed by rynaxypyr 20 SC (2.80% DH), dinotefuran 20 SG (2.97% DH), and Neem Baan (Aza. 1% EC) (3.17% DH), while the unprotected crop recorded 9.56% DH incidence. Finally, at 10 DAA, Achook (Aza. 0.03% EC) continued to show the lowest DH incidence at 3.14%, statistically similar to rynaxypyr 20 SC (3.75% DH), and followed by dinotefuran 20 SG (4.02% DH), Neem Baan (Aza. 1% EC) (4.34% DH), and Neemazal (Aza. 1% EC) (4.68% DH). The highest DH incidence was observed in the untreated crop at 11.27%. Across all observation periods, all botanical insecticides demonstrated significantly greater efficacy in reducing DH incidence compared to the untreated control.

The pooled mean incidence of white ear (WE) caused by yellow stem borer at the dough and pre-maturity stages during 2016 and 2017 revealed significant differences among treatments (Table 3). At the dough stage, plants treated with Achook (Aza. 0.03% EC) recorded the lowest WE incidence at 2.80%, which was superior to most other tested insecticides, though statistically on par with rynaxypyr 20 SC (3.30% WE). This was followed by dinotefuran 20 SG (3.57% WE), Neem Baan (Aza. 1% EC) (3.89% WE), and Neemazal (Aza. 1% EC) (4.22% WE). The untreated control exhibited the highest WE incidence at 11.03%.

At the pre-maturity stage, Achook again demonstrated the lowest WE incidence at 3.68%, comparable to rynaxypyr 20 SC (4.17% WE) and dinotefuran 20 SG (4.44% WE), followed by Neem Baan (Aza. 1% EC) (4.75% WE), Neemazal (Aza. 1% EC) (5.09% WE), and pongamia oil (5.48% WE). The unprotected crop recorded the highest WE incidence at 12.73%. Across both stages, all botanical insecticides showed significantly greater efficacy in reducing WE incidence compared to the untreated control.

Dhuyo and Soomro (2007) [17] conducted a field experiment using neem seed kernel extract against rice yellow stem borer and found that comparable lowest dead heart was present in comparison to untreated control. Similarly, [11] did a field experiment using botanicals and chemical insecticides and found that Fipronil (Neema 50SC) and neem extract caused 51.89% and 38.38% reduction of dead hearts respectively. Chakraborty *et al.,* (2011) [15] earlier reported that application of botanical insecticides and recorded on yellow stem borer were found to fall in line with those findings of the present investigation indicating that maximum efficacy. [15] also suggested that neem extract can be a suitable alternate option for synthetic pesticide for controlling rice stem borer without disrupting agro-ecosystem. [2] revealed that, among the neem formulations, the treatment with Multineem 1.0% EC @ 2500 ml/ha recorded lower yellow stem borer damage.

The two-year pooled mean yield of rice recorded during the kharif seasons of 2016 and 2017 (Table 3) indicated that the highest grain yield (49.70 q/ha) was achieved through foliar spray with Achook (Aza. 0.03% EC), providing effective protection against the major insect pest complex. This yield was significantly higher than the lowest yield of 34.98 q/ha observed in the unprotected crop. The yield achieved with Achook was statistically on par with rynaxypyr 20 SC (48.50 q/ha) and dinotefuran 20 SG (47.75 q/ha), followed by Neem Baan (Aza. 1% EC) (46.40 q/ha), Neemazal (Aza. 1% EC) (45.67 q/ha), pongamia oil (44.72 q/ha), and Nimbecidine (Aza. 0.03% EC) (43.98 q/ha). Previous studies, such as those by [7], have also highlighted the efficacy of botanical insecticides in enhancing rice yield. Dhaliwal's findings reported a higher rice yield of 50.50 q/ha with monocrotophos and 46.4 q/ha using Neemazal, compared to the minimum yield of 34.3 q/ha in the unprotected crop. These results are consistent with the present study, underscoring the effectiveness of botanical insecticides in improving rice yield. Despite limited literature on the bio-efficacy of botanical insecticides and their impact on rice yield, the current study aligns with these findings, demonstrating that botanical formulations can significantly enhance grain yield compared to unprotected crops.

Economics of different botanical insecticides against rice yellow stem borer

Data on economics of different treatments are presented in Table 3. The grain and straw yield among the different treatments were found to be ranging from 34.96 to 49.70 q ha^{-1} and 45.47 to 64.61 q ha^{-1} respectively. All the botanicals were found to be significantly superior in increasing the yield over untreated check. The maximum incremental grain yield (42.08 q ha^{-1}) was obtained with the application of Achook 0.03 % followed by Rynaxypyr 20 SC (38.65 q ha^{-1}) and Dinotefuran 20 SG (36.51 q ha^{-1}). Similarly, the maximum cost of incremental grain yield (Rs 25760 ha^{-1}) was obtained with Achook 0.03 % followed by Rynaxypyr 20 SC (Rs 23600 ha^{-1}) and Dinotefuran 20 SG (Rs 22347.5 ha^{-1}).

Neem oil registered minimum cost of incremental yield (Rs 10395 ha -1) and it was followed by Multineem 0.03 % EC (Rs 11935 ha^{-1}) and Neembecidine 0.03 % EC (Rs 15750 ha^{-1}). The cost of protection was lowest (Rs 994 ha^{-1}) for Dinotefuran 20 SG followed by Karanj oil (Rs 1704 ha^{-1}) and Neem oil (Rs 2204 ha^{-1}). However, the maximum cost of protection (Rs 3704 ha^{-1}) was obtained for Neembecidine 0.03 % EC followed by Achook 0.03 % (Rs 3454 ha^{-1}) and Rynaxypyr 20 SC (Rs 3004 ha^{-1}). Based on cost of protection, the maximum net profit (Rs 26133.2 ha^{-1}) was obtained with Achook 0.03 % followed by Dinotefuran 20 SG (Rs 24673.7 ha^{-1}) and Rynaxypyr 20 SC (Rs 24171.2 ha^{-1}). However, the lowest net profit (Rs 9735.4 ha^{-1}) was obtained with the use of Neem oil and it was followed by Neembecidine 0.03 % EC (Rs 14386 ha^{-1}) and Multineem 0.03 % EC (Rs 11004.2 ha^{-1}). The benefit-cost ratio was calculated based on cost of protection wherein Dinotefuran 20 SG resulted in a maximum benefit-cost ratio of 24.82:1 followed by Karanj oil (10.48:1) and Neem Baan (8.20:1). However, the minimum benefit-cost ratio (3.88:1) was obtained with Neembecidine 0.03 % EC followed by Multineem 0.03 % EC (4.06:1) and Neem oil (4.41:1).The findings of this investigation align with those of [12], who reported that neem formulations like Nimbecidine, Neemark, Neem Gold, Econeem, Neemzal, and Fortune were as effective as chlorpyriphos in reducing the incidence of stem borer, hispa, and leaf folder in rice varieties Kasturi and Basmati, resulting in significantly higher grain yields (30-31 q/ha) compared to untreated plots (28 q/ha). Similarly, [6] found that monocrotophos and Neemzal effectively reduced dead heart and white ear incidence, leading to higher grain yields. [15] also suggested that neem extract could be a viable alternative to synthetic pesticides for controlling rice stem borer, and plant hoppers, and increasing rice yield without disrupting the agro-ecosystem.

Conclusion

The results of this study demonstrate that botanical insecticides, particularly Achook (Aza. 0.03%), are highly effective in reducing the incidence of rice yellow stem borer damage, leading to significantly higher grain yields and economic returns compared to untreated controls. Achook consistently outperformed other botanicals and was on par with chemical insecticides like Rynaxypyr 20 SC and Dinotefuran 20 SG in terms of pest control and yield enhancement. The cost-effectiveness and high benefit-cost ratio associated with these treatments further underscore the potential of neem-based formulations as viable, eco-friendly alternatives to synthetic pesticides. These findings support the integration of botanical insecticides into sustainable pest management strategies for rice cultivation.

Future Scope

The future scope of this study includes optimizing botanical insecticide formulations by improving concentration, application methods, and synergistic combinations to enhance efficacy against *Scirpophaga incertulas*. Further research should evaluate the long-term environmental impact on beneficial insects, soil microbiota, and non-target organisms while assessing the degradation patterns of botanical insecticides compared to synthetic alternatives. Resistance management strategies, including integrated pest management (IPM) approaches, need to be developed to mitigate potential resistance in *S. incertulas*. Large-scale multi-location trials across diverse agro-climatic zones and rice varieties will be crucial for assessing the consistency of efficacy. Additionally, economic feasibility studies should focus on cost-effectiveness and farmer adoption, addressing potential barriers to large-scale implementation. Investigating the physiological and biochemical mechanisms underlying the action of Azadirachtin and other botanicals will further elucidate their pest control efficacy and potential secondary benefits, such as induced plant resistance. Finally, integrating botanical insecticides with sustainable agricultural practices, including organic farming and climate-resilient rice cultivation, will contribute to environmentally friendly and economically viable pest management strategies.

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Authors' contributions

Munna Yadav and Rabindra Prasad were involved in the conception and design of the research experiment. Lalbabu Kumar Chaman Kumar and assisted with data recording in the field. Gautam Kunal Awdhesh Kumar, Pankaj Kumar and Dr. Rajendra Prasad contributed to the analysis and interpretation of the data. Mina Kumari, Sneha Kumari and Ashok Pandit helps in drafting the paper.

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

Table: 2 Relative field efficacies of different botanical insecticides against rice yellow stem borer during 2016-2017

Treatment	Formulations	Dose g or ml/ha	2016							2017						
			Percent Dead heart				Percent White ear			Percent Dead heart				Percent White ear		
			4 DAA	7 DAA	10 DAA	Mean	Dough stage	Pre- maturity	Mean	4 DAA	7 DAA	10 DAA	Mean	Dough stage	Pre- maturity	Mean
Neem Baan	1.00	1000 ml	1.83 (7.40)	2.88 (9.22)	4.06 (11.42)	2.92 (9.53)	3.60 (10.64)	4.33 (11.72)	3.97 (11.19)	2.43 (8.61)	3.45 (10.10)	4.63 (12.17)	3.51 (10.43)	4.17 (11.45)	5.17 (12.89)	4.67 (12.20)
Neemazal	1.00	1000 ml	2.13 (8.13)	3.13 (9.80)	4.40 (11.94)	3.22 (10.11)	3.94 (11.16)	4.68 (12.20)	4.31 (11.69)	2.75 (9.24)	3.78 (10.74)	4.97 (12.67)	3.83 (11.00)	4.51 (11.95)	5.51 (13.33)	5.01 (12.66)
Nimbecidine	0.03	2500 ml	2.65 (9.14)	3.37 (10.25)	5.11 (12.92)	3.71 (10.9)	4.63 (12.18)	5.39 (13.18)	5.01 (12.69)	3.27 (10.14)	3.94 (11.06)	5.68 (13.60)	4.29 (11.71)	5.20 (12.91)	6.23 (14.23)	5.71 (13.59)
Multineem	0.03	2500 ml	3.54 (10.71)	3.70 (10.94)	5.49 (13.43)	4.25 (11.76)	4.91 (12.55)	5.77 (13.66)	5.34 (13.12)	4.16 (11.59)	4.27 (11.73)	6.06 (14.09)	4.83 (12.52)	5.48 (13.27)	6.60 (14.68)	6.04 (13.99)
Neemoil	-	2500 ml	3.73 (11.00)	3.82 (11.11)	5.98 (14.04)	4.51 (12.13)	5.24 (12.95)	6.18 (14.18)	5.71 (13.58)	4.34 (11.86)	4.40 (11.89)	6.55 (14.68)	5.10 (12.88)	5.81 (13.65)	7.02 (15.16)	6.41 (14.43)
Achook	0.03	2500 ml	0.97 (4.60)	1.91 (7.18)	2.86 (9.40)	1.91 (7.48)	2.51 (8.69)	3.26 (10.03)	2.89 (9.39)	1.59 (6.72)	2.48 (8.29)	3.43 (10.27)	2.50 (8.59)	3.08 (9.64	4.10 11.39)	3.59 (10.56)
Pongamia oil (karanj oil)	-	2500 ml	2.51 (8.89)	3.25 (10.06)	4.72 (12.41)	3.49 (10.57)	4.30 (11.73)	5.07 (12.77)	4.68 (12.26)	2.99 (9.73)	3.85 (10.93)	5.29 (13.12)	4.04 (11.36)	4.87 (12.48)	5.90 (13.85)	5.39 (13.18)
Dinotefuran	20 SG	200 g	1.62 (6.84)	2.68 (8.85)	3.74 (10.89)	2.68 (9.04)	3.28 (10.09)	4.03 (11.25	3.65 (10.69)	2.20 (8.15)	3.25 (9.77)	4.31 (11.66)	3.26 (9.98)	3.85 (10.93)	4.86 12.47)	4.36 (11.73)
Rynaxypyr	20SC	150 ml	1.50 (6.55)	2.51 (8.51)	3.46 (10.40)	2.49 (8.66)	3.02 (9.61)	3.75 (10.81)	3.38 (10.23)	2.13 (7.92)	3.08 (9.46)	4.03 (11.20)	3.08 (9.64)	3.59 (10.48)	4.58 (12.08)	4.09 (11.32
Untreated control	Water spray	500 lit.	8.14 (16.30)	9.44 (17.61)	10.99 (18.87)	9.52 (17.62)	10.74 (18.60)	12.32 (20.05)	11.53 (19.36)	8.42 (16.36)	9.67 (17.62)	11.56 (19.36)	9.88 (17.82)	11.31 (19.10	13.15 (20.81)	12.23 (19.99)
SEm±			0.48	0.58	0.67	0.50	0.64	0.75	0.66	0.55	0.64	0.65	(0.58)	0.62	0.73	0.64
CD 5%			1.43	1.71	1.99	1.48	1.91	2.23	1.97	1.63	1.90	1.92	(1.73)	1.85	2.16	1.90
CV %			9.30	9.62	9.23	8.03	9.40	10.03	9.25	9.48	9.91	8.42	(8.68)	8.56	8.96	8.31

Figures under the parenthesis are angular transformed values; DAA: Day after application

Table: 3 Relative field efficacies of different botanical insecticides against rice yellow stem borer

Treatments	Formulation	Dose g or ml/ha	Pooled mean of Dead Heart (%)			Pooled mean of White ear (%)		Grain yield	Additional gain in yield over control	Increase in grain yield	Straw yield	Additional gain in straw over control	Increase in straw yield
			4 DAS	7 DAS	10 DAS	Dough stage	Pre-maturity	(q/ha)	(q/ha)	(%)	(q/ha)	(q/ha)	(%)
Neem Baan	1 % EC	1000 ml	2.13 (8.00)	3.17 (9.66)	4.34 (11.80)	3.89 (11.05)	4.75 (12.30)	46.40	11.42	32.65	60.32	14.85	32.65
Neemazal	1 % EC	1000 ml	2.45 (8.68)	3.45 (10.27)	4.68 (12.30)	4.22 (11.56)	5.09 12.77)	45.67	10.69	30.56	59.37	13.90	30.56
Nimbecidine	0.03 % EC	2500 ml	2.96 (9.64)	3.65 (10.66)	5.39 (13.26)	4.92 (12.54)	5.81 (13.70)	43.98	9	25.73	57.17	11.70	25.73
Multineem	0.03 % EC	2500 ml	3.85 (11.15)	3.99 (11.34)	5.78 (13.76)	5.20 (12.91)	6.18 (14.17)	41.80	6.82	19.50	54.34	8.87	19.50
Neemoil	-	2500 ml	4.04 (11.43)	4.11 (11.50)	6.27 (14.36)	5.52 (13.30)	6.60 (14.67)	40.92	5.94	16.98	53.19	7.72	16.98
Achook	0.03 % EC	2500 ml	1.28 (5.66)	2.20 (7.74)	3.14 (9.84)	2.80 (9.17)	3.68 (10.71)	49.70	14.72	42.08	64.61	19.14	42.08
karanj oil	-	2500 ml	2.75 (9.31)	3.54 (10.50)	5.01 (12.76)	4.59 (12.11)	5.48 (13.31)	44.72	9.74	27.84	58.13	12.66	27.84
Dinotefuran*	20 SG	200 g	1.91 (7.50)	2.97 (9.31)	4.02 (11.28)	3.57 (10.51)	4.44 (11.86)	47.75	12.77	36.51	62.07	16.60	36.51
Rynaxypyr*	20SC	150 ml	1.82 (7.24)	2.80 (8.98)	3.75 (10.80)	3.30 (10.05)	4.17 (11.44)	48.50	13.52	38.65	63.05	17.58	38.65
Untreated control	-	500 lit.	8.28 (16.36)	9.56 (17.61)	11.27 (19.11)	11.03 (18.85)	12.73 (20.43)	34.98			45.47		
SEm±			0.35	0.39	0.42	0.40	0.47						
CD 5%			0.99	1.11	1.19	1.14	1.34						
CV %			9.42	9.79	8.81	8.97	9.47						

Figures under the parenthesis are angular transformed values.
*DAS: Day after spray | *Chemical insecticides (kept as check)*

Table: 4. Economics of different botanical insecticides against rice yellow stem borer

Treatments	Formulation	Dose g or ml/ha	Price	Quantity of the insecticides for two spray	Cost of insecticides for 2 spray	Cost of protection**	Money value of the extra yield of grains	Money value of the extra yield of rice straw	Total income	Net profit	B:C ratio
			(Rs./lit. or Kg)	(litre/ha)	(Rs/ha)	(Rs/ha)	@Rs.1750/q	@ Rs.200/q	(Rs/ha)	(Rs/ha)	
Neem Baan	1 % EC	1000 ml	1020	2	2040	2494	19985	2969.20	22954.2	20460.2	8.20:1
Neemazal	1 % EC	1000 ml	950	2	1900	2354	18707.5	2779.40	21486.9	19132.9	8.12:1
Nimbecidine	0.03 % EC	2500 ml	650	5	3250	3704	15750	2340.00	18090	14386	3.88:1
Multineem	0.03 % EC	2500 ml	450	5	2250	2704	11935	1773.20	13708.2	11004.2	4.06:1
Neemoil	-	2500 ml	350	5	1750	2204	10395	1544.40	11939.4	9735.4	4.41:1
Achook	0.03 % EC	2500 ml	600	5	3000	3454	25760	3827.20	29587.2	26133.2	7.56:1
karanj oil	-	2500 ml	250	5	1250	1704	17045	2532.40	19577.4	17873.4	10.48:1
Dinotefuran*	20 SG	200 g	1350	0.4	540	994	22347.5	3320.20	25667.7	24673.7	24.82:1
Rynaxypyr*	20SC	150 ml	8500	0.3	2550	3004	23600	3515.20	27175.2	24171.2	8.04:1
Untreated control	-	500 lit.									

**Chemical insecticides (kept as check)*

***Cost of protection comprising of money value of the total quantity of the respective insecticide use in 02 application and cost of labourer @ Rs 227 per labourer per day. Two labourers were used in four rounds of foliar spray.*

References

1. Annual report. Department of Agricultural, Cooperation and Farmers welfare. Ministry of Agriculture and Farmers Welfare, Government of India. 2016-17, 3p.

2. Balasubramaniam, P., Palaniappan, SP and Gopalan, M. 1983. Effect of Carbofuran and nitrogen on leaf folder incidence. Int. Rice Research Newsl. 5(5):13-14.

3. Bhumireddy S, S Simon and S Nagar. 2018. Seasonal incidence of rice leaf folder, *Cnaphalocrocis medinalis* (Guen) in Allahabad region. Journal of Pharmacognosy and Phytochemistry 7 (4): 2528-2530.

4. Chakraborty, K. (2011). Assessment of the efficacy of some biorational pesticide formulations for the management of yellow stem borer, *Scirpophaga incertulas* Wlk. in paddy field Journal of Biopesticides, 4: 75-80.

5. DAC&FW. State of Indian Agriculture. Ministry of Agriculture and Farmers Wlfare, Directorate of Economics & Statistics, New Delhi. 2015-16; 150p

6. Dhaliwal, GS., Multani, JS., Singh, S., Gagandeep, K., Dilawari, VK and Singh, J. (2002). Field evaluation of azadirachtin rich neem formulation against *Cnaphalocrocis medinalis* (Gueene) and *scirpophaga incertulas* (Walker) in rice. Pesticide Research Journal, 14:69-76.

7. Dhaliwal, GS., Singh, R and Chhillar, BS. (2006). Essentials of Agricultural Entomology. Kalyani Publishers.

8. Dhuyo, AR and Soomro, NM. 2007. Efficacy of plant extracts against yellow rice stem borer, *Scirpophaga incertulas* (Walk.) In Rice at Dokri, Sindh, Pakistan. Pakistan Entom., 29(1): 23-26.

9. Dinesh GK, Ramesh PT, Chitra N and Sugumaran MP. 2018. Ecology of birds and insects in organic and conventional (In-organic) Rice ecosystem. International Journal of Current Microbiology and Applied Sciences 7(4): 1769-1779.

10. Gomez KA, Gomez AA. Statistical Procedure for Agricultural Research. John Wiley and Sons, New York. 1984; 680p.

11. Islam, MS., Das, S., Islam, KS., Rahman, A., Huda, MN and Dash, PK. (2013). Evaluation of different insecticides and botanical extracts against yellow stem borer, *Scirpophaga incertulas* in rice field. International Journal of Biosciences, 3:117-125.

12. Kaul, BK and Sharma, PK. (1999). Efficacy of neem based insecticides against the major insect pests of rice in the hill of Himachal Pradesh. Journal of Entomology Research, 23: 377-379.

13. Khanjani, M. Crop pests of Iran. Buali Sina Uiversity Press. 2006; 717p.

14. Mandal A and RP Mondal. 2018. Impact of weather parameters on yellow stem borer. Research Journal of Life Sciences, Bioinformatics, Pharmaceutical and Chemical Sciences 4(6): 731.

15. Ogah, EO, Omoloye, AA. Nwilene, F.E. and Nwogbaga, A.C. (2011). Effect of Neem Seed Kernel Extracts in the Management of Rice Stem Borers in the Field in Nigeria Nig Journal of Biotechnology, 23: 13 – 21

16. Prasad, SS., Gupta, PK., & Mishra, J.P. (2014). Evaluation of certain new insecticides against yellow stem borer, *Scirpophaga incertulas*on semi deep water rice. International Journal of Current Microbiology and Applied Sciences. 3:736-740.

17. Shahbandeh M (2019). Statista. (https://www.statista.com/statistics/271969/world-rice-acreage-since-2008/).

18. Sharma KR, SVS Raju, DR Roshan, and DK Jaiswal. 2018. Effect of abiotic factors on yellow stem borer, *Scirpophaga incertulas* (Walker) and rice leaf folder, *Cnaphalocrocis medinalis* (Guenee) population. Journal of Experimental Zoology. India. 21(1): 233-236.

19. Tiwari A, Pandey JP, Tripathi K, Pandey D, Pandey B, Nisha S. Effectiveness of Insecticides and Biopesticides against Gundhi Bug on Rice Crop in (M. P.), India. International Journal of Scientific and Research Publications. 2014; 4(1): 2050-3153.

20. Yarasi B, V Sadumpati, CP Immanni, DR Vudem andVR Khareedu. 2008. Transgenic rice expressing *Allium sativum* leaf agglutinin (ASAL) exhibits high-level resistance against major sap sucking pests. BMC Plant Biology 8(1): 102-115.