SCIENTIA
AGRICULTURAE
BOHEMICA

Article

Strategic Management of Rice Stem Borer: Evaluating Tobacco Based Alternatives to Reducing Insecticide Dependency

Tapon Kumar Roy[1*], Sanjida Akter[1], Mir Md Moniruzzaman Kabir[1], S.M.M. Shahriar Tonmoy[2], Seuli Sharmin[3], Md Asaduzzaman Riad[4], Md Masud Rana[5], Md Asib Biswas[2], ABM Anwar Uddin[1], Anamika Sannal[6]

[1] Entomology Division, Bangladesh Rice Research Institute, BRRI, Bangladesh; tapon.entom@brri.gov.bd; sanjida.bgr@gmail.com; mkabir1985@gmail.com; masumbrri@gmail.com

[2] Farm Management Division, Bangladesh Rice Research Institute, BRRI, Bangladesh; smstonmoy47@gmail.com; asibbau71@gmail.com

[3] Department of Crop Physiology and Ecology, Hajee Mohammad Danesh Science & Technology University, HSTU, Bangladesh; seulisharminhstu@gmail.com

[4] Plant Breeding Division, Bangabandhu Sheikh Mujibur Rahman Agricultural University, BSMRAU, Bangladesh; riadzaman014@gmail.com

[5] Agronomy Division, Bangladesh Rice Research Institute, BRRI, Bangladesh; masudrana.brri@gmail.com

[6] Plant Pathology Division, Bangabandhu Sheikh Mujibur Rahman Agricultural University, BSMRAU, Bangladesh; sannalanamika9@gmail.com

*Corresponding author: tapon.entom@brri.gov.bd; taponroy.brri@gmail.com (Bangladesh)

Abstract: Stem borer infestation is a common challenge in rice fields, often managed through synthetic insecticides application, which pose environmental and health risks. A field experiment was conducted at the Bangladesh Rice Research Institute, Regional Station, Rangpur, during the T. Aman (July-November) 2022 and Boro (November-June) 2022-23 seasons to evaluate the efficacy of insecticides, botanicals, and hand sweeping in managing stem borer. The study employed a Randomized Complete Block Design with three replications and five treatments: T_1=control, T_2=tobacco dust, T_3=chloropyrips, T_4=sweeping and T_5=tobacco extract. Chlorpyrifos consistently reduced 'deadheart' and 'whitehead' symptoms, followed closely by tobacco dust and tobacco extract. Yield analysis revealed that chlorpyrifos resulted in a 13.43% yield increase over the control in T. Aman, while tobacco dust and tobacco extract both showed 10.22% increases. Similar trends were observed in the Boro season, with yield increases of 10.98% (chlorpyrifos), 6.66% (tobacco dust), and 7.99% (tobacco extract). Correlation analysis revealed that higher 'deadheart' and 'whitehead' symptoms significantly reduced tiller number, panicle number, and grain yield, while filled grains and panicle length increased. Rice plants demonstrated resilience by reallocating resources during the reproductive stage to mitigate yield losses. Tobacco-based treatments offer a sustainable alternative to synthetic insecticides for stem borer management, reducing yield loss and environmental risks.

DOI: 10.7160/sab.2025.560313

Keywords: Integrated Pest Management; Tobacco extracts; Eco-friendly; Whitehead; Dead-heart; Botanicals.

Received for publication on 27.01.2025

Accepted for publication on 22.04.2025

1. Introduction

Rice (*Oryza sativa* L.; Family: Poaceae) is one of the most widely cultivated cereals crops and the staple food crops in many countries as well as Bangladesh. It is grown extensively across the country during three distinct rice growing seasons: Aus (monsoon rice), Aman (rain-fed with supplemental irrigation) and Boro (irrigated rice). However, the production of rice is influenced by various factors, including the selection of variety, cultural practices, biotic and abiotic factors, and environmental conditions (Roy et al., 2024b). Throughout the rice cultivation process, rice fields are often inhabited by insect pests. The presence of rice insect pests can lead to production losses both directly and indirectly at different growth stages of crops, from its early development to maturity stage (Roy et al., 2024b). Many arthropods complete their life cycle in rice plants, some of them also used rice plants as hosts like Fall Armywarm (Ali et al., 2023). In rice fields of Bangladesh, 232 insect pest species and 375 beneficial insects have been identified, of which 20-33 insect species are the most economically damaging insect pest (Ali et al., 2021; Islam & Catling, 2012; Kabir et al., 2023; Roy et al., 2024a). In Asia, where the world's rice production is concentrated, the presence of insect pests results in an average yield loss of 20% (Ali et al., 2021).

Rice stem borers are prevalent insect pests in many rice-growing countries including Bangladesh. Based on the extent of the affected areas, stem borers rank as the most significant rice pests in Bangladesh and they are present in nearly all rice ecosystems throughout the year (Islam & Catling, 2012; Roy et al., 2024a). The extent of the infested areas and the intensity of infestation have fluctuated over the years (Roy et al., 2024a). Several species of stem borer, namely: the yellow stem borer (*Scirpophaga incertulas* Walker), the dark-headed borer (*Chilo polychrysa* Meyrick), the gold-fringed rice stem borer (*Chilo auricilia* Dudgeon), the striped stem borer (*Chilo suppressalis* Walker) and the pink stem borer (*Sesamia inferens* Walker), have been identified. Among these, the yellow stem borer is the dominant species in all three rice seasons with 60-90% among all borer populations (Islam & Catling, 2012; Roy et al., 2024a). Its population is most pronounced during the monsoon season. Conversely, the prevalence of the other species generally peaks at the beginning of the monsoon, declines significantly during the monsoon, and increases slightly as the monsoon gradually subsides (Islam & Catling, 2012). The stem borer larva damages the rice stem, disrupting the translocation of nutrients from the root to the leaf. As a result, tillers in the vegetative stage infestation get die, and this conditions known as 'deadheart'. When the larva infests the rice during the reproductive stage, it leads to the formation of empty panicles, a phenomenon referred to as 'whitehead'. So, the management of stem borer in rice is very crucial.

In Bangladesh, for the management of stem borer of rice the farmers depends heavily on synthetic insecticides due to their accessibility, aggressive promotion, affordability, easy of application, and rapid effectiveness by either killing insect pests or altering their harmful behaviors (Horgan et al., 2021; Rahman et al., 2020; Roy et al., 2023). For the management of rice stem borer about 90 percent farmers use insecticides (Islam & Catling, 2012). Moreover, the large scale and frequently application of insecticides has adverse effects to the animal and environment. The insecticides residues mixed with water and disrupt aquatic animal and caused health hazards. The significant rice yield losses caused by stem borers, coupled with farmer's heavy reliance on insecticides for management, underscore the urgent need to develop sustainable management strategies for stem borers. Recently, innovative principles, technologies, and pest management strategies have been developed, with 'green plant protection' gaining significant acceptance in China (Zhongxian et al., 2012). Another group of strategies, known as ecological control practices, seeks to minimize insecticide use, with ecological engineering standing out as a prominent approach. However, beneficial insects, often categorized as predators or natural enemies, play a crucial role in managing pest populations, thus helping to keep pests at manageable levels. These natural enemies, including ladybird beetle, spider, carabid beetle, and damsel fly, effectively target harmful insects across different life stages, from eggs to adults. Notably, the highest prevalence of spider was observed during the tillering stage (Roy et al., 2024a), indicating its role as a predator of both larval and adult stages of stem borer and rice leaf folder (Akter et al., 2024). However, the use of synthetic insecticides also results in the unintended killing of non-target arthropods, including beneficial insects involved in pollination, as well as natural predators like spiders and beetle (Hamza et al., 2016; Rahman et al., 2020; Roy et al., 2023).

The use of plant-derived products is one such alternative, which are considered more ecologically compatible than synthetic insecticides. The practice of using plant materials, crude plant extracts, and essential oils as botanical insecticides (such as *Azadirachta indica, Ocimum tenuiflorum, Nepeta cataria, Swietenia macrophylla, Persicaria hydropiper, Zingiber officinale, Nicotiana tabacum* etc) for the protection of agricultural crops and stored products from insect pests dates back to the origins of agriculture itself (El-Wakeil, 2013; Roy et al., 2023). The bioactive metabolites (such as Azadirachtin, flavonoids, gingerols, shogaols, saponins, limonoids, phenylpropanoid derivatives, quercetin, quinolone and sesquiterpenoids, etc) found in various botanicals are responsible for the manifestation of toxic properties, repellent characteristics, and antifeedant actions against insect pests. Plant-derived products are generally non-toxic to non-target organisms and have a lower environmental footprint compared to synthetic pesticides and can disrupt pest physiology effectively, offering a sustainable alternative to chemical pesticides.

So, for the alternate search and for the reduction the applications of synthetic insecticides our present investigation is undertaken to know the efficacy of tobacco based treatment and hand sweeping along with chloropyrips for the management of stem borer of rice during T. Aman 2022 and Boro 2022-23 seasons.

2. Materials and Methods

2.1. Study area and weather variable

The experiment was conducted at the research field of the Bangladesh Rice Research Institute (BRRI), regional station in Rangpur (Latitude: 25.69586; Longitude: 89.26843, Fig. 1). The study period extended from July to November during the T. Aman season of 2022, and from November to June during the Boro season of 2022-23. The experimental site was experienced by tropical rainfall from April to October, with scatter rainfall occurring throughout the rest of the year. During the study period, data on monthly minimum and maximum temperatures, relative humidity and total rainfall were recorded (Table 1).

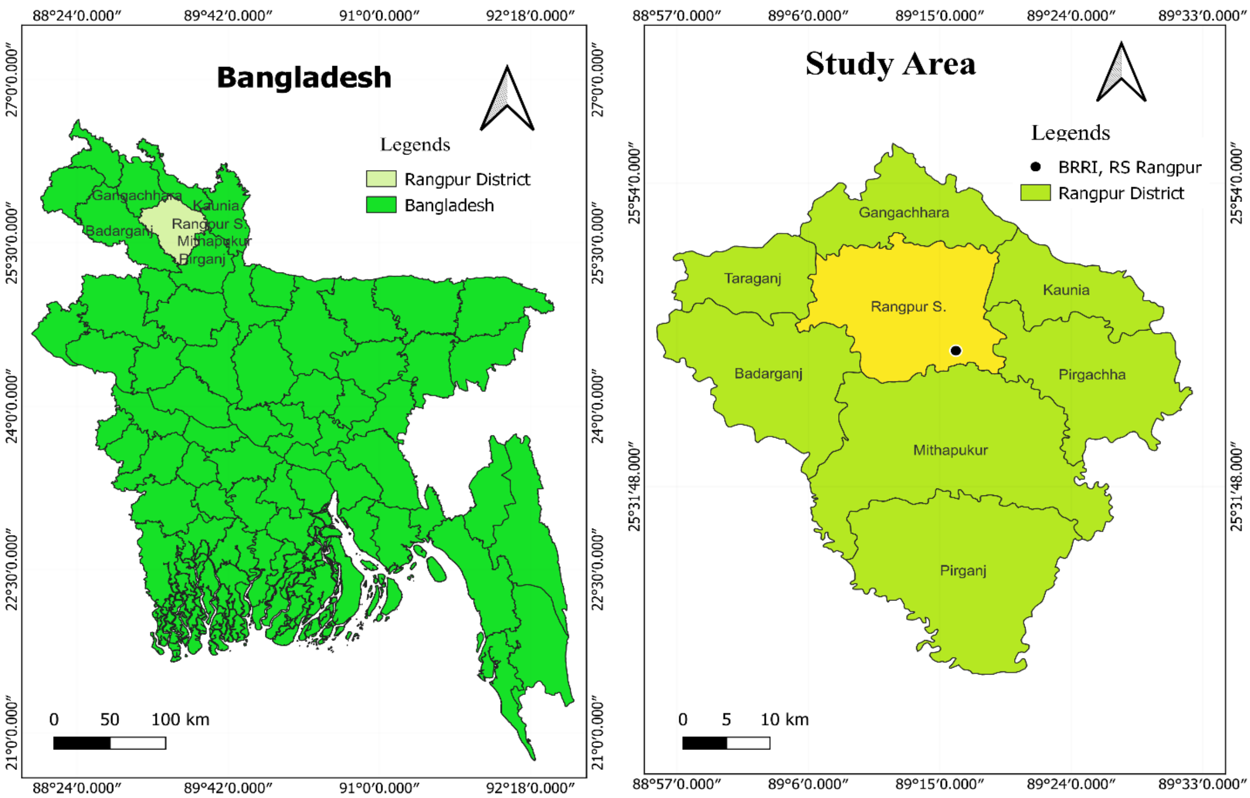

Figure 1. Study area of Rangpur District

Table 1. Month wise weather information of the study area from July 2022 to June 2023

Year	Month	Maximum temperature °C	Minimum temperature (°C)	Mean temperature (°C)	Rain fall (mm)	Humidity (%)
2022	July	33.16	26.50	29.83	207.08	76.66
2022	August	32.74	26.09	29.41	200.57	77.94
2022	September	31.47	25.32	28.40	177.60	83.30
2022	October	31.20	22.45	26.82	63.86	77.74
2022	November	29.37	16.31	22.84	2.10	69.73
2022	December	26.24	13.41	19.82	0.00	73.02
2023	January	23.11	10.37	16.74	0.00	79.02
2023	February	26.89	14.31	20.60	0.00	72.48
2023	March	29.59	18.48	24.04	31.93	68.00
2023	April	32.42	20.99	26.70	21.00	66.18
2023	May	32.66	22.64	27.65	137.33	68.26
2023	June	32.62	25.06	28.84	405.3	79.03

2.2. Variety and agronomic management

The variety used in the T. Aman season was BRRI dhan93, and in the Boro season, BRRI dhan89 was used. Pre-soaked seeds were sown on the wet seedbed. In the T. Aman season, 25-day-old seedlings, and in the Boro season, 40-day-old seedlings were transplanted in the main fields. The spacing between plants and rows was maintained at 20 × 20 cm, with a 60 cm gap between plots in both seasons. The size of individual plots was 40 m². The crop was grown following the recommended fertilizer package, which included urea, triple superphosphate (TSP), muriate of potash (MoP), gypsum, and zinc sulfate, applied at rates of 170, 50, 80, 65, and 7 kg ha^{-1} respectively in the T. Aman season and 250, 90, 150, 110, and 11 kg ha^{-1}, respectively, in the Boro season. The cultivation also adhered to the standard practices recommended by (BRRI, 2022).

2.3. Experimental design and treatment

The experiment in both seasons were carried out Randomized Complete Block Design (RCBD) with three replications and four treatments along with one untreated control (Table 2).

Table 2. Name and doses of the treatment against rice stem borer.

Treatments	Groups/Parts used	Dose (ha^{-1})
T_1	Untreated control	-
T_2	Tobacco dust	10 kg ha^{-1}
T_3	Chloropyrips	1.8 L ha^{-1}
T_4	Sweeping	-
T_5	Tobacco extract	7.00 L ha^{-1}

2.4. Preparation and application of treatments

The tobacco leaf was collected from local market. After then leaf was converted into powder by using electric grinder machine, then sieved and stored at 4°C freezer until further used. For making tobacco extract, the powder of tobacco leaf was mixed with water (1:3) then boiled for 30 minutes. After boiling the solution allowed to keep another 2 hour for cooling. The treatments were applied according to the design. The treatments were applied for two times in both seasons. Before the first application, the number of deadhearts was counted and removed. Chlorpyrifos and tobacco extract were then applied by using knapsack sprayers. Tobacco dust was applied by hand, and sweeping was done by using hand sweep nets simultaneously. Sweeping was carried out at various levels within the plant canopy, including the interspaces between plants and extending as close to the plant bases as possible. The same procedure was followed during the second application of the treatments. In the T. Aman season, the first application of treatments was done at 35 days after transplanting (DAT), while in the Boro season, it was done at 45 DAT. During the reproductive stage, the 2nd application of treatments for counting whiteheads was done at 70 DAT in the T. Aman season and at 80 DAT in the Boro season.

2.5. Collections of data

The total number of deadheart as well as whitehead were counted at 15 days after treatments of full replicated plot individually. Then randomly hills of 5.00 m^2 area were selected and number of tiller as well as number of panicle were counted and recorded. Randomly five panicle were selected and panicle length was recorded. The number of filled grain and unfilled grain were counted from these panicle and recorded. For the yield data, after harvesting of whole individual plot data was recorded.

2.6. Data analysis

All data were analyzed separately using analysis of variance (ANOVA) via R studio software (version 2024.04.1). The "doebioresearch" package was employed for conducting the ANOVA. To identify significant differences among treatment means, the Least Significant Difference (LSD) test was applied, with a significance levels of 5%. For analyzed correlation coefficient "metan" package was used.

3. Results and Discussion

3.1. Number of deadheart and whitehead:

The number of deadheart showed statically significant differences in both the T. Aman and Boro season. In the T. Aman season, the highest number of deadheart symptoms was observed at T_1 (2.61) treatments followed by T_2, T_4, T_5 and T_3 treatments (Table 3). However, in the Boro season the highest number of deadhearts was found in T_1 (0.37) followed by T_4, T_5, T_2 and T_3 treatments (Table 2). The number of whiteheads also showed statistically significant difference in both T. Aman and Boro seasons. As shown in Table 3, the highest number of whiteheads was observed in T_1 (2.20), while treatments T_2 (1.62), T_4 (1.54) and T_5 (1.50) showed statistically identical results in T. Aman season. The lowest number of whiteheads was found at T_3 (1.20), which was superior than other treatments. Similar type of findings were also observed in Boro season. The reduction percentage of deadheart over control varied from 37.93% to 56.70% in the T. Aman season and 56.76% to 78.38% in the Boro seasons. While, the reduction of the whitehead percentage over control varied from 26.36% to 45.45% in the T. Aman season and 53.26% to 77.13% in the Boro season (Table 3). For the reduction of deadheart and whitehead percentage T_3 showed superior performance followed by T_5, T_2 and T_4 respectively. The performance of tobacco dust and tobacco extract in comparison with chloropyrips showed identical results. In the context of botanical studies, (Rahman et al., 2014) conducted an investigation into the efficacy of four distinct botanical extracts, including tobacco leaf extract and neem seed kernel extract, in their impact on the tomato fruit borer and reported that the samples treated with neem seed kernel extract and tobacco leaf extract exhibited the lowest level of fruit infestation (27.15%) and achieved the most significant reduction in pest population (28.68%) when compared to the control group. Similar types of findings also demonstrated by (Dabalo, 2024) in fruit borer of tomato and stated that tobacco extract showed highest reduction of borer population after karate. (Sohail et al., 2012) reported that 98% mortality of aphid population was demonstrated at a 2% concentration of tobacco leaf extract. Furthermore,(Deepthi & Yadav, 2022) reported that the application of tobacco leaf extract effectively reduced the tomato fruit borer's impact, resulting in a significantly reduced fruit infestation rate (15.61%) in tomatoes, as contrasted with the control group, which recorded the highest rate of fruit infection (24.46%). Moreover, tobacco contained an alkaloid, has been shown to not only cause acute toxicity but also to disrupt biological membranes, malfunction of internal organ and metabolism, create redox imbalances, and interfere with developmental and reproductive processes in insects as well as inhibit food intake (Chowański et al., 2016; Kanmani et al., 2021). However, tobacco powder and extract contains nicotin, a bioactive compound that interferes with acetylcholine receptors in the nervous system, and acetylcholine inhibits resistant to insecticide (Dono et al., 2014). This is one of the reasons for the effectiveness of tobacco treatments compared to synthetic insecticide. Also the interruption in the nervous system can ultimately result in the death of the insect pest (Kanmani et al., 2021) thus reduced the deadheart and whitehead symptoms in tobacco treatments. Among the two rice growing seasons, the Boro seasons showed least infestation than the T. Aman season. Due to the climatic condition of Bangladesh, the Boro season is the winter season and the temperature is lower and due to low temperature, the stem borer infestation was lower during the Boro season comparative to T. Aman season (Table 1). Similar findings also reported by (Roy et al., 2024b), the Boro season, which corresponds to winter in Bangladesh, is characterized by lower temperatures and misty conditions and these environmental factors negatively impact insect wing functionality, thereby restricting their movement, development, and maturation, therefore lower insect abundance during the Boro season.

Table 3. Effect of Chloropyrips, tobacco and hand sweeping on deadheart and whitehead symptoms in both T. Aman and Boro seasons

Treatment	T. Aman, 2022				Boro 2022-23			
	Deadheart m^{-2}	Deadheart (%) reduction over control	Whitehead m^{-2}	Whitehead (%) reduction over control	Deadheart m^{-2}	Deadheart (%) reduction over control	Whitehead m^{-2}	Whitehead (%) reduction over control
T_1 (control)	2.61 a	-	2.20 a	-	0.37 a	-	0.92 a	-
T_2 (Tobacco dust)	1.52 bc	41.76	1.54 b	30.00	0.12 b	67.57	0.36 bc	60.87
T_3 (Chloropyrips)	1.13 c	56.70	1.20 c	45.45	0.08 b	78.38	0.21 c	77.13
T_4 (Sweeping)	1.62 b	37.93	1.62 b	26.36	0.16 b	56.76	0.43 b	53.26
T_5 (Tobacco extract)	1.37 bc	47.51	1.50 b	31.82	0.13 b	64.86	0.35 bc	61.96
Levels of significance	***	-	***	-	***	-	***	-
LSD	0.43	-	0.19	-	0.08	-	0.17	-
CV	13.79	-	6.19	-	26.04	-	19.58	-

Footnote, LSD: Least significant difference; CV: coefficient of variation; ***: significance at 0.1%

3.2 Effects of yield and yield contributing traits after treatments

The number of tiller plant^{-1} showed statistically significant difference during Boro season and the number of panicle plant^{-1} showed statistically significant difference during the T. Aman season as shown in Table 4 and Table 5. During the T. Aman season, the superior number of panicle plant^{-1} was observed at T_3 (7.86) and T_2 (7.82) treatment. While, the panicle length showed non-significance difference in both the T. Aman and the Boro seasons. In many cases, especially when stem borers infested young seedling, tillering stage of rice plants, the losses of yield are often minimal, because the plants can compensate for the damage by producing additional tillers or even overcompensate by reallocating resources to generate larger and more abundant rice grains supported by (Horgan et al., 2016, 2021; Islam & Catling, 2012). Among the yield and yield contributing traits the number of filled grains showed statically significant difference in both T. Aman and Boro seasons and T_1 showed significantly superior performance than other treatments. In case of unfilled grains panicle^{-1}, significantly the lowest number of unfilled grains panicle^{-1} was observed in T_1 in T. Aman season. But, non-significant difference was observed in Boro season. Since, number of deadheart and whitehead was highest in T_1 and so the highest number of filled grain observed in T_1 due to the increased photosynthesis by leaves which enhancing filled grains and reducing unfilled grains (Islam & Catling, 2012). Among the two seasons, the number of deadheart and whitehead was found higher at the T. Aman season than the Boro seasons due to climatic condition (Islam & Catling, 2012). The Boro season in Bangladesh occurs during winter and spring, when low temperatures reduce the fecundity, mating and growth of insects, thus decreasing the insect population compared to other seasons (Table 1). Since, highest number of deadheart as well as whitehead was found in T_1 in both T. Aman and Boro seasons, it might be due to when stem borers attack young rice plants during the vegetative stage, the plants can respond by generating new tillers or by channeling nutrients to the tillers that remain unaffected also supported by (Horgan et al., 2021; Islam & Catling, 2012). But, in cases of reproductive stage attacks, the plants may adapt by boosting the proportion of productive tillers or by enhancing filled grain also supported by (Horgan et al., 2021; Lv et al., 2008).

Table 4. Effect of Chloropyrips, tobacco and hand sweeping on yield and yield contributing traits during T. Aman season 2022

Treatment	Tiller number plant^{-1}	Panicle number plant^{-1}	Panicle length (cm)	Filled grain panicle^{-1}	Unfilled grain panicle^{-1}	Grain yield (t ha^{-1})	Yield (%) increase over control
T_1 (control)	8.35	6.50 c	24.61	194.00 a	21.67 b	4.99 b	-
T_2 (Tobacco dust)	8.53	7.82 a	25.47	185.33 bc	29.00 a	5.50 a	10.22%
T_3 (Chloropyrips)	8.55	7.86 a	25.48	182.00 c	32.67 a	5.66 a	13.43%
T_4 (Sweeping)	8.22	6.98 bc	24.33	189.67 ab	30.00 a	5.16 b	3.41%
T_5 (Tobacco extract)	8.22	7.18 b	25.86	183.67 b	34.00 a	5.50 a	10.22
Levels of significance	ns	**	ns	*	**	**	-
LSD	-	0.56	-	4.89	5.03	0.31	-
CV	4.05	4.07	2.39	1.37	9.07	3.12	-

Footnote, LSD: Least significant difference; CV: coefficient of variation; **: significance at 1%; *: significance at 5%; ns: non-significance

Statically the highest and identical yield was found in T_3 (5.66), T_2 (5.50) and T_5 (5.50) treatments in T. Aman season (Table 4). Similar trends were also observed in the Boro season as showed in Table 5. The percentage of yield increased over control was varied from 3.41% to 10.43% in the T. Aman season, where highest percent of yield was increased in T_3 (13.43%) followed by T_2 (10.22%) and T_5 (10.22%). The percentage of yield increased over control was varied from 2.50% to 10.98% in the Boro season, where highest percent of yield was increased in T_3 (10.98%) followed by T_5 (7.99%) and T_2 (6.66%). (Dabalo, 2024) reported that yield of tobacco treated field was statically significant with synthetic insecticide (karate) treated field for the management of fruit borer of tomato. In this present investigation, 10-15% of rice yield losses occurred due to rice stem borer, whereas an average yield loss of 20% due to rice insect pest infestation (Ali et al., 2021). However, reproductive stage infestation convert unproductive tiller to productive tillers, while, the late-stage infestation enhance the filled grains, grain weight by reallocating resources to grain (Lv et al., 2008). So, normally rice plant have the recovery system to minimize the yield loss during stem borer infestations. Synthetic insecticides are frequently misused, resulting in negative effects on ecosystems and human health, particularly within the context of developing nations. The utilization of botanicals, such as extracts derived from pesticidal plants, has been extensively advocated as a more sustainable and appropriate alternative for smallholder agriculturalists in developing regions (Seni et al., 2025; Sola et al., 2014). The application of pesticidal plants can effectively regulate insect pest populations and can be assimilated into sustainable agricultural methodologies.

Table 5. Effect of Chloropyrips, tobacco and hand sweeping on yield and yield contributing traits during T. Aman season 2022

Treatment	Tiller number plant^{-1}	Panicle number plant^{-1}	Panicle length (cm)	Filled grain panicle^{-1}	Unfilled grain panicle^{-1}	Grain yield (t ha^{-1})	Yield (%) increase over control
T_1 (control)	10.82 a	9.46	23.73	138.67 a	22.67	6.01 c	-
T_2 (Tobacco dust)	10.66 ab	9.91	23.97	130.33 bc	28.67	6.41 ab	6.66%

T_3 (Chloropyrips)	10.05 bc	10.13	23.67	126.67 c	31.00	6.67 a	10.98%
T_4 (Sweeping)	10.25 abc	9.65	23.87	133.00 b	26.67	6.16 bc	2.50%
T_5 (Tobacco extract)	9.80 c	9.06	23.10	127.33 c	28.67	6.49 ab	7.99%
Levels of significance	*	ns	ns	**	ns	*	-
LSD	0.70	-	-	5.66	-	0.35	-
CV	3.60	3.85	3.37	2.29	17.44	2.94	-

Footnote, LSD: Least significant difference; CV: coefficient of variation; **: significance at 1%; *: significance at 5%; ns: non-significance

3.3 Correlation coefficient of deadheart and whitehead among yield and yield contributing traits

The correlation coefficient estimates the strength and direction of the relationship between a pair of traits, proving useful for the simultaneous improvement of correlated traits through selection. The estimated of pearson's correlation computed between five characters of two rice varieties along with deadheart and whitehead symptoms are presented in Fig. 2. The present study revealed that the tiller number (TN), panicle number (PN) and grain yield (GY) decreased significantly by increased of deadheart and whitehead. While, the number of filled grain (FG) and panicle length (PL) increased significantly by increased of deadheart and whitehead. Due to deadheart and whitehead, the number of infested tillers and panicles was damaged, and since the number of tillers and panicles directly influences yield, this led to yield losses. Our research findings also supported by (Horgan et al., 2021). The PN, TN and GY increased significantly by decreased of FG and PL. However, in a normal scenario, GY increases with the increase in FG and PL. In contrast, stem borer infestation causes deadheart and whitehead damage, reducing the total number of tillers (TN) and productive tillers (PN). As a result, FG and PL increased by reallocating resources, but the total FG is lower than in the normal scenario, leading to reduced yield. While, PN increased significantly by increased of TN and GY increased significantly by increased of TN and PN. Our findings also supported by (Roy et al., 2024) except the association between GY, FG and PL. GY decreased by increased of FG and PL may be due deadheart and whitehead symptoms which decreased the total number of panicle as a result grain yield decreased. Consequently, the findings of the present investigation suggest that the tobacco powder and tobacco extract possesses certain toxicological properties and farmers might be used against stem borer of rice.

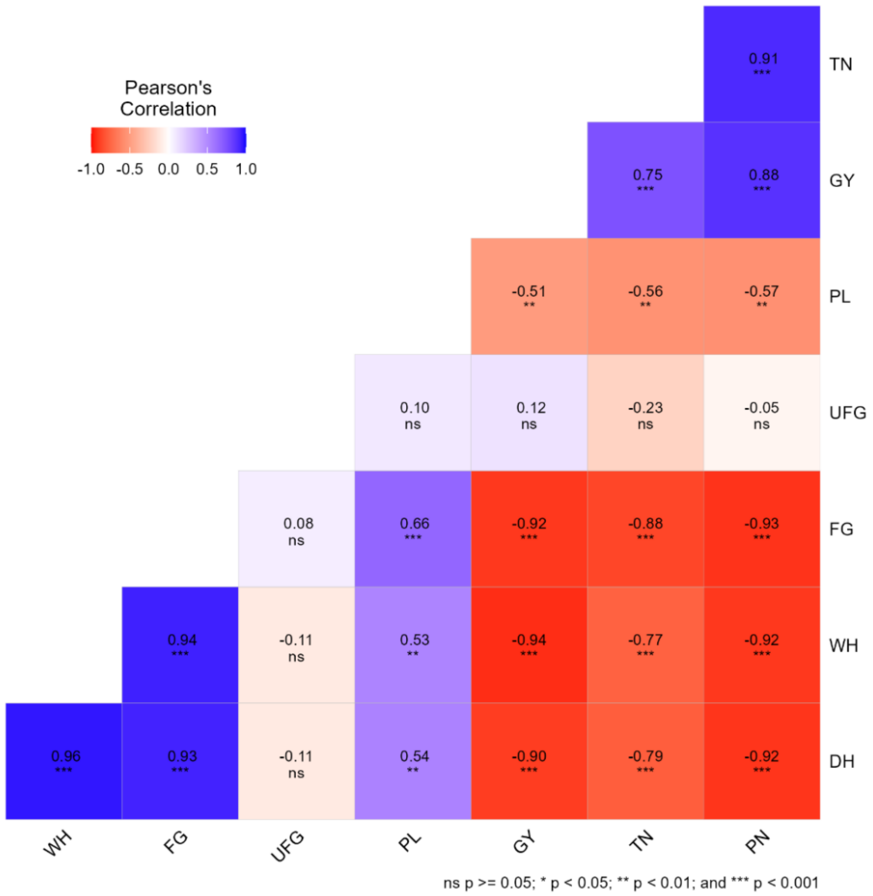

Figure 2. Correlation coefficient of deadheart and whitehead among yield and yield contributing traits.

Footnote, DH: Deadheart; WH: Whitehead; PN: Panicle Number; TN: Tiller Number; GY: Grain Yield; PL: Panicle Length; UFG: Unfilled Grain; FG: Filled grain.

4. Conclusions

The study was conducted to know the efficacy of tobacco treatments and hand sweeping as well as chloropyrips for the management of stem borer of rice across T. Aman and Boro seasons. In the T. Aman season, the highest incidence of deadheart and whitehead symptoms was observed in the control treatment (T_1), while the lowest was in the chloropyrips treatment (T_3), demonstrating its superior efficacy followed by tobacco treatments T_2 and T_4. The Boro season showed a similar trend. The treatments also significantly influenced yield and yield-contributing traits. During the T. Aman season, T_3 (Chloropyrips) and T_2 (Tobacco dust) treatments produced the highest panicle numbers and significantly increased grain yield compared to the control, with T_3 showing a 13.43% yield increase. In the Boro season, T_3 again resulted in the highest yield increase at 10.98%. The study also found a negatively significant correlation between deadheart and whitehead symptoms with traits such as tiller number, panicle number, and grain yield, while filled grains and panicle length showed a positive and significant correlation with these symptoms. These findings indicate that chloropyrips, tobacco extract and tobacco dust are effective in reducing stem borer damage and enhancing yield. Our findings highlighting the importance of selecting appropriate management strategies to optimize rice yield under stem borer pressure. Future studies should analyze the effects of tobacco on beneficial insects, such as pollinators and natural predators, to promote integrated pest management and these are also the limitation of our present study.

Author Contributions: Conceptualization, T.K. Roy.; Experiment and statistical analysis, T.K. Roy, A. Sannal, M.M. Rana, A. Riad; writing-original draft preparation, T.K. Roy, A. Sannal, S. Akter., M.M. Kabir, S.M.M.S. Tonmoy, & A.Sannal; writing—review and editing, T.K. Roy, A. Sannal, M.M. Kabir, S. Akter, A. Riad, M.M. Rana., S.M.M.S. Tonmoy, M.A. Biswas, & ABM.A.Uddin; materials and equipment, T.K. Roy and M.M. Rana; supervision, T.K. Roy, A. Sannal, & M.M. Rana. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Acknowledgments: Authors are greatly thankful to Principle Scientific Officer & Head, Bangladesh Rice Research Institute (BRRI), regional station Rangpur for the assistance and equipment.

Conflicts of Interest: The authors declare no conflict of interest.

Data availability statement: All data accessed and analyzed in this study are available in the article and data will be made available on request.

5. References

1. Akter S, Roy TK, Haque MM, Alam Z (2024). Effective multidimensional treatment identification of different chemical fertilizers: Response of insect dynamics and rice production. *Heliyon*, *10*(11), e32567. https://doi.org/10.1016/j.heliyon.2024.e32567

2. Ali MP, Haque SS, Hossain MM, Bari MN, Kabir MMM, Roy TK, Datta J, Howlader MTH, Alam SN, Krupnik TJ (2023). Development and demographic parameters of Fall Armyworm (*Spodoptera frugiperda* J.E. Smith) when feeding on rice (*Oryza sativa*). *CABI Agriculture and Bioscience*, *4*(1), 29. https://doi.org/10.1186/s43170-023-00162-6

3. Ali MP, Nessa B, Khatun M, Salam MU, Kabir M (2021). A Way Forward to Combat Insect Pest in Rice. *Bangladesh Rice Journal*, *25*(1), 1–22. https://doi.org/10.3329/brj.v25i1.55176

4. BRRI (2022). *Modern Rice Cultivation* (Vol. 24). Bangladesh Rice Research Institute. https://knowledgebank-brri.org/wp-content/uploads/2023/01/ADC2022.pdf

5. Chowański S, Adamski Z, Marciniak P, Rosiński G, Büyükgüzel E, Büyükgüzel K, Bufo S (2016). A review of bio insecticidal activity of Solanaceae alkaloids. *Toxins*, *8*, 1–28.

6. Dabalo B (2024). Evaluation of Intercropping and Tobacco Leaf Extract for Management of Fruit Borer (Helicoverpa armigera) and Some Associated Beneficial Insects on Tomato in Eastern Hararghe, Ethiopia. *Journal of Biology and Life Science*, *15*(2), 33. https://doi.org/10.5296/jbls.v15i2.22085

7. Deepthi YN, Yadav U (2022). Comparison with botanicals and the bio-agents on Fruit borer, *Helicoverpa armigera* (Hubner) in Tomato. *Journal of Entomology and Zoology Studies*, *10*(2), 223–226. https://doi.org/10.22271/j.ento.2022.v10.i2c.8992

8. Dono D, Natawigena WD, Kharismansyah HR (2014). Resistance status of *Crocidolomia pavonana* F. (Lepidoptera : Crambidae) from pasirwangi garut, WEST JAVA to the insecticide profenofos and its

susceptibility to the methanolic leaf extract of *Nicotiana tabacum* L. (SOLANACEAE). . *Journal of International Society for Southeast Asian Agricultural Sciences*, *20*, 121–130.

9. El-Wakeil NE (2013). RETRACTED ARTICLE: Botanical Pesticides and Their Mode of Action. *Gesunde Pflanzen*, *65*(4), 125–149. https://doi.org/10.1007/s10343-013-0308-3

10. Hamza AF, El-Orabi MN, Gharieb OH, El-Saeady AH A, Hussein ARE (2016). Response of *Sitophilus granarius* L. to fumigant toxicity of some plant volatile oils. *Journal of Radiation Research and Applied Sciences*, *9*(1), 8–14. https://doi.org/10.1016/j.jrras.2015.05.005

11. Horgan FG, Crisol-Martínez E, Almazan MLP, Romena A, Ramal AF, Ferrater JB, Bernal CC (2016). Susceptibility and tolerance in hybrid and pure-line rice varieties to herbivore attack: biomass partitioning and resource-based compensation in response to damage. *Annals of Applied Biology*, *169*(2), 200–213. https://doi.org/10.1111/aab.12296

12. Horgan FG, Romena AM, Bernal CC, Almazan MLP, Ramal AF (2021). Stem borers revisited: Host resistance, tolerance, and vulnerability determine levels of field damage from a complex of Asian rice stemborers. *Crop Protection*, *142*, 105513. https://doi.org/10.1016/j.cropro.2020.105513

13. Islam Z, Catling D (2012). *Rice Pests of Bangladesh: Their Ecology and Management*. University Press Limited.

14. Kabir MM, Ali MP, Datta J, Topy SN, Debonath A, Nasif SO, Roy TK, Uddin A (2023). Period of effective catching of insect pests and natural enemies in light traps. *International Journal of Agricultural and Applied Sciences*, *4*(1), 12–16. https://doi.org/10.52804/ijaas2023.412

15. Kanmani S, Kumar L, Raveen R, Tennyson S, Arivoli S, Jayakumar M (2021). Toxicity of tobacco *Nicotiana tabacum* Linnaeus (Solanaceae) leaf extracts to the rice weevil *Sitophilus oryzae* Linnaeus 1763 (Coleoptera: Curculionidae). *The Journal of Basic and Applied Zoology*, *82*(1). https://doi.org/10.1186/s41936-021-00207-0

16. Lv J, Wilson LT, Longnecker MT (2008). Tolerance and compensatory response of rice to sugarcane borer (Lepidoptera: Crambidae) injury. *Environmental Entomology*, *37*(3), 796–807. https://doi.org/10.1603/0046-225x(2008)37[796:tacror]2.0.co;2

17. Rahman A, Haque M, Alam S, Mahmudunnabi M, Dutta N (2014). Efficacy of Botanicals against *Helicoverpa armigera* (Hubner) in tomato. *The Agriculturists*, *12*(1), 131–139. https://doi.org/10.3329/agric.v12i1.19868

18. Rahman MM, Jahan M, Islam KS, Adnan SM, Salahuddin M, Hoque A, Islam M (2020). Eco-friendly management of rice yellow stem borer, *Scirpophaga incertulus* (pyralidae: lepidoptera) through reducing risk of insecticides. *Malaysian Journal of Sustainable Agriculture*, *4*(2), 59–65. https://doi.org/10.26480/mjsa.02.2020.59.65

19. Roy TK, Kabir MMM, Akter S, Nayeem A, Alam Z, Hasan MR, Bari MN, Sannal A (2024a). Seasonal variations of insect abundance: Correlating growth stage-specific metrics with weather patterns in Rangpur Region, Bangladesh. *Heliyon*, *10*(18), e38121. https://doi.org/10.1016/j.heliyon.2024.e38121

20. Roy TK, Sannal A, Akter S, Tonmoy S, Chakrobarty T, Hasan M, Bari M (2023). Pesticidal effect of naphthalene and different Botanicals against anguimous grain moth (*Sitotroga cerealella*). *Bangladesh Journal of Scientific and Industrial Research*, *58*(3), 155–162. https://doi.org/10.3329/bjsir.v58i3.66797

21. Roy TK, Sannal A, Kabir MMM, Monir N, Tareq KH, Rana MM (2024b). Evaluation of the insecticidal effectiveness of *Azadirachta indica* plant parts and naphthalene on rice weevil infestation during storage. *African and Mediterranean Agricultural Journal-Al Awamia*, *142*, 73–88. https://doi.org/https://doi.org/10.34874/IMIST.PRSM/afrimed-i142.47704

22. Roy TK, Sannal A, Tonmoy SMMS, Akter S, Roy B, Rana MM, Alam Z, Hasan MR (2024). Trait analysis of short duration boro rice (*Oryza sativa* L.) varieties in northern region of Bangladesh: Insights from heatmap, correlation and PCA. *Nova Geodesia*, *4*(2), 175. https://doi.org/10.55779/ng42175

23. Seni A, Pal R, Mohapatra S, Mandal D, Bansude SK, Seth P, Barla S, Sahu J (2025). Pesticidal plant extract effect against major lepidopteran insect pests and their natural enemies in rice *Oryza sativa* L. *Frontiers in Insect Science*, *4*. https://doi.org/10.3389/finsc.2024.1500542

24. Sohail A, Hamid F, Waheed A, Ahmed N, Aslam N, Zaman Q, Ahmed F, Islam S (2012). Efficacy of different botanical materials against APHID *Toxoptera aurantii* on tea (*Camellia sinensis* L.) cuttings under high shade nursery. . *Journal of Materials and Environmental Science.* , *3*, 1065–1070.

25. Sola P, Mvumi BM, Ogendo JO, Mponda O, Kamanula JF, Nyirenda SP, Belmain SR, Stevenson PC (2014). Botanical pesticide production, trade and regulatory mechanisms in sub-Saharan Africa: making a case for plant-based pesticidal products. *Food Security*, *6*(3), 369–384. https://doi.org/10.1007/s12571-014-0343-7

26. Zhongxian L, Yajun Y, Puyun Y, Zhonghua Z (2012). China's 'Green Plant Protection' Initiative: Coordinated Promotion of Biodiversity-Related Technologies. In *Biodiversity and Insect Pests* (pp. 230–240). Wiley. https://doi.org/10.1002/9781118231838.ch14