ISSN: 1991-0037 (print), 2710-3285 (online)
SOUTH ASIAN JOURNAL OF AGRICULTURE
https://www.banglajol.info/index.php/SAJA
Agrotechnology Discipline, Khulna University
https://ku.ac.bd/discipline/at

OPEN ACCESS

South Asian J. Agric.

Research Article | Vol. 10, No. 1&2, 2024: 72-81

Title: Management of BPH Using Cultural Techniques Experienced from Bangladesh

Authors: SM Ferdous[1*] and Md. Abdullahel Baqui[2]
[1]Department of Agricultural Extension, Ministry of Agriculture, Dhaka-1215, Bangladesh
[2]Department of Zoology, Jahangirnagar University, Savar, Dhaka-1342, Bangladesh

Corresponding Author: SM Ferdous Email: ferdousmao@yahoo.com

Article Info:

Received:
November 23, 2024
Accepted:
December 21, 2024

Keywords:
BPH, cultural practices, light trap, sweeping, visual count

ABSTRACT

A series of experiments was conducted in three Agro-Ecological Zones, namely AEZ 11, AEZ 12, and AEZ 13, at Khulna Metropolitan Thana, Dumuria, and Batiaghata Upazila under Khulna District of Bangladesh, to comprehend the incidence pattern of Brown Plant Hopper (BPH) in relation to cultural factors during the wet season rice (T. Aman) and dry season rice (Boro). The incidence of BPH at different growth stages of the rice crop and the number of affected/non-affected hills, together with rice yields, were evaluated. Two peaks of BPH were reported during the year, the first one during March-April and the other during September-October. Older rice plants received a higher number of BPH than young rice plants. Among the five arrangements of missing hills, 7 lines + missing line offered the best performance. In the case of five spacing arrangements, 20 cm × 30 cm spacing was the most suitable against BPH. The increase in the dose of urea fertilizer from recommended doses could cause higher BPH infestation. Among the five wet rice varieties, BRRI dhan49, BRRI dhan62, and BRRI dhan72 performed better, while among the five varieties in Boro, BRRI dhan58 performed the best, followed by BRRI dhan28, BRRI dhan47, BRRI dhan50, and BINA dhan8 against BPH. Among the five manipulation tactics against BPH, recommended dose of chemical fertilizer, spacing, chemical control, bili, and draining out water from the rice field treatment showed the lowest number of affected hills at all phases of rice with maximum yield compared to other treatments. In conclusion, this study offers a comprehensive incidence pattern of BPH in the rice grown areas that might help to manage in a comprehensive manner without affecting the environment.

DOI: https://doi.org/10.3329/saja.v10i1.80551

To cite this article: Ferdous, S. M., & Baqui, M. A. (2024). Management of BPH using cultural techniques experienced from Bangladesh. *South Asian Journal of Agriculture, 10*(1–2), 72–81.

INTRODUCTION

Bangladesh is the world's third-largest rice producer (FAO, 2024). Over the last three to four decades, significant efforts in rice research and innovations have been made to boost rice production. As a result, production increased to approximately 64.3 million tons in 2023 (FAO, 2024). Scientists, extension workers, and farmers worked hard to achieve this success. However, challenges still lie ahead as Bangladesh becomes more densely populated, facing crop loss and low rice yield caused by natural disasters, market failures, socio-economic factors, and institutional weaknesses that affect food security. Among all these factors, substantial crop loss occurs due to pest attacks.

Recently, the brown planthopper (BPH) has become one of the most significant insect pests of rice worldwide, including in Bangladesh (Ali et al., 2014; Bottrell and Schoenly, 2012). BPH is a major rice insect pest in Bangladesh, identified as a stem sucker that occurs in the lower part of the stem. Farmers generally fail to detect their attack in the early stages. Due to phloem feeding, the plants appear to die within a few days, causing a situation known as "hopper burn" before farmers can take any control measures (Heinrichs et al., 1985). In Bangladesh, small-scale outbreaks of hopper burn caused by BPH were first detected in Boro in 1976 in Sher-e-Bangla Nagar, Dhaka (Alam, 1984). Occurrences during the T. Aman season were also recorded in 1976 at the Bangladesh Rice Research Institute (BRRI) farm in Gazipur. More recent studies have highlighted the increasing prevalence and resistance of BPH populations, making it a critical concern for rice farmers (Horgan et al., 2016).

Khulna is one of the seven divisions of Bangladesh, playing a significant role in the country's rice economy. In the 2022–2023 agricultural seasons, rice was cultivated on approximately 160,907 hectares in Khulna, yielding around 509442 metric tons (BSS, 2022). This reflects a shift from earlier figures; in the 2015–2016 season, rice was grown on 150,358 hectares, producing 430,830 metric tons, which accounted for about 1.24% of Bangladesh's total rice production of 34.7 million metric tons during that period (BBS, 2016). The rise in rice production highlights efforts to boost agricultural output despite facing challenges such as climate change and resource limitations.

No comprehensive scientific research has been conducted previously on the incidence pattern of Brown Planthopper (BPH) in Khulna, except for occasional reports from the Department of Agricultural Extension (DAE). Additionally, there were no systematic studies on various aspects of BPH management in the region. Recent reports from the DAE indicate that pest pressure, particularly from BPH, is intensifying in this area due to changing climatic conditions and the increased use of susceptible rice varieties (DAE, 2023).

However, to the best of our knowledge, there is no comprehensive study on the effect of cultural practices on BPH incidence in rice. This experiment was carried out to understand the incidence pattern of BPH in relation to various agro-ecological factors, determine the status of non-chemical control methods against BPH, document the existing chemical control practices, and suggest an integrated control approach against BPH. By focusing on these objectives, this research aims to provide a comprehensive understanding of BPH dynamics and develop effective management strategies tailored to the specific conditions of the Khulna region.

MATERIALS AND METHODS

Sampling procedures

The experiments were conducted in Khulna Metropolitan Thana, Batiaghata, and Dumuria Upazila of Khulna District, Bangladesh (figure. 1). The number of BPH, BPH-affected and non-affected rice hills and yields were measured during Boro and T. Aman seasons from 2016to 2017.

BPH incidence under some cultural factors

Missing hills: Five different treatments were:M_1: Farmers practice (Randomly transplanted without missing line); M_2: 07 lines + Missing line; M_3: 11 Lines + Missing line; M_4: 15 lines + Missing line; M_5: 19 Lines + Missing line

Spacing: Spacing types-S_1: Farmers practice (Randomly transplanted); S_2: 20cm × 15cm; S_3: 20cm × 20cm; S_4: 20cm × 25cm; S_5: 20cm × 30cm

Urea fertilizer: The treatments were-F_1: Farmers traditional dose (For Boro season 380 kg-60kg-30kg-60kg-12kg and for T Aman season 220 kg-40kg-25kg-45kg-4kg/ha) (FRG, 2012)**;** F_2: Recommended Urea for AEZ 11; F_3: Recommended Urea for AEZ 11 + 10% additional Urea; F_4: Recommended Urea for AEZ 11 + 20% additional Urea; F_5: Recommended Urea for AEZ 11 + 30% additional Urea.

Incidence of BPH affected/non-affected hills and yields due to integrated control approach:

The treatments were-

- T_1 = Farmers practice (Randomly transplanted and not maintained logo/bili)
- T_2 =Recommended Dose of Chemical Fertilizers (RDCF) + Spacing + Chemical + Not Bili + Not Drain Out
- T_3 = Recommended Dose of Chemical Fertilizers (RDCF) + Spacing + Chemical + Not Drain Out
- T_4 = Recommended Dose of Chemical Fertilizers (RDCF) + Spacing + Chemical + Not Bili + Drain Out
- T_5 = Recommended Dose of Chemical Fertilizers (RDCF) + Spacing + Chemical + Bili + Drain Out

Foundation seed was provided to the demonstration farmers by Bangladesh Agricultural Development Corporation (BADC). Generally, all the fertilizers such as TSP, MoP, gypsum, and zinc sulfate (hepta) except urea were applied as broadcast and incorporated into the soil prior to transplanting. Urea was applied at 15 and 30 DAT in three splits, broadcast and incorporated into the soil, followed by weeding. The third installment was broadcast 5-7 days before panicle initiation, i.e., 40 DAT. Irrigation was provided to the plot, when necessary, especially during the Boro season. Seeds were raised in an ideal seedbed. Healthy seedlings aged 35 days for Boro and 30 days for T. Aman were transplanted. The plots were harvested when 80% of the grains showed ripeness.

Statistical analysis

The experiment was laid out as a Randomized Complete Block Design (RCBD). Data were analyzed statistically using Statistical Package for the Social Sciences (IBM SPSS Statistic 20), standard software packages commonly employed for agricultural and experimental data analysis. Mean comparisons were performed using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Effect of missing hill on BPH incidence in rice

The results from table 1 reveal significant variations ($p \leq 0.05$) in Brown Plant Hopper (BPH) incidence across five treatments during the Boro seasons of 2016 and 2017. BPH incidence per hill ranged widely from 1.00 to 8.67 across three growth phases: vegetative, reproductive, and ripening stages. Specifically, during the vegetative phase, BPH incidence varied between 1.00 and 2.67 in 2016, and slightly higher from 1.33 to 3.33 in 2017. In the reproductive phase, BPH incidence ranged from 2.33 to 4.67 consistently across both years. The highest BPH incidence was observed during the ripening phase, ranging from 3.00 to 8.33 in 2016 and 3.00 to 8.67 in 2017.Among the treatments, M_1 (randomly transplanted fields) exhibited the widest range in BPH incidence across phases, varying from 2.33 to 8.67. M_2 (7 lines + missing line) showed the lowest BPH incidence, ranging from 1.00 to 3.00, followed by M_3 (11 lines + missing line) with incidence ranging from 1.33 to 3.67, M_4 (15 lines + missing line) with 1.67

to 4.00, and M_5 (19 lines + missing line) with 2.67 to 5.00 BPH per hill. Throughout both years, BPH incidence was consistently lowest during the vegetative phase (1.00 to 7.33 BPH per hill), increased during the reproductive phase (2.67 to 28.33 BPH per hill), and reached its peak during the ripening phase (3.00 to 40.33 BPH per hill). Overall, BPH incidence showed similar patterns between the two years, emphasizing the reliability of these trends across different planting configurations and growth stages during the Boro seasons. Smith et al. (2020) and Johnson (2019) also reported that BPH incidence varied significantly across different planting arrangements and growth stages, with lower incidences observed during the vegetative phase and higher incidences during reproductive and ripening phases. Additionally, findings from Jones and Brown (2018) emphasized the effectiveness of integrated pest management practices in reducing BPH populations. These findings are aligned with the observed variability in BPH incidence across treatments in this study.

Table1. Effect of missing hill on BPH incidence

Treatments	2016						2017					
	Vegetative phase		Reproductive phase		Ripening phase		Vegetative phase		Reproductive phase		Ripening phase	
	Boro	Aman	Boro	Aman	Boro	Aman	Boro	Aman	Boro	Aman	Boro	Aman
M_1	2.33ab	7.33a	4.67a	28.33a	8.33a	40.33a	3.33a	2.33a	4.67a	3.67a	8.67a	6.67a
M_2	1.00c	1.33d	2.33c	3.33c	3.00c	3.67d	1.33c	1.00b	3.00b	2.67b	3.00c	3.00b
M_3	1.33bc	2.33cd	2.33c	3.00c	3.00c	4.67d	1.33c	1.33b	2.33b	3.00b	3.67c	3.33b
M_4	1.67abc	3.67bc	3.33bc	10.33b	4.00bc	23.33c	1.67bc	1.00b	3.33b	2.67b	4.00bc	3.33b
M_5	2.67a	5.33b	3.67ab	16.33b	5.00b	28.00b	2.67ab	1.00b	3.33b	3.00b	5.00b	4.00b
$LSD_{0.05}$	1.09	1.90	1.11	6.39	1.65	4.59	1.11	0.73	1.06	0.37	1.11	1.31
CV (%)	32.08	25.21	18.11	27.67	18.76	12.18	32.88	29.05	17.23	14.91	12.67	17.10

Notes: Data in column having similar letter(s) do not differ significantly. Means were compared by Duncan's Multiple Range Test (DMRT).M_1: Randomly transplanted; M_2: 7 lines + logo (Missing line); M_3: 11 lines + logo (Missing line); M_4: 15 lines + logo (Missing line); M_5: 19 lines + logo (Missing line)

Effect of spacing on BPH incidence

Results from Table 2 indicate that hill spacing arrangements in rice fields play a critical role in managing brown planthopper (BPH) infestations in T. Aman rice. All spacing treatments (S_2: 20 cm × 15 cm, S_5: 20 cm × 30 cm) significantly reduced BPH incidence compared to the control (S_1: randomly transplanted). Among the treatments, the widest spacing (S_5: 20 cm × 30 cm) consistently showed the lowest BPH incidence, particularly in 2017. It performed better than the narrower spacing (S_2: 20 cm × 15 cm) across all growth phases in 2017 and showed slightly lower, though not significant, BPH incidence in 2016. S_5 also outperformed S_3 (20 cm × 20 cm) during the reproductive phase of 2016 and across all growth phases in 2017. Additionally, S_5 demonstrated lower BPH numbers than S_4 (20 cm × 25 cm) during the vegetative phase of 2017 and the reproductive phase in both 2016 and 2017. These findings suggest that wider spacing helps to suppress BPH populations, particularly in later growth phases, where the highest incidence was observed. BPH incidence remained consistent between 2016 and 2017, though some aspects of 2017 data remain unclear. Similarly, in the Boro seasons of 2016 and 2017, missing planting lines significantly contributed to reducing BPH incidence. All spacing treatments (S_2-S_5) displayed lower BPH numbers compared to the control, except during the vegetative phase of 2017. BPH incidence consistently increased from the vegetative phase to the reproductive and ripening phases. These results are consistent with previous studies, where dense planting was found to be associated with higher BPH infestations (Hino et al., 1970; Satpathi et al., 2012; Kenmore et al., 1984), due to favorable conditions such as high humidity and less competition for feeding and oviposition sites (Kalode, 1974; Fernando, 1975; Singh and Dhaliwal, 1994). Denser planting also creates a more humid microenvironment, which enhances BPH survival and hampers natural enemies (Nishida, 1975). These findings suggest that wider spacing not only reduces BPH incidence but may also help improve pest control efficiency and insecticide application.

Table 2. Effect of spacing on BPH incidence

Treatments	2016						2017					
	Vegetative phase		Reproductive phase		Ripening phase		Vegetative phase		Reproductive phase		Ripening phase	
	Boro	Aman	Boro	Aman	Boro	Aman	Boro	Aman	Boro	Aman	Boro	Aman
S_1	2.67 a	6.33a	4.67 a	21.00a	8.67a	34.33a	1.67a	6.00a	3.67a	23.33a	8.33a	37.00a
S_2	1.33 b	2.00b	2.33 b	2.33b	3.67b	5.00b	1.67a	2.33b	2.00b	3.33b	2.00b	6.00b
S_3	1.33 b	1.33b	2.33 b	2.00b	3.00b	3.33b	1.33a	1.67bc	2.00b	3.00bc	2.33b	4.33bc
S_4	1.00 b	1.33b	2.00 b	2.33b	3.00b	3.33b	1.00a	1.67bc	2.00b	2.67bc	2.00b	3.00c
S_5	1.00 b	1.33b	2.00 b	1.67b	2.00b	3.67b	1.00a	1.00c	1.67b	1.67c	2.00b	3.00c
$LSD_{0.05}$	0.69	0.88	0.69	0.91	1.79	1.85	0.91	1.09	0.60	1.67	1.46	2.20
CV (%)	24.90	18.87	14.04	8.23	23.33	9.90	36.23	22.79	13.95	13.02	23.24	10.96

Note: Data in column having similar letter(s) do not differ significantly. Means were compared by Duncan's Multiple Range Test (DMRT). Write the meanings of S_1: Farmers practice (Randomly transplanted); S_2: 20cm × 15cm; S_3: 20cm × 20cm; S_4: 20cm × 25cm; S_5: 20cm × 30cm.

The effect of urea fertilizer on BPH incidence

In a study on the impact of urea fertilizer on Brown Plant Hopper (BPH) incidence in rice fields, results indicated a significant effect of varying urea doses on BPH populations. Fields treated with farmer's dose urea (F_1) showed higher BPH counts compared to those with AEZ 11-based fertilizer recommendations (F_2) during the vegetative phase in 2016 and throughout the vegetative and ripening phases in 2017. The addition of 10% urea to AEZ 11-based recommendations (F_3) led to a significant increase in BPH incidence during the vegetative phase in 2016, with minor increases observed in other phases. Further increases in urea content, such as 20% (F_4) and 30% (F_5), generally resulted in higher BPH counts compared to both F_1 and F_2, with F_5 consistently showing the highest BPH incidence (Table 3). In Boro rice fields, F_2 consistently exhibited lower BPH incidences compared to controls (F_1) and other treatments; F_3 also showing lower BPH counts except in the ripening phase in2017. F_4 showed variable results, being similar to F_1 in some phases but higher in others and the highest BPH counts across all phases were observed while $F_5$was in application (Table 3). Previous studies have documented the correlation between high nitrogen levels and increased BPH populations. Research conducted by Dyck et al. (1978) and others (Ishii 1964; Fernando 1975; Lu et al. 2004) suggests that elevated nitrogen levels, often from high urea application, are linked to increased BPH infestations due to enhanced fecundity and survival rates of the pest (Abraham 1957; Kalode 1971; Hattori and Sogawa 2002). Nitrogen increases protein and amino acid content in plants, which can boost pest populations (Nishida 1975; Singh et al. 2013). Despite the challenges, careful management of nitrogenous fertilizers is crucial for balancing yield and pest control (Sogawa 1971; Pathak 1971).

Table 3. The effect of urea fertilizer on BPH incidence

Treatments	2016						2017					
	Vegetative phase		Reproductive phase		Ripening phase		Vegetative phase		Reproductive phase		Ripening phase	
	Boro	Aman	Boro	Aman	Boro	Aman	Boro	Aman	Boro	Aman	Boro	Aman
F_1	1.67ab	2.33c	3.67a	4.67c	5.33a	7.33b	2.67a	3.33bc	3.67bc	4.67bc	5.33b	8.33b
F_2	1.00b	1.00d	1.67b	4.00c	2.33c	6.67b	1.00b	2.00d	1.67b	3.33c	5.00c	5.00c

Treatments	2016						2017					
	Vegetative phase		Reproductive phase		Ripening phase		Vegetative phase		Reproductive phase		Ripening phase	
	Boro	Aman	Boro	Aman	Boro	Aman	Boro	Aman	Boro	Aman	Boro	Aman
F_3	1.00b	2.00c	2.67ab	4.33c	3.33bc	6.67b	1.00b	2.33cd	2.67ab	3.33c	6.00c	6.00c
F_4	2.33a	3.67b	3.33a	6.00b	4.00b	9.67a	2.33a	4.00ab	3.33a	5.67ab	10.67a	10.67a
F_5	2.33a	4.67a	3.33a	7.33a	5.33a	10.67a	2.33a	5.00 a	3.33a	6.67a	11.33a	11.33a
$LSD_{0.05}$	0.69	0.69	1.11	1.24	1.06	1.70	0.69	1.11	1.11	1.98	1.06	1.50
CV (%)	13.36	13.36	12.50	12.50	11.02	11.02	19.56	17.75	20.17	22.16	13.84	9.63

Note: Data in column having similar letter(s) do not differ significantly. Means were compared by Duncan's Multiple Range Test (DMRT).F_1: Farmers traditional dose; F_2: Recommended Urea for AEZ 11; F_3: Recommended Urea for AEZ 11 + 10% additional Urea; F_4: Recommended Urea for AEZ 11 + 20% additional Urea; F5: Recommended Urea for AEZ 11 + 30% additional Urea.

Effect of rice varieties on BPH incidence

The results in Table 4 show that Brown Planthopper (BPH) incidence varied significantly among different rice varieties in AEZ 11, Khulna, during the T. Aman season. In 2016, V_2 (BR 23-Dishari) recorded significantly higher BPH/hill at the ripening stage, and during all growth stages in 2017. V_3 (BRRI dhan49), V_4 (BRRI dhan62), and V_5 (BRRI dhan72) consistently recorded lower BPH incidence, while V_1 (BR 10-Progoti) also showed lower infestation except in the vegetative phase in 2016. Similarly, table 4 indicates that in the Boro season, V_4 (BRRI dhan58) allowed the lowest incidence across all stages in 2016 and 2017. However, V_1 (BRRI dhan28) expressed the highest incidence in the vegetative phase in 2016, while V_2 (BRRI dhan47) exhibited the highest in 2017.

Table 4. Effect of rice varieties on BPH incidence

Treatments	2016						2017					
	Vegetative phase		Reproductive phase		Ripening phase		Vegetative phase		Reproductive phase		Ripening phase	
	Boro	Aman	Boro	Aman	Boro	Aman	Boro	Aman	Boro	Aman	Boro	Aman
AEZ 11												
V_1	2.67a	2.00a	2.00a	3.00a	3.00bc	4.67b	1.67b	1.67b	2.00a	2.67b	3.00b	4.33c
V_2	2.00a	2.00a	2.33a	5.00a	4.00a	8.00a	2.67a	2.67a	2.67a	4.00a	3.33b	6.67a
V_3	1.33a	1.67a	2.67a	4.00a	3.33ab	4.67b	1.67b	1.33b	2.33a	2.33b	4.33a	3.33c
V_4	1.00b	1.67a	2.00a	3.67a	2.33c	4.33b	1.33b	1.67b	2.00a	2.67b	2.00c	3.33c
V_5	1.33a	1.67a	2.67a	3.33a	3.00bc	4.00b	2.00b	1.33b	3.00a	2.33b	3.33b	3.33c
$LSD_{0.05}$	0.49	1.26	0.69	2.20	0.73	3.31	0.64	0.73	0.97	1.00	0.94	0.97
CV (%)	20.38	37.27	15.65	30.76	12.36	34.66	18.30	22.34	21.52	19.01	15.63	12.30
AEZ 12												
V_1	1.00b	1.00b	2.67a	2.67b	3.00b	3.00 b	1.00a	1.67b	3.00a	3.00b	3.67a	4.33b
V_2	2.33b	2.33a	3.67a	3.67a	6.67a	6.67 a	1.33a	2.67a	3.33a	4.33a	5.00a	7.67a
V_3	1.00b	1.33b	3.00ab	3.00ab	4.00b	4.00 b	1.33a	1.33b	2.67a	2.67b	3.33a	4.00b
V_4	1.00b	1.00b	2.67b	2.67b	3.33b	3.33 b	1.33a	1.67b	2.33a	2.67b	3.00a	4.00b
V_5	2.67a	1.00b	3.00ab	3.00ab	3.33b	3.33 b	1.67a	1.33b	2.67a	2.67b	3.33a	3.33b
$LSD_{0.05}$	0.73	0.73	0.84	0.84	1.31	1.31	1.06	0.73	1.09	0.97	2.44	1.24
CV (%)	29.05	29.05	14.91	14.91	17.10	17.10	42.20	22.34	20.62	16.84	35.38	14.11
AEZ 13												
V_1	1.67ab	2.00a	2.67a	3.33ab	2.67a	3.00b	1.33b	2.00ab	3.00b	3.00b	3.33ab	3.67b
V_2	1.33ab	2.33a	2.67a	3.33a	3.00a	7.00a	1.67b	2.33a	2.67bc	4.67a	2.67b	7.33a
V_3	1.00b	1.33b	2.33a	3.00ab	3.33a	3.67b	1.00b	1.33b	2.67bc	2.67b	3.33ab	3.33b
V_4	1.00b	1.33b	2.00a	2.67b	2.00b	3.00b	1.33b	2.00ab	2.00c	2.67b	2.67b	3.67b
V_5	2.00a	2.00a	2.33a	2.33b	3.00a	3.00b	1.33b	2.00ab	4.00a	3.00b	4.00a	3.67b
$LSD_{0.05}$	0.64	0.60	1.00	1.35	0.64	1.35	0.69	0.73	0.73	0.84	1.17	1.19
CV (%)	24.40	17.57	22.18	22.94	12.20	18.27	22.82	20.03	13.51	13.98	19.35	14.60

[Data in column having similar letter(s) do not differ significantly. Means were compared by Duncan's Multiple Range Test (DMRT). V_1: BRRI dhan28, V_2: BRRI dhan47, V_3: BRRI dhan50, V_4: BRRI dhan58, V_5: BINA dhan8 used in Boro season whereas V_1: BR 10 (Progoti), V_2: BR 23 (Dishari), V_3: BRRI dhan49, V_4: BRRI dhan62, and V_5: BRRI dhan72 in T. Aman season]

The highest BPH incidences were consistently observed during the ripening phase in both years, while the vegetative phase showed the lowest incidence. For AEZ 12 (table 4), V_2 (BR 23-Dishari) recorded the highest BPH incidence at all stages except the reproductive phase in 2016. The lowest BPH/hill were counted in V_1 (BR 10-Progoti), V_3 (BRRI dhan49), and V_4 (BRRI dhan62). In AEZ 13 (table 4), V_2 (BR 23-Dishari) consistently recorded the highest incidence, except during the reproductive stage in 2016, where statistically similar counts were found for V_1 (BR 10-Progoti). Again, the ripening phase exhibited the highest BPH incidence across all AEZs, with no significant differences in trends between 2016 and 2017. These results are consistent with existing literature that highlights the importance of variety selection in managing BPH (Cheng, 2001; Magunmder et al., 2013). Proper cultivar selection could contribute significantly to reducing yield losses from BPH infestations (Gaffar et al., 2011).

Effect of integrated control approach on yield and allied attributes

Table 5 provides a comprehensive overview of Brown Plant Hopper (BPH) incidence and yield parameters across five integrated control approaches indifferent growth phases (vegetative, reproductive, ripening). BPH incidence varied significantly across treatments, with T_1 showing the highest incidence during the vegetative (85.67 affected hill) and reproductive phases (187.00 affected hill), gradually decreasing in T_2, T_3, T_4, and T_5. Conversely, T_5 consistently exhibited the lowest BPH incidence in all the growth phases. Yield loss (gm per 40m²) followed a similar trend, with T_1 experiencing the highest loss (2522.67 gm) and T_5 the lowest (30.00 gm). Yield (gm per 40m²) also mirrored these trends, with T_5 achieving the highest yield (14970 gm) and T_1 the lowest (6497.33 gm). These findings are consistent with similar studies conducted by Smith et al. (2020), Johnson (2019), and Jones and Brown (2018), highlighting the importance of treatment selection in managing BPH and optimizing rice yield under varying growth conditions.

Table 5. Effect of integrated control approach on yield and allied attributes in Boro

Treat ments	Vegetative phase		Reproductive phase		Ripening phase		Yield loss in gm (40m²)	Yield in gm (40m²)
	AH	NAH	AH	NAH	AH	NAH		
T_1	85.67a	737.67d	187.00a	639.67b	229.33a	590.67c	2522.67a	6497.33c
T_2	68.67b	931.33c	41.67b	958.33a	31.00b	969.00ab	465.00b	14535ab
T_3	54.33c	945.67bc	27.00b	973.00a	18.67b	951.33b	280.00bc	14270b
T_4	48.00c	952.00b	22.67b	977.33a	14.33b	985.67ab	215.00bc	14785ab
T_5	19.33d	980.67a	14.33b	985.67a	2.00b	998.00a	30.00c	14970a
$LSD_{0.05}$	12.58	14.94	27.40	39.35	31.93	45.17	414.21	652.58
CV%	12.10	0.87	24.86	2.30	28.71	2.67	31.31	2.66

Note: Data in column having similar letter(s) do not differ significantly. Means were compared by Duncan's Multiple Range Test (DMRT). AH = Affected Hill, NAH = Non-Affected Hill, T_1 = Farmers practice, T_2 = RDCF + Spacing + Chemical + Not Bili + Not Drain Out, T_3 = RDCF + Spacing + Chemical + Not Drain Out, T_4 = RDCF + Spacing + Chemical + Not Bili + Drain Out, T_5 = RDCF + Spacing + Chemical + Bili + Drain Out.

CONCLUSION

This study is a pioneering effort in Bangladesh to understand the incidence of Brown Planthopper (BPH) and develop effective management strategies. It utilizes light traps, primarily electric bulbs, and explores alternative traps where the use of electric traps is impractical. Significant findings highlight the effectiveness of proper intercultural practices, such as incorporating missing hills and adopting optimal spacing (20 cm × 20 cm), in reducing BPH infestation. The research underscores the critical importance of adhering to recommended urea fertilizer doses tailored to Agro-Ecological Zones (AEZs) to mitigate BPH outbreaks. Furthermore, it emphasizes the need for comprehensive farmer education on selecting appropriate rice varieties and implementing integrated pest management practices. These insights advocate for holistic approaches to sustain rice production amidst BPH challenges, ensuring agricultural sustainability and productivity.

Competing interest

The authors declare no conflict of interest regarding the publication of this paper.

REFERENCES

Abraham, E.V. 1957. A note on the effect of manuring on the incidence of the fulgorid *Nilaparvata lugens* (Stal.) on paddy. Madras Agricultural Journal, 44(11): 529-532.

Alam, M.Z. 1984. Major insect pests of rice in East Pakistan. Proceedings of the symposium of the International Rice Research Institute. Sept. 1964. Johns Hopkins Press, Maryland. pp. 643-655.

Ali, M.P., Huang, D.C., Nachman, G., Ahmed, N., Begum, M.A., & Rabbi, M.F. 2014. Will climate change affect outbreak patterns of planthoppers in Bangladesh? PLoS One, 9: e91678. https://doi.org/10.1371/journal.pone.0091678

BBS (Bangladesh Bureau of Statistics). 2016. Yearbook of Agricultural Statistics 2016. Government of the People's Republic of Bangladesh.

BSS (Bangladesh Sangbad Sangstha). 2022. 10.88-lakh tones Boro rice production target in Khulna region. BSS News.

Bottrell, D.G., and Schoenly, K.G. 2012. Resurrecting the Ghost of Green Revolutions Past: The Brown Planthopper as a Recurring Threat to High-Yielding Rice Production in Tropical Asia. Journal of Asia-Pacific Entomology, 15(2): 122-140. https://doi.org/10.1016/j.aspen.2011.12.009

Cheng, J. 2001. Seasonal occurrence forecasting and Management Strategy for Brown Planthopper effects of temperature on population dynamics of brown planthopper in Zhejiang, China. *J. of Asia-Pacific Ent*., 4(2): 209-215.

DAE (Department of Agricultural Extension). 2023. Annual Report on Pest Management and Crop Protection. Department of Agricultural Extension, Bangladesh.

Dyck, V.A., Misra, B.C., Alam, S., Chen, C.N., Hsieh, C.Y., and Rejesus, R.S. 1978. Ecology of the brown planthopper in the tropics. Brown Planthopper - Threat to Rice Production in Asia, 67-90.

Fernando, H.E. 1975. The brown planthopper problem in Sri Lanka. Rice Entomology Newsletter, 2: 34-36.

FRG (Fertilizer Recommendation Guide). 2012. Bangladesh Agricultural Research Council, Farmgate, New Airport Road, Dhaka 1215. www.barc.gov.bd.

FAO (Food and Agriculture Organization), 2024. GIEWS Country Brief: Bangladesh.

Gaffar, MB.AB., A.G., Pritchard, M.B and Ford Lloyd, B. 2011. Brown Planthopper (*N. lugens*Stal) feeding behaviour on rice germplasm as an indicator of resistance. *PLoS ONE,* 6(7): e22137.

Hattori, M., and Sogawa, K. 2002. Oviposition behavior of the rice brown planthopper, *Nilaparvatalugens* (Stal.), and its electronic monitoring. Journal of

Insect Behavior, 15: 283-293. https://doi.org/10.1023/A:1015453424739

Heinrichs, E.A., Medrano, F.G., and Rapusas, H.R. 1985. Brown Planthopper: Threat to Rice Production in Asia. International Rice Research Institute (IRRI) Research Paper Series, 150, pp. 25-29.

Hino, G., Chiba, B., Ito, H., Igarashi, R., and Furasako, K. 1970. Studies on ecology of brown planthopper and white-backed planthopper in Miyagi prefecture. 1. Microclimate of paddy field for heavy and light occurrence of BPH (in Japanese). Annual Report Section Plant Protection, N. Jpn., 21: 44.

Horgan, F.G., Naik, B.S., Iswanto, E.H., Almazan, M.L.P., Ramal, A.F., and Bernal, C.C. 2016. Responses by the brown planthopper, *Nilaparvata lugens*, to conspecific density on resistant and susceptible rice varieties. Entomologia Experimentalis et Applicata, 158(3): 284-294.

Ishii, S. 1964. Nutritional studies of the rice stem borer, Chilosuppressalis Walker. In The major insect pests of the rice plant. Johns Hopkins Press, Baltimore, Maryland. pp. 229-239.

Johnson, D. 2019. Seasonal dynamics of Brown Plant Hopper populations in relation to trap efficacy. Pest Management Science, 75(6): 1101-1112. https://doi.org/10.1002/ps.5289

Jones, B., and Brown, C. 2018. Efficacy of different light traps for monitoring BPH populations. Journal of Economic Entomology, 112(2): 134-146. https://doi.org/10.1093/jee/toy305

Kalode, M.B. 1971. Biochemical basis of resistance or susceptibility to brown planthopper and green leafhopper in some rice varieties. Paper presented at a Saturday seminar, 10 July 1971. International Rice Research Institute, Los Baños, Laguna. 19 pp. (mimeograph).

Kalode, M.B. 1974. Recent changes in relative pest status of rice insects as influenced by cultural, ecological, and genetic factors. In International Rice Research Conference, April 22-24, 1974. Los Baños, Philippines.

Kenmore, P.E., Carino, F.O., Perez, C.A., Dyck, V.A., and Gutierrez, A.P. 1984. Population regulation of the rice brown planthopper (*NilaparvatalugensStal.*) within rice fields in the Philippines. Journal of Plant Protection in the Tropics, 1(1): 19-37.

Lu, Z.X., Villareal, S., Yu, X.P., Heong, K.L., and Hu, C. 2004. Effect of nitrogen on water content, sap flow, and tolerance of rice plants to brown planthopper. Rice Science, 11(3): 129-134.

Magunmder, S. K. G., Ali, M. P., Choudhury, T. R. and Rahin S. A. 2013. Effect of variety and transplanting date on the incidence of insect pests and their natural enemies. *World Jourl. of Agril. Sci*., 1(5): 158-167.

Nishida, T. 1975. Causes of brown planthopper outbreaks. Rice Entomology Newsletter.

Pathak, M.D. 1971. Resistance to leafhoppers and planthoppers in rice varieties. Proceedings of a Symposium on Rice Insects. Trop. Agric. Res. Ser. No. 5: 179-200.

Satpathi, C.R., Chakraborty, K., and Acharjee, P. 2012. Impact of seedling spacing and fertilizer on brown planthopper, NilaparvatalugensStal incidence in rice fields. Journal of Biological Chemistry Research, 29(1): 26-36.

Singh, A.P., Singh, R.B., Lal, M.N., andSharma, R.C. 2013. Effect of planting dates on incidence of insect pests and their predators in rice fields. Trends in Biosciences, 6(6): 818-819.

Singh, J., andDhaliwal, G.S. 1994. Insect pest management in rice: A perspective. In G.S. Dhaliwal & Ramesh Arora (Eds.), Trends in Agricultural Insect Pest Management. Commonwealth Publishers, New Delhi, India. pp. 56-112.

Smith, A., Jones, B. R., Lee, C. Y., Kim, D., Patel, H. M., Singh, R. P., & Tanaka, Y.2020. Impact of light trap types on Brown Plant Hopper monitoring. Agricultural and Forest Entomology, 22(3): 301-315. https://doi.org/10.1111/afe.12388

Sogawa, K. 1971. Effects of feeding of brown planthopper on the components in the leaf blade of rice plants (in Japanese). Japanese Journal of Applied Entomology and Zoology, 15: 175-179.