International Journal of Plant & Soil Science

Volume 36, Issue 8, Page 270-275, 2024; Article no.IJPSS.120225
ISSN: 2320-7035

Impact of Hasanta Rice on Yield and Brown Plant Hopper Incidence in Rain-Fed Semi-lowland Ecosystems: A Farmer-centric Study

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/ijpss/2024/v36i84855

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/120225

Original Research Article

Received: 16/05/2024
Accepted: 18/07/2024
Published: 26/07/2024

ABSTRACT

The field experiment was conducted during the Kharif seasons of 2021 and 2022 in farmers' fields across four adopted villages, involving 13 farmers. The results exhibited that the Brown Plant hopper (BPH) incidence was significantly lower in the rice variety Hasanta compared to the farmers' variety, Pratikshya. Notably, Hasanta recorded higher performance metrics in several key areas. The number of tillers per hill, panicle length, plant height, and test weight were all superior in Hasanta compared to Pratikshya in both years of the study. This indicates a consistent advantage

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Cite as: *Rai, A. K., S. Panda, T.C. Panda, S. R. Dash, P.J. Mishra, A. Phonglosa, and C. Patra. 2024. "Impact of Hasanta Rice on Yield and Brown Plant Hopper Incidence in Rain-Fed Semi-Lowland Ecosystems: A Farmer-Centric Study". International Journal of Plant & Soil Science 36 (8):270-75. https://doi.org/10.9734/ijpss/2024/v36i84855.*

in these agronomic traits. The average grain yield of Hasanta was also notably higher, achieving 43.83 q/ha in 2021 and 45.0 q/ha in 2022. In comparison, the farmers' variety, Pratikshya, yielded 39.25 q/ha in 2021 and 40.10 q/ha in 2022. This demonstrates Hasanta's superior yield performance under the given conditions. Overall, the study determined that the rice variety Hasanta showed consistent tolerance to BPH incidence and performed well under rain-fed conditions. Given its higher yield and resilience, Hasanta is a promising supernumerary over Pratikshya in the rain-fed semi-lowland rice ecosystem, offering substantial yield benefits and higher net returns (Rs. 38290/ha) for farmers.

Keywords: Rice; Hasanta; Pratikshya; BPH; economy; yield.

1. INTRODUCTION

Rice is the most important crop in India, serving as the staple food for over 65% of the population and providing employment and livelihood security to 70% of Indians. This crop is crucial for millions of rural households and is essential for the country's food security, making the phrase "rice is life" highly appropriate in the Indian context. India ranks second in rice production globally, after China. Worldwide, rice is grown on 158 million hectares, yielding 700 million tons [1] whereas in India rice is cultivated on 43.86 million hectares, producing about 106.54 million tons annually, with an average yield of 2,424 kg per hectare and accounts 26% of the world's total rice production [2].

In Odisha, rice farming covers 4.4 million hectares, with an average yield of 1,538 kg per hectare. It represents 89% of the state's cereal-growing area and contributes 92% to the total cereal production in Odisha [3]. The demand for rice is increasing annually, and it is estimated that by 2025, the requirement will reach 140 million tons. To meet the food needs of future generations and to be self-sufficient in current food requirements, India's annual rice productivity needs to increase by 3%. Rice production is significantly impacted by pests, causing approximately 23% in losses. Among the various rice pests, the Brown Plant hopper (BPH), *Nilaparvata lugens*, is a major pest that inflicts severe damage on rice crops. One of the main symptoms of BPH infestation is "hopper burn," which appears as yellowing, wilting, and eventually drying of the rice plants. This damage occurs because BPH feeds on the plant's phloem sap, draining its nutrients and water. The affected areas often show a distinct bronzed appearance before the plants die off Heong & Hardy, [4]. The nymph stages are especially harmful as they undergo five molts before becoming adults, with each stage actively feeding on the rice plants. Adult BPHs can fly and spread over long distances, facilitating the rapid spread of infestations across rice-growing regions. Their high reproduction rate leads to large population increases under favorable conditions. The use of pesticides for pest management is costly, increasing the overall cost of crop cultivation and farmers typically use Imidacloprid in higher doses, which have become ineffective due to pest resurgence. It is suspected that the resurgence of BPH is due to the continuous use of a single pesticide, despite advice to farmers to alternate pesticides. Extensive investigations over the past few years have examined insecticide-induced BPH resurgence in rice [5,6]. Additionally, pesticides negatively impact soil health and human health in various ways [7]. Therefore, developing pest-resistant or tolerant varieties is a better solution. Hasanta, a medium-long duration (145–150 days) rice variety, was developed by Odisha University of Agriculture and Technology, Bhubaneswar. It has an average yield of 6.5–7.0 tons per hectare (DAC indent, 2021) and shows moderate resistance to BL, BLB, SB, LF, and tolerance to BPH. This investigation aimed to assess the field performance of the rice variety Hasanta against BPH incidence under rain-fed conditions in Jharsuguda district.

2. MATERIALS AND METHODS

The Jharsuguda district consists of five community blocks: Jharsuguda, Kolabira, Kirmira, Laikera, and Lakhanpur. Among these, Jharsuguda, Laikera, and Kolabira blocks were selected for conducting Front Line Demonstrations (FLD). Four villages were chosen based on initial surveys where farmers were cultivating the Pratikshya rice variety in their cropping systems. A total of thirteen farmers were selected across these villages. FLDs were conducted during Kharif seasons of 2021 and 2022 across four different locations within the three blocks. Hasanta rice variety was provided to farmers for demonstration purposes, and some farmers also used seeds of the same variety collected from others who had grown it in the previous year. The trials covered an area of 4.0 hectares. Initial soil properties varied across different locations: organic C ranged from 0.43% to 0.50%, available N from 200 to 230 kg/ha, available P_2O5 from 20 to 25 kg/ha, available K_2O from 110 to 122 kg/ha, and soil pH ranged from 5.1 to 5.4. Rice was seeded in nurseries during the third week of July at a rate of 50 kg/ha, and 21-day-old seedlings were transplanted with 15 cm spacing between rows and 10 cm between plants. The recommended fertilizer application was 100 kg/ha of N, 80 kg/ha of P_2O5, and 60 kg/ha of K_2O. The full dose of P_2O5 and K2O, along with 25% of N, was applied as basal fertilizer. The remaining 50% of N was top-dressed three weeks after transplanting, and the final 25% was applied at the panicle initiation stage. Field days and group meetings were also organized with the district officials as well as village farmers to provide the opportunities for other farmers to witness the benefits of demonstrated technologies. The yield-related data were collected from farmers across all four locations from both FLD plots as well as farmer's practices plots. Each farmer represented one replication, and a total of thirteen sets of data were collected. During data collection, crop characteristics such as plant height (cm), number of tillers per hill, panicle length (cm), test weight (g), and yield (q/ha) were recorded as well as cost of cultivation, net income, and benefit cost ratio were also worked out (Samui et al., 2000). .The net return and B:C ratio were calculated by using following formula as given below:

$$\text{Net Return (Rs/ha)} = \text{Gross Return} - \text{Cost of Cultivation}$$

$$\text{BC Ratio} = \frac{\text{Gross Return}}{\text{Cost of cultivation}}$$

All data from the thirteen replications were statistically analyzed using ANOVA as a randomized block design to determine significant differences among treatments through OPSTAT.

3. RESULTS AND DISCUSSION

The presented data Table 1 encapsulates the performance of two different treatment conditions, denoted as FP (Farmer's Practice) i.e. variety Pratikshya and RP (Recommended Practice) i.e. Hasanta variety, evaluated across two consecutive years. The metrics considered include plant height (cm), panicle length (cm), number of tillers per plant, test weight (g), and yield (q/ha).

Plant Height (cm): In the first year, the average plant height for Pratikshya was 96.76 cm, while demonstrated variety exhibited a significantly greater height of 117.56 cm. This trend persisted in the second year, with Pratikshya at 97.80 cm and Hasanta at 119.11 cm, highlighting that variety Hasanta consistently resulted in taller plants across both years. The mean plant height across both years was 107.16 cm and 108.45 cm, respectively. The consistent taller stature of Hasanta compared to Pratikshya across both years underscores its potential for enhanced biomass production and possibly higher grain yield. Taller plants like Hasanta can benefit from increased light interception and better competition for resources, contributing to overall crop productivity [8]. However, excessive height can also pose risks such as lodging, which needs careful management to optimize yield [9].

Panicle Length (cm): The panicle length showed minimal variation between the two varieties. In the first year, Pratikshya recorded a panicle length of 22.89 cm, closely matched by variety Hasanta at 22.97 cm. The second year showed a similar pattern with Pratikshya at 22.67 cm and Hasanta at 23.16 cm. The mean values were nearly identical at 22.93 cm for the first year and 22.92 cm for the second year, indicating that panicle length remained stable regardless of the practice employed.

Tillers per hill (nos): A significant difference was observed in the number of tillers per plant. Pratikshya variety had an average of 11.55 tillers in the first year and 11.10 in the second year. Conversely, variety Hasanta demonstrated a higher tiller count with 13.66 in the first year and 13.38 in the second year. This increase in tiller number is crucial as it directly correlates with potential grain yield [10]. Enhanced tillering is often associated with better nutrient uptake and utilization, contributing to improved overall plant performance [11].

Test Weight (g): The test weight of rice, an important indicator of grain quality, showed a consistent difference between the two practices observed in the study. Over the two-year period, the rice variety Hasanta demonstrated shows significantly higher test weights compared to Pratikshya, suggesting a superior performance in grain quality. In the first year, Hasanta had a test weight of 25.05 g compared to Pratkshya's 22.31 g. This trend continued in the second year, with

Hasanta at 24.82 g and Pratikshya at 22.10 g. The average test weights for Hasanta were significantly higher, indicating a consistent advantage in grain quality. The mean test weights over the two years were 23.68 g in the first year and 23.46 g in the second year. Similar findings have been reported by Singh et al. (2018) highlighted that higher test weights are often associated with improved resistance to biotic and abiotic stresses, contributing to better overall performance in varied growing conditions. Additionally, varietal differences in test weight have been linked to genetic factors influencing grain filling and plant metabolism.

Yield (q): The rice yield was consistently significantly higher for the Hasanta variety in both years. Pratikshya recorded 40.10 q/ha in the first year and 39.25 q/ha in the second year, while Hasanta yielded 45.00 q/ha and 43.83 q/ha, respectively. The mean yield was 42.55 q/ha in the first year and 41.54 q/ha in the second year, showcasing Hasanta's efficacy in achieving higher productivity.

The results indicate a significant yield advantage for the Hasanta variety over Pratikshya. This consistent performance across two years suggests that Hasanta may possess superior genetic traits or a better adaptation to the growing conditions of the study area. Such yield improvements are crucial for meeting the increasing food demand and ensuring food security [12,13]. High-yielding varieties like Hasanta contribute to higher productivity through several mechanisms, including better resistance to pests and diseases, efficient nutrient uptake, and improved photosynthetic capacity [14]. The higher yield of Hasanta may also be attributed to its greater tiller number and higher test weight, as observed in this study. These traits are often linked to improved agronomic practices and genetic improvements, which enhance overall plant vigor and grain filling [15,17]. Moreover, the superior performance of Hasanta aligns with previous studies that have highlighted the importance of selecting and cultivating high-yielding rice varieties to boost agricultural productivity [17]. The findings from this study reinforce the potential benefits of adopting Hasanta in similar agro-ecological zones, thereby contributing to sustainable rice production and economic gains for farmers [18].

Table 1. Performance of rice variety Hasanta under demonstration

Characters / Varieties	Plant Height (cm)		Panicle Length (cm)		Tillers/Hill (Nos)		Test Weight (g)		Yield (q/ha)	
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
Pratikshya	96.76	97.80	22.89	22.67	11.55	11.10	22.31	22.10	40.10	39.25
Hasanta	117.56	119.11	22.97	23.16	13.66	13.38	25.05	24.82	45.00	43.83
Mean	**107.16**	**108.45**	**22.93**	**22.92**	**12.61**	**12.24**	**23.68**	**23.46**	**42.55**	**41.54**
Sem(±)	**1.91**	**1.65**	**0.24**	**0.20**	**0.12**	**0.11**	**0.20**	**0.18**	**0.69**	**0.60**
CD (5%)	**5.89**	**5.08**	**NS**	**NS**	**0.38**	**0.35**	**0.61**	**0.54**	**2.11**	**1.85**

FP- Pratikshya, RP- Hasanta

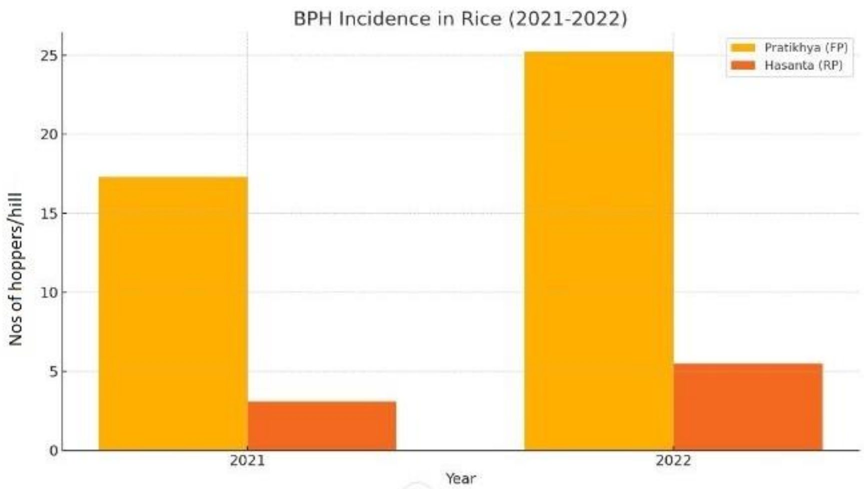

Chart 1. Incidence of Brown Plant hopper (BPH) in rice for the years 2021 and 2022

Table 2. Average Economics of two years data comparison between Farmer's practice and recommended practice

Variety	Yield (q/ha)	Gross Cost (Rs./ha)	Gross Return (Rs/ha)	Net Return (Rs/ha)	B:C
Pratikshya (FP)	39.7	39750	69488	29738	1.7
Hasanta (RP)	44.4	39500	77790	38290	2.0

The chart is the incidence of Brown Plant hopper (BPH) in rice for the years 2021 and 2022. The chart highlights that the Pratikshya (FP) variety experienced significantly higher numbers of hoppers in compared to the Hasanta (RP) variety in both years. The hoppers increased for both varieties from 2021 to 2022, with Pratikshya (FP) reaching 25.2% in 2022 compared to Hasanta (RP) at 5.5% only. This indicates a greater susceptibility of Pratikshya to BPH.

The above economic data reveals that the Pratikshya (FP) variety has a yield of 39.7 q/ha, a gross cost of Rs. 39,750/ha, and generates a gross return of Rs. 69,488/ha, resulting in a net return of Rs. 29,738/ha with a benefit-cost ratio (B: C) of 1.7 (Table 2). In comparison, the Hasanta (RP) variety shows a higher yield of 44.4 q/ha, a slightly lower gross cost of Rs. 39,500/ha, and a gross return of Rs. 77,790/ha, leading to a net return of Rs. 38,290/ha and a B: C ratio of 2.0. This indicates that Hasanta has higher yield with less pest attack, it ultimately provides better economic returns and efficiency than Pratikshya.

4. CONCLUSION

The outcomes indicate that the Hasanta (RP) variety outperforms over the Pratikshya (FP) variety in terms of yield, pest resistance, and economic returns. Hasanta demonstrated significantly higher resistance to BPH, with lower incidence rates in both 2021 and 2022. Economically, Hasanta's higher yield and slightly lower gross cost resulted in a better net return and a higher benefit-cost ratio. These findings support the adoption of Hasanta as a more productive and cost-effective rice variety for farmer and for preventing outbreaks of BPH needed regular monitoring, use of resistant varieties, good water management and balance use of fertilizer in rice field.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

ACKNOWLEDGEMENT

The authors are grateful to Director, ICAR-ATARI, Kolkata and Odisha University of Agriculture and Technology, Bhubaneswar for providing necessary support and guidance for completion of the work.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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