Plant Archives Vol. 26, No. 2, 2026 pp. 2767-2773 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2026.v26.no.2.379

TRADITIONAL GENOTYPES HIDDEN POTENTIAL AGAINST BROWN PLANT HOPPER (*Nilaparvata lugens* STAL) STRESS IN RICE FOR CLIMATE-RESILIENT BREEDING

T.S. Patel[1*], Deepak Sharma[1] and V.K. Soni[2]

[1]Department of Genetics and Plant Breeding, Indira Gandhi Agricultural University, Raipur (C.G.), India – 492012
[2]Department of Entomology, Indira Gandhi Agricultural University, Raipur (C.G.), India - 492012
[*]Corresponding author E-mail: tarungpb@gmail.com
(Date of Receiving-27-08-2026; Date of Revision-27-10-2026; Date of Acceptance-30-10-2026)

ABSTRACT

Brown planthopper (*Nilaparvata lugens* Stal) is one of the destructive insect pests of rice reducing rice yield relentlessly every year particularly in Asian continents where more than 90% rice has noticed to grown worldwide. Resistance over several pesticides year by year and lack of suitable resistant cultivar make the insect more dangerous, leading to yield reduction from 10% - 100%. In this context, 100 rice genotypes including two standard checks PTB-33 (resistant) and TN-1 (susceptible) were investigated for three seasons, during *kharif* 2024, *kharif* 2025 and *rabi* 2025 under glasshouse of department of Entomology, IGKV Raipur, Chhattisgarh (CG) following the standard seed-box screening technique (SSST). Results revealed that nine genotypes namely PTB-33 (resistant check), Kumhdaphool parent, Mehar, Khatiyapati, Gopalbhog parent, Bearanguda, Karanphool, Ramigali and Chaptigurmatiya mut-1 illustrated resistance against *Nilaparvata* populations by consistently performing score (1) over three seasons. Two genotypes Ramigali and Chaptigurmatiya mut-1 scored (3) and identified as moderately resistant genotypes. Remaining 91 genotypes showed susceptible to highly susceptible under study.

***Key words*:** Brown planthopper, resistant, susceptible, SSST, PTB-33

Introduction

Rice (*Oryza sativa* L.) is a member of poaceae family, comprised 22 wild species and two cultivated species *i.e.*, *O. sativa* (Asian rice) and *O. glaberrima* (African rice). Rice is one of the most vital cereal crops globally, serving as the primary staple food for more than half of the world's population, supplying approximately 19% to 20% of global dietary energy and 13% of human protein requirements (Evamoni *et al*., 2024; Kumar *et al*., 2025). Its production and consumption form the foundation of global food security, agrarian livelihoods and national economic stability (Chaity *et al*., 2026). In many Asian nations, rice accounts for up to 80% of daily caloric intake and 65% of total food consumption (Jahin *et al*., 2024; Jarin *et al*., 2024). Economically, rice represents the second largest crop by cultivated area and production worldwide after maize (Jarin *et al*., 2024). Global milled rice production reaches 500 to 560 million metric tons annually, grown on more than 160 million hectares worldwide (FAO, 2026). Rice is central to food security and rural economic stability in major Asian producer countries. In India alone, rice production reached at 137.8 MT in the cultivated area of 47.8 Mha with the productivity of 4400 kilograms per ha (USDA, 2025). With the global population projected to reach 9 billion by 2050, demand for rice will continue to rise (Chaity *et al*., 2026; Das *et al*., 2024). However, severe biotic and abiotic stresses such as Brown Planthopper (BPH), drought and soil salinity threaten future productivity (Chaity *et al*., 2026; Das *et al*., 2024). Developing high-yielding, climate-resilient, and nutrient-efficient rice genotypes is imperative to ensure future economic

sustainability and global food security (Hallajian, 2024; Salomi *et al*., 2024).

Besides abiotic stresses like drought, rice production is significantly impacted by biotic constraints, such as insect pests (Kumari *et al*., 2022). Biotic stresses account for about 52% of decreased global rice production (Savary *et al*., 2019). The Brown Planthopper *Nilaparvata lugens* Stål), is one of the most important insect pests of rice, especially in Asia and India (Roy *et al*., 2022; Soni and Tiwari, 2017). BPH directly feed on plant surface and suck the sap from base of the rice plant (sheath) and causes significant economic damage of over 60% under favourable conditions, and also transmits rice ragged stunt virus (RRSV) and rice grassy stunt virus (RGSV) (Kanngan *et al*., 2023). At the high population density of these pests, crop became complete drying at patches on the field *i.e*., hopper burn, which may result in yield loss by 20-80% (Balachiranjeevi *et al*., 2019); up to 40 – 70% yield loss or complete yield loss by 70 – 100% (Min *et al*., 2014; Jena *et al*., 2018; Pandi *et al*., 2018). Factors that favour BPH development include high humidity (>80%), temperatures (25°C-32°C), excessive use of nitrogenous fertilizers, high plant density and water submergence Haliru *et al*., (2020). Inappropriate and over application of chemical insecticides has disrupted natural predator habitat, cause environment pollution, toxic to human health and fear to emergence of new pest biotype against certain chemicals. Therefore, identification of new sources of resistant gene, particularly from landraces, wild cultivars, and germplasms, is essential task to plant breeders for sustainable production (Roy *et al*., 2022; Kumar *et al*., 2014).

Materials and Methods

Materials

Experimental material for the screening of BPH comprised of 100 rice genotypes including standard resistant check PTB-33 and susceptible check TN-1. Ninety-eight genotypes consisted land races, mutants and popular varieties of Chhattisgarh origin.

Methods

Brown planthopper (BPH) evaluation was carried out during *kharif* 2024, *kharif* 2025, *Rabi* 2025 under glasshouse of department of Entomology, IGKV Raipur, Chhattisgarh (CG) following the standard seed-box screening technique (SSST) for evaluation as suggested by Heinrichs *et al*., (1985). Chhattisgarh is located between 17°14'N to 24°45'N latitudes and 79°16'E to 84°15'E longitudes with an annual rainfall of 1000-1350 mm. Raipur the capital of the Chhattisgarh state located at 21°16'N latitude and 81°36'E longitude with an altitude of 289.60 meters above mean sea level. In this technique the plastic tray of size (58cm × 37cm × 7cm) was filled with well manured soil up to a height of 2 cm from the base, so that 5 cm water level could be maintained above the soil surface. Soil was puddled properly followed by uniform levelling with the help of a smooth tool to facilitate sowing of sprouted seeds in a row. 20-25 pre-germinated seeds of each genotype were placed in each line with the help of forceps. After 12 days (3-leaf stage) 2nd and 3rd instar *N. lugens* (biotype-4) nymphs were released at a density of 6–7 nymphs per seedling over the tray (Fig. 1). Observations were recorded at 0-9 scale as prescribed in standard evaluation system for rice (SES), once susceptible check TN-1 showed 90% mortality by feeding.

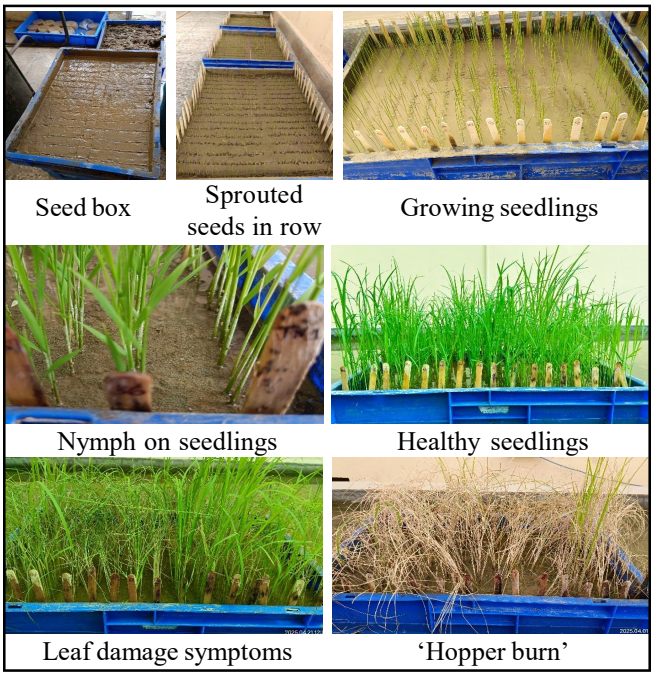


Fig. 1: Glass-house screening steps for *N. lugens.*

Scoring, descriptions and interpretations of leaf damage symptoms as per standard evaluation system for rice (SES), IRRI, 2013 are listed below:

Scale	Description	Interpretations
0	No damage	Highly resistant
1	Very slight damage	Resistant
3	1st and 2nd leaves of most plants partially yellowing	Moderately resistant
5	Pronounced yellowing and stunting or about 10 to 20% of the plants wilting or dead and remaining plants severely stunted or dying	Moderately susceptible
7	More than half of the plants wilted and dying	Susceptible
9	All plants dead	Highly susceptible

Table 1: Plant damage scores in 100 rice genotypes (SES, IRRI 2013).

Code	Genotypes	*Kharif,* 2024	*Kharif,* 2025	*Rabi,* 2025	Total	Mean	Finalscore
DC1	PTB-33	1	1	1	3	1	1
DC2	TN-1	9	9	9	27	9	9
DT1	Dowal	5	5	9	19	6.33	7
DT2	Swarna	9	7	9	25	8.33	9
DT3	Safri-17-2	3	3	9	15	5	5
DT4	Vikram TCR	5	5	9	19	6.33	7
DT5	Safri-17-2-48	7	5	7	19	6.33	7
DT6	Safri-17 Parent	5	5	9	19	6.33	7
DT7	Sanchuriya Mutant-6	7	7	5	19	6.33	7
DT8	TCSM	5	5	5	15	5	5
DT9	TCDM-1	9	9	9	27	9	9
DT10	TCVM	3	1	9	13	4.33	5
DT11	Sitamani	9	9	9	27	9	9
DT12	Mai Dubraj	5	5	9	19	6.33	7
DT13	Jhilli Mutant-13-5	7	7	9	23	7.67	9
DT14	Jhilli Mutant-15-1	9	9	9	27	9	9
DT15	Jhilli Parent	9	9	9	27	9	9
DT16	Dawar Mutant-19-1	9	9	7	25	8.33	9
DT17	Dawar Parent	7	7	7	21	7	7
DT18	Kumhdaphool Mutant-4	7	7	9	23	7.67	9
DT19	Kumhdaphool Parent	1	1	1	3	1	1
DT20	Chaptigurmatiya Mutant-1	3	3	1	7	2.33	3
DT21	Chaptigurmatiya Parent	9	9	9	27	9	9
DT22	Bathras Mutant-2	9	9	9	27	9	9
DT23	Bathras Parent	7	7	7	21	7	7
DT24	Alsakar Mutant-3	7	7	9	23	7.67	9
DT25	Alsakar Parent	5	5	7	17	5.67	7
DT26	R-BLB-570-242-IET-22585	9	9	9	27	9	9
DT27	R-BLB-ISM	7	7	9	23	7.67	9
DT28	R-BLB-599-66-IET-2226	9	9	9	27	9	9
DT29	R-BLB-571-320	7	7	7	21	7	7
DT30	R-BLB-ICS-21289-CRR-3833	9	9	9	27	9	9
DT31	Falu-Dhan-Mutant-2	9	9	7	25	8.33	9
DT32	Falu-Dhan-Mutant-4	9	9	9	27	9	9
DT33	Falu-Dhan-Mutant-20	7	5	9	21	7	7
DT34	Nagri Dubraj Parent	9	9	9	27	9	9
DT35	Falu-Dhan-Mutant-22	7	5	7	19	6.33	7
DT36	Falu-Dhan-Mutant-23	9	9	9	27	9	9
DT37	Sanchuriya Parent	7	7	9	23	7.67	9
DT38	Falu-Dhan Parent	9	9	9	27	9	9
DT39	Lalpari	9	9	9	27	9	9
DT40	Safri-17-1	9	9	9	27	9	9
DT41	Laxmibhog Mutant-21	9	9	9	27	9	9
DT42	Laxmibhog Parent	9	9	7	25	8.33	9
DT43	Makdo mutant-29	9	9	9	27	9	9
DT44	Makdo Parent	9	9	9	27	9	9
DT45	Ambemohar Mutant-1	9	9	9	27	9	9
DT46	Ambemohar Parent	9	9	7	25	8.33	9
DT47	Red Jawaphool Mutant-5	9	9	9	27	9	9

Continue ...1

DT48	Red Jawaphool Parent	9	9	9	27	9	9
DT49	Adanga Mutant-16	5	5	5	15	5	5
DT50	Adanga Parent	5	5	5	15	5	5
DT51	Chinnor Mutant-5	9	9	9	27	9	9
DT52	Chinnor Parent	9	9	9	27	9	9
DT53	Ramjeera	9	9	7	25	8.33	9
DT54	Jeeraphool	9	9	9	27	9	9
DT55	Sanjeevani	9	9	9	27	9	9
DT56	Karhani	9	9	7	25	8.33	9
DT57	Chirainakhi	9	9	9	27	9	9
DT58	CG Jawaphool Trombay	5	5	7	17	5.67	7
DT59	Jawaphool	9	9	9	27	9	9
DT60	Badshahbhog	9	9	9	27	9	9
DT61	Gudma Parent	9	9	9	27	9	9
DT62	Samundchini	9	9	9	27	9	9
DT63	Kadamphool	9	9	7	25	8.33	9
DT64	Nagri Dubraj Mut-1	9	9	9	27	9	9
DT65	Lohandi	9	9	9	27	9	9
DT66	Rudra	9	9	9	27	9	9
DT67	Tilkasturi	9	9	9	27	9	9
DT68	Haldi Sari	9	9	9	27	9	9
DT69	Mehar	1	1	1	3	1	1
DT70	Khatiyapati	1	1	1	3	1	1
DT71	Khandsaar	5	5	9	19	6.33	7
DT72	Gopalbhog-4	3	3	9	15	5	5
DT73	Gopalbhog	1	1	1	3	1	1
DT74	Loktimachi-9	9	9	7	25	8.33	9
DT75	Loktimachi	9	9	9	27	9	9
DT76	Tulsi Manjari Mutant-1	9	9	9	27	9	9
DT77	Tulsi Manjari	9	9	9	27	9	9
DT78	Kalachampa Mutant-11	9	9	9	27	9	9
DT79	Kalachampa	9	9	7	25	8.33	9
DT80	Ooni	9	9	9	27	9	9
DT81	Saariphool	9	9	9	27	9	9
DT82	Sarsophool	9	9	9	27	9	9
DT83	Chandni Dhan	9	9	9	27	9	9
DT84	Barki Bari	5	5	9	19	6.33	7
DT85	Jhummachudi	9	9	9	27	9	9
DT86	Sabri Kenduwa	1	1	9	11	3.67	5
DT87	Radhe Dhan	7	7	7	21	7	7
DT88	Nariyal Phool	1	1	9	11	3.67	5
DT89	Ramigali	1	1	7	9	3	3
DT90	Gadakhuta	9	9	7	25	8.33	9
DT91	Bearanguda	1	1	1	3	1	1
DT92	Karanphool	1	1	1	3	1	1
DT93	Kawagodi	9	9	9	27	9	9
DT94	Govind	9	9	9	27	9	9
DT95	Mayur	5	5	5	15	5	5
DT96	Rajeshwari	9	9	9	27	9	9
DT97	Sahbhagi Dhan	5	5	7	17	5.67	7
DT98	IR 64	9	9	9	27	9	9

Table 2: Grouping of 100 rice genotypes based on SES scores of IRRI, 2013.

Score	Description	Number	Genotypes
0	Highly Resistant	0	Nil
1	Resistant	7	PTB-33, Kumhdaphool Parent, Mehar, Khatiyapati, Gopalbhog, Bearanguda, Karanphool
3	Moderately Resistant	2	Chaptigurmatiya Mutant-1, Ramigali
5	Moderately Susceptible	9	Safri-17-2, TCSM, TCVM, Adanga Mutant-16, Adanga Parent, Gopalbhog-4, Sabri Kenduwa, Nariyal Phool, Mayur
7	Susceptible	17	Dowal, Vikram TCR, Safri-17-2-48, Safri-17 Parent, Sanchuriya Mutant-6, Mai Dubraj, Dawar Parent, Bathras Parent, Alsakar Parent, R-BLB-571-320, Falu-Dhan-Mutant-20, Falu-Dhan-Mutant-22, CG Jawaphool Trombay, Khandsaar, Barki Bari, Radhe Dhan, Sahbhagi Dhan
9	Highly Susceptible	65	TN-1, Swarna, TCDM-1, Sitamani, Jhilli Mutant-13-5, Jhilli Mutant-15-1, Jhilli Parent, Dawar Mutant-19-1, Kumhdaphool Mutant-4, Chaptigurmatiya Parent, Bathras Mutant-2, Alsakar Mutant-3, R-BLB-570-242-IET-22585, R-BLB-ISM, R-BLB-599-66-IET-2226, R-BLB-ICS-21289-CRR-3833, Falu-Dhan-Mutant-2, Falu-Dhan-Mutant-4, Nagri Dubraj Parent, Falu-Dhan-Mutant-23, Sanchuriya Parent, Falu-Dhan Parent, Lalpari, Safri-17-1, Laxmibhog Mutant-21, Laxmibhog Parent, Makdo mutant-29, Makdo Parent, Ambemohar Mutant-1, Ambemohar Parent, Red Jawaphool Mutant-5, Red Jawaphool Parent, Chinnor Mutant-5, Chinnor Parent, Ramjeera, Jeeraphool, Sanjeevani, Karhani, Chirainakhi, Jawaphool, Badshahbhog, Gudma Parent, Samundchini, Kadamphool, Nagri Dubraj Mut-1, Lohandi, Rudra, Tilkasturi, Haldi Sari, Loktimachi-9, Loktimachi, Tulsi Manjari Mutant-1, Tulsi Manjari, Kalachampa Mutant-11, Kalachampa, Ooni, Saariphool, Sarsophool, Chandni Dhan, Jhummachudi, Gadakhuta, Kawagodi, Govind, Rajeshwari, IR 64
Total		**100**	

Results and Discussion

Out of 100 genotypes, nine genotypes namely PTB-33 (check), Kumhdaphool parent, Mehar, Khatiyapati, Gopalbhog parent, Bearanguda, Karanphool, Ramigali and Chaptigurmatiya mut-1 were consistently performed resistant against BPH populations over three seasons. Seven genotypes (Kumhdaphool parent, Mehar, Khatiyapati, Gopalbhog parent, Bearanguda, Karanphool) including resistant check (PTB-33), scored (1) and identified as resistant genotypes whereas, two genotypes Ramigali and Chaptigurmatiya mut-1 scored (3) and identified as moderately resistant under three seasons screening (Table 1; Fig. 2). It was observed that all popular cultivars under study *viz*. Swarna, Vikram TCR, Rajeshwari, IR-64, Sahbhagi Dhan, failed to survive against BPH attack and marked as susceptible varieties.

BPH has already been notified as the most destructive insect pest for rice plant all over the world and economic loss was facing by farmers every year due to non-availability of suitable resistant variety. Therefore, the hidden genetic architecture of identified indigenous lines might be helpful to combat heavy infestation caused by destructive pest *Nilaparvata* (biotype-4), an Indian biotype natively South Asian biotype of brown planthopper. All the 100 genotypes were grouped into six distinct classes according to the SES and listed in Table 2.

Selected resistant genotypes will further might be used as a parent in crossing programme to develop elite segregants and climate- resilient cultivar specially, for BPH resistant. Top 10 selected resistant genotypes listed below in the Table 3.

Findings were corroborated with the research data of Kanngan *et al*., (2023) which stated that only two varieties were reported as resistant out of 143 upland rice varieties. Balachiranjeevi *et al*., (2019) reported forty-two BC1F1 plants as resistant and fifty-nine as

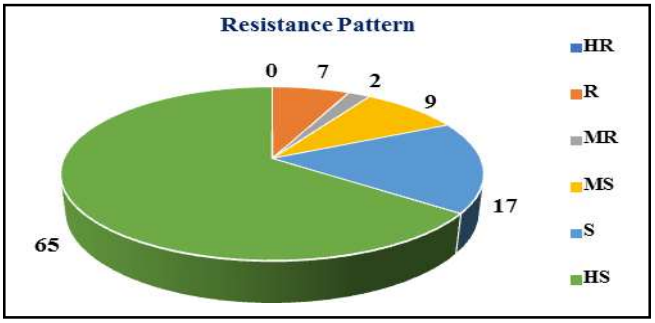


Fig. 2: Pie chart depicting resistance frequency against *Nilaparvata*.

Table 3: Selection of resistant genotypes based on three seasons screening.

Code	Genotypes	*Kharif* 2024	*Kharif* 2025	*Rabi* 2025	Total	Mean	Final score	Class
DC01	PTB-33 (resistant check)	1	1	1	3	1	1	Resistant (R)
DT19	Kumhdaphool Parent	1	1	1	3	1	1	Resistant (R)
DT69	Mehar	1	1	1	3	1	1	Resistant (R)
DT70	Khatiyapati	1	1	1	3	1	1	Resistant (R)
DT73	Gopalbhog	1	1	1	3	1	1	Resistant (R)
DT91	Bearanguda	1	1	1	3	1	1	Resistant (R)
DT92	Karanphool	1	1	1	3	1	1	Resistant (R)
DT89	Ramigali	1	1	7	9	3	3	Moderately Resistant (MR)
DT20	Chaptigurmatiya Mutant-1	3	3	1	7	2.33	3	Moderately Resistant (MR)

susceptible rice genotypes. In the experiment of Govindharaj *et al*., (2025) 33 rice genotypes showed resistant (score 1) and 70 genotypes showed moderate resistant (score 3). Similar investigations were performed by Verma *et al*., (2025); Huang *et al*., (2025); Pandi *et al*., (2024); Thornavalli *et al*., (2024); Zhou *et al*., (2024); Yang *et al*., (2023) and Ishwarya Lakshmi *et al*., (2022).

Conclusions

Nilaparvata biotype-4 has been considered the most destructive insect pest of rice due to the lack of resistant variety and resistance ability of hoppers for broad spectrum pesticides. Genetic diversity present in the rice has ability to overcome the damage causing by BPH but due to poor yield performing and other agronomic inferiority they have not been cultivated. In the present investigation six traditional landraces of rice (Kumhdaphool Parent, Mehar, Khatiyapati, Gopalbhog, Bearanguda and Karanphool) has been identified as the resistant genotypes and two genotypes (Chaptigurmatiya Mutant-1 and Ramigali) showed moderately resistance for BPH biotype-4. These landraces might be useful and effective to develop resistant cultivars against brown planthopper either by traditional techniques (hybridization, backcross) or advanced marker assisted and genome edited tools like MAS and CRISPR-Cas.

Acknowledgements

The authors express their sincere gratitude to the Vice-chancellor and director of research for providing the infrastructure, laboratory and experimental farm for the research work. The authors are thankful to the head of the department for providing technical and official aspects during the research period.

Author's contributions

All authors contributed to the study conception and design. Field experiments, data collection, data analysis and original draft of the manuscript by TS Patel. Deepak Sharma did supervision and supplied the study materials. VK Soni did review and editing. All authors read and approved the final manuscript.

Declaration of interest: Authors declare no competing interests.

References

Balachiranjeevi, C.H., Prahalada G.D., Mahender A., Jamaloddin M., Sevilla M.A.L., Marfori-Nazarea C.M., Vinarao R., Sushanto U., Baehaki S.E., Li Z.K. and Ali J. (2019). Identification of a novel locus, *BPH38*(t), conferring resistance to brown planthopper (*Nilaparvata lugens* Stal.) using early backcross population in rice (*Oryza sativa* L.). *Euphytica*, **215(11)**, 185.

Chaity, S.S., Islam M.R., Faruquee M, Ahmed J.U. and Islam A.K.M.A. (2026). Identification of elite rice lines with better breeding values using genomic prediction and multi-trait genotype ideotype distance index (MGIDI) for grain yield under irrigation cropping system. *PLoS One* **21(2)**, e0340188. https://doi.org/10.1371/ journal.pone. 0340188

Das, K.R., Zaman F., Islam M.M, Siddiqui S., Alshaharni M.O. and Algopishi U.B. (2024). Physiological responses and yield performance of selected rice (*Oryza sativa* L.) genotypes under deficit moisture stress, *Saudi Journal of Biological Sciences*, **31(4)**, 103961.

Evamoni, F.Z., Nulit R., Ibrahim M.H., Sidek N., Yap C.K., Yong C.S.Y. and Mohiuddin A.K.M. (2024). Evaluation of Drought Tolerance of Malaysian Rice Genotypes through Morphological Study, Grain Yield and Drought Tolerance Indices. *Annals of Agri-Bio Research*, **29(1)**, 63-71.

FAO (2026). Food Outlook – Biannual report on global food markets. *Food Outlook*, June 2026. https://doi.org/ 10.4060/ce0204en

Govindharaj, G.P.P., Babu S.B., Anilkumar C., Roy D., Parameswaran C., Basana-Gowda G., Bansal R. and Mohapatra S.D. (2025). Identification of candidate genes for *Nilaparvata lugens* (stal) resistance through genomic dissection from diverse Indigenous rice genotypes. *Bot. Stud*., **66(20)**, 1-14. https://doi.org/10.1186/s40529-025-00461-3

Haliru, B.S, Rafii M.Y., Mazlan N., Ramlee S.I., Muhammad I., Akos I.S., Halidu J., Swaray S. and Bashir Y.R. (2020). Recent Strategies for Detection and Improvement of Brown Planthopper Resistance Genes in Rice: A Review. *Plants*, **9(9)**, 1202.

Hallajian, M.T., Ebadi A.A. and Kordrostami M. (2024). Advancing rice breeding for drought tolerance: a comprehensive study of traditional and mutant lines through agronomic performance and drought tolerance indices. *BMC Plant Biol* **24**, 1087. https://doi.org/10.1186/s12870-024-05771-5.

Heinrichs, E.A., Medrano E.G. and Rapusas H.R. (1985). Genetic Evaluation for Insect Resistance in Rice. *Int. Rice Res. Inst*. IRRI, Los Baños, 163-172.

Huang, F., Zhang Z., Liao S., Shen J., Long L., Li J., Zhong X., Liao Z., Lu B., Li F., Jiang Z., Cheng L., Wang C., Xia X., Yang X., Guo H., Nong B., Li D. and Qiu Y. (2025). Exploring resistance mechanisms and identifying QTLs for brown planthopper in tropical and subtropical rice (*Oryza sativa* L.) germplasm. *Theoretical and Applied Genetics*, **138(1)**, 49.

IRRI (2013). Standard Evaluation System (SES) for Rice, 5th ed.; International Rice Research Institute (IRRI), Manila, Philippines, 28-48.

Ishwarya Lakshmi, V.G., Sreedhar M., JhansiLakshmi V., Gireesh C., Rathod S., Bohar R., Deshpande S., Laavanya R., Kiranmayee K.N.S.U., Siddi S. and Vanisri S. (2022). Development and Validation of Diagnostic KASP Markers for Brown Planthopper Resistance in Rice. *Front. Genet*., **13**, 914131.

Jahin, S.A., Das B., Abdullah A., Akter S., Siddique M.K.S. and Hossain M.A. (2024). Phenotypic Characterization of Advanced Breeding Lines of Rice (*Oryza sativa* L.) for Drought and Low Phosphorus Stress Tolerance. *OBM Genetics*, **8(4)**, 1-28. http://dx.doi.org/10.21926/obm.genet.2404270.

Jarin, A.S., Islam M.M., Rahat A., Ahmed S., Ghosh P. and Murata Y. (2024). Drought Stress Tolerance in Rice: Physiological and Biochemical Insights. *Int. J. Plant Biol*., **15**, 692–718.

Jena, M., Pandi G.G.P., Adak T., Rath P.C., Gowda G.B., Patil N.B., Prasanthi G. and Mohapatra S.D. (2018). Paradigm shift of insect pests in rice ecosystem and their management strategy. *ORYZA-An International Journal on Rice*, **55(spl.)**, 82-89.

Kanngan, K., Umalee P., Tangtrakulwanich K., Nilthong R. and Nilthong S. (2023). Identification of Major Brown Planthopper Resistance Genes in Indigenous Thai Upland Rice Germplasm Using Molecular Markers. *Agronomy* **13(10)**, 2605.

Kumar, K., Katlam B.P., Sahu H. and Bangennavar S.S. (2025). Screening of advanced biofortified rice lines for resistance to brown planthopper (*Nilaparvata lugens*) using standard seed box technique. *Int. J. Adv. Biochem. Res*., **9(9)**, 431-434. DOI: 10.33545/26174693.2025.v9.i9f.5667

Kumar, S., Dwivedi S.K., Singh S.S., Jha S.K., Lekshmy S., Elanchezhian R., Singh O.N. and Bhatt B.P. (2014). Identification of drought tolerant Rice genotypes by analysing drought tolerance indices and morpho-physiological traits. *SABRAO J Breed Genet*., **46(2)**, 217-230.

Kumari, R.P., Anusha C., Kumar R.S., Prasad K.R. and Hari Y. (2022). Screening of Rice Genotypes for their Resistance against Brown Plant Hopper, *Nilaparvata lugens* (Stal) under Field and Glasshouse conditions. *Biological Forum-An International Journal*, **14(3)**, 824-828.

Min, S., Lee S.W., Choi B.R., Lee S.H. and Kwon D.H. (2014). Insecticide resistance monitoring and correlation analysis to select appropriate insecticides against Nilaparvata lugens (Stål), a migratory pest in Korea. *Journal of Asia-Pac Entomology*, **17(4)**, 711-716.

Pandi, G.G.P., Chander S., Singh M.P. and Pathak H. (2018). Impact of elevated CO_2 and temperature on brown planthopper population in rice ecosystem. Proceedings of the National Academy of Sciences, India Section B: *Biological Sciences*, **88**, 57-64.

Pandi, G.G.P., Kar M.K., Chakraborti M., Behera L., Jena M., Sahu R.K., Sah R.P., Mohapatra S.D., Kumar G.A.K. and Nayak A.K. (2024). Brown planthopper resistant rice: A journey from landraces to varieties. *NRRI Research Bulletin No. 53*. ICAR-National Rice Research Institute, Cuttack. 44.

Roy, D., Biswas A., Sarkar S., Chakraborty G., Gaber A., Kobeasy M.I. and Hossain A. (2022). Evaluation and characterization of indigenous rice (*Oryza sativa* L.) landraces resistant to brown planthopper *Nilaparvata lugens* (Stål.) biotype 4. *PeerJ.,* **10**, e14360.

Salomi, R., Vignesh P. and Bharathkumar S. (2024). Drought tolerance improvement for grain yield of a modern rice variety based on morphological and physiological response. *Environmental and Experimental Biology*, **22**, 11–16. http://doi.org/10.22364/eeb.22.02

Savary, S., Willocquet L., Pethybridge S.J., Esker P., McRoberts N. and Nelson A. (2019). The global burden of pathogens and pests on major food crops. *Nat Ecol Evol*., **3**, 430–439.

Soni, V.K. and Tiwari S.N. (2017). Glasshouse Evaluation of New Source of Resistance against Brown Plant Hopper *Nilaparvata lugens* (Stal) in Rice. *Int. J. Curr. Microbiol. App. Sci.*, **6(9)**, 1187-1192.

Thornavalli, B., Venugopal S., Soundararajan R.P., Mohankumar S., Suresh R., Baskaran V., Alagar M., Geetha B., Vignesh S. and Manonmani S. (2024). Phenotypic and genotypic insights into rice germplasm resistance against a biotype of the brown planthopper *Nilaparvata lugens* (stal). *Plant Science Today*, **11 (sp4)**, 01-11. https:/doi.org/10.14719/ pst.5677

USDA (2025). Global Market Analysis. FAS/USDA. *WAP*, 12-25. https://www.fas.usda.gov/data/production/IN?source=ipad_redirect.

Verma, R.K., Dey P.C., Chetia S.K. and Modi M.K. (2017). Development of advanced breeding lines of rice for drought tolerance based on physiological and yield traits. *Oryza*, **54(2)**, 169-173. https://epubs.icar.org.in/index.php/OIJR/article/view/75164

Yang, K., Liu H., Jiang W., Hu Y., Zhou Z., An X., Miao S., Qin Y., Du B., Zhu L., He G. and Chen R. (2023). Large scale rice germplasm screening for identification of novel brown planthopper resistance sources. *Mol Breeding* **43(70)**, 1-14. https://doi.org/10.1007/s11032-023-01416-x

Zhou, C., Jiang W., Guo J., Zhu L., Liu L., Liu S., Chen R., Du B. and Huang J. (2024). Genome-wide association study and genomic prediction for resistance to brown planthopper in rice. *Front. Plant Sci*., **15**, 1373081. doi: 10.3389/fpls.2024.1373081