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A Study of Blast Resistance Genes in Rice

Among the biotic stresses, the blast disease (Fig.1) has emerged as a major threat to rice in Bangladesh. Rice yield losses amounting to 11-46% occur at low to medium pressures of the blast disease. Leaf blast epidemics occur mainly during the vegetative stage, but the most damaging injury at the reproductive stages is associated with neck blast. Blast on leaves of the rice plant has a high probability of infecting necks of the plant through a pathogen population shift. An outbreak of this disease in BRRI dhan28 and BRRI dhan29 during Boro 2014-15 caused as high as 90% neck infection in some rice fields of the Rangpur region resulting in almost 100% yield loss. The disease historically prevails as a chronic problem in the southern coastal region and the northern region of Bangladesh in both wet and dry seasons. Farmers can hardly recognize the neck blast disease early on and, thus, fail to take control measures which results in complete crop failures at times. On-farm management practices of the disease rely solely on chemical control which increases not only the cost of production but also causes serious environmental pollution contaminating the food chain affecting public health, pest resurgence and further crop vulnerability. A crop and environment friendly safe option would be to develop and grow blast resistant rice varieties. Host resistance with single and multiple genes could be a potential option for rice blast management. Exploring resistant gene(s) in native germplasm and their utilization as well as development of monogenic/pyramided blast resistant line(s) could be the potential means of sustainable blast disease management in rice culture. This KGF sponsored basic research project was implemented with the objective of developing durable blast resistant lines/varieties, identification of new resistance sources, data generation for germplasm characterization which will be useful in developing sustainable and environment friendly rice blast disease management practices.

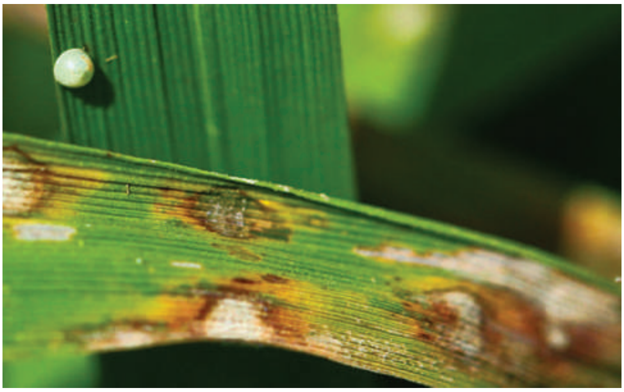

Fig. 1. Telltale symptoms of rice leaf blast

Methodology

The project was implemented by the Plant Pathology Division of BRRI using the facilities of its molecular laboratory, general plant pathology laboratory, control house, resistance breeding hub and experimental fields. Native rice germplasm was collected from the BRRI Gene Bank/other sources and screened in a uniform blast nursery (UBN). Selected resistant materials were further tested in the blast hot spots. Breeding work was performed in the Resistance

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Breeding Hub (RBH). BRRI plant pathologists, plant physiologists and rice breeders teamed up to work for the project.

Two monogenic blast resistant japonica lines, IRBL-ta2Pi and IRBL-9W, were used as donor parents for *Pita2* and *Pi9* genes, respectively. Both the genes confer broad spectrum resistance to blast. The varieties BRRI dhan28, BRRI dhan29 and BRRI dhan63 were used as recurrent parents, because of their low blast resistance, to develop segregating populations. The breeding strategy consisted in back cross breeding followed by marker assisted selection (MAS) and pathogenicity. Firstly, the polymorphic marker NMSMPi9-1 was identified for Pi9 introgression in the above parents. For the Pita2 gene, RM27970 was used for BRRI dhan63 and YL155/YL87 was selected for BRRI dhan28 and BRRI dhan29 as polymorphic markers. F_1 populations of BRRI dhan28/Pi9 or Pita2, BRRI dhan29/Pi9 or Pita2 and BRRI dhan63/Pi9 or Pita2 were developed. Intercrosses between F1-Pi9 and F1-Pita2 were subsequently generated in the same background. Each F_1 plant was backcrossed with the recurrent parent and confirmed by MAS. The plants that were homozygous at the resistance loci were selected based on molecular markers in $BC3F_2$ and $BC3F_3$ generations. These selected plants were used to produce advance generations through the head-to-row method of selection. Pathogenicity tests of all the advanced generations were done at UBN (Fig. 2). Selected resistant lines were further challenged with representative blast isolates in controlled conditions as well as in regional yield trials (RYT) with advanced lines in different blast prone environments in Cumilla, Rangpur, Khulna and Gazipur districts (Fig. 3).

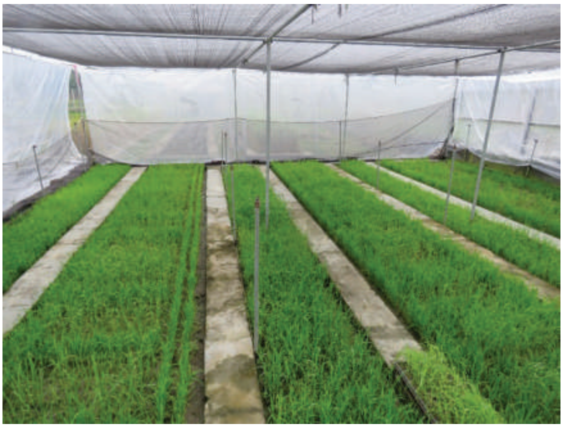

Fig. 2. Screening of rice germplasm in uniform blast nursery (UBN)

Results and Outputs

In total, 290 genotypes were screened in UBN and some at blast prone hot spots in different regions of Bangladesh. Out them, 25 were identified as resistant to the blast disease. Details are given below:

a. Four resistant germplasm were selected from the screening of 50 jhum rice germplasm in UBN. Two HYV type genotypes (ZM82 and ZM81) which yielded 5.1-5.6 t/ha were selected through pure line selection.

b. Thirty-one fragrant rice germplasm were screened against blast at UBN, BRRI and different hot spots of Rangpur, Dinajpur, Satkhira and Gazipur. One Kalijira and one Kataribhog germplasm were selected as resistant to moderately resistant in UBN which also showed resistance in hot spot areas. The genotypic assay for Pi9/Pi2/piz gene indicated presence of the putative Pi9 gene in Kalijira and some other accessions.

c. Among the 43 Aus germplasm, 4 were found to be as resistant, e.g., Pukhi DA-8, and Burikatari (BRRI Gene Bank Acc nos. 1729 and 1704).

d. Out of 45 Patnai germplasm, three (Acc. nos. 3076, 3080 and 3085) were found resistant to blast at UBN. Four Aus (Pukhi DA-8, Burikatari, Acc No. 1729 and 1704), 3 Patnai (Acc. No. 3076, P3080 and 3085), 3 BRRI Aman varieties, 6 Mota rices of the Barisal local stock and 5 black rices were identified as resistant which can be used for the identification of novel blast resistance genes.

e. BRRI developed T. Aman varieties, BRRI dhan57, BRRI dhan33 and BR16 were found to be resistant.

f. One HYV type pure line (ZM82) was selected from jhum germplasm that yielded 5.62 t/ha.Three blast resistant advanced lines were developed which can be used as pre-breeding materials/variety. One of them, BR(Path)12452-BC3-42-22-11-4, yielded 6.0 t/ha.

Fig. 2. Screening of rice germplasm in uniform blast nursery (UBN)

Expected Impact

The identified resistant germplasm and advanced resistant lines can be used in future blast resistance varietal development programs. Five blast resistant lines could be used as varieties in the interim period. Identified resistant local germplasm have created new opportunities for gene expression study and mapping of novel gene(s).

Recommendations

- Five blast resistant rice breeding lines have been developed that can be promoted as blast resistant varieties
- Advanced materials having Pi9 or Pita2 gene can be used as pre-breeding materials for the development of blast resistant varieties
- Backcross generations of pyramided lines having Pita2 and Pi9 genes need to be advanced
- Gene expression, sequencing, QTL analysis and proteomics studies of the identified blast resistant germplasm or developed lines will be needed for advanced basic research in the future in addition to germplasm screening and resistance breeding in regular programs.

This Technical Bulletin has been prepared on the basis of technical information available from a completed BKGET-KGF Funded Project, the details of which are given below:

Project Code and Title: BR3-C/17. Exploring New Source of Blast Resistance and Pyramiding Blast Resistant Genes into Boro Rice

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