# 2022 PhilRice R&D Highlights

# Crop Protection Division

Philippine Rice Research Institute
Central Experiment Station
Maligaya, Science City of Muñoz, 3119 Nueva Ecija

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DIVISION

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Jennifer T. Niones

## EXECUTIVE SUMMARY

The Crop Protection Division (CPD) aims to prevent yield loss so that abundant rice will be harvested. Specifically, CPD aims to generate, develop and promote sustainable pest management strategies to help farmers improve their decision-making on pests. Pest management strategies should be ecosystem-based, promote ecological diversity, be environment-friendly, safe, economical, sustainable, and compatible with other management options.

During the year, the division implemented three core-funded projects. The first project evaluated rice materials for insect pests and disease resistance. Screening helps identify rice lines that possess resistance to major diseases and insect pests, which expedites rice varietal development. The second project characterized the resistance of PhilRice breeding lines and other rice germplasm as potential sources of resistance genes against rice blast and bacterial leaf blight diseases. The third project monitored the populations of rice bugs through developing and improving traps; determined the dynamics of major diseases of irrigated-lowland rice as influenced by Trichoderma harzianum; determined the ecology and cultural management of selected major weeds of rice; identified and mitigated the spread of multiple herbicide-resistant weeds; and determined the ecology of golden apple snails, ricefield rats, and rice paddy eels as influenced by cultural management techniques.

CPD also pursued four extra-core and one externally funded project, including (1) developing a diagnostic platform for forecasting the effectiveness of resistance genes against rice blast; (2) studying mechanisms of rice disease resistance in traditional rice varieties and developing genetic stocks with novel sources of resistance genes; (3) monitoring the occurrence, host plant specificity, and management of the Fall Armyworm (*Spodoptera frugiperda*) in and around rice ecosystems in the country; (4) pest risk identification and management (PRIME); and, (5) establishing a prevention network for the migratory rice planthopper (RPH) in Asia Region.

CORE-FUNDED PROJECT 1

# Evaluation of Rice Lines for Disease and Insect Pests Resistance

**Juliet P. Rillon, Salvacion E. Santiago, Genaro S. Rillon, Gracia B. Amar, Gilely DC. Santiago, Alvin D. Palanog, Eleanor S. Avellanoza, Keith Marielle B. Guarin, Zarah Faith T. Lunag, Ellie Zandrew S. Ganella, and Cesjoy Carl B. Encarnacion**

Screening helps identify rice lines resistant to major diseases and insect pests that could be used for breeding purposes. In 2022, 5,030 entries, composed of 2,118 inbred lines, 414 hybrid parent lines, and 2,498 germplasm accessions were evaluated in PhilRice CES to determine their resistance to major rice diseases and insect pests. The hybrid parent lines were evaluated in PhilRice Isabela against major rice diseases and stem borer (SB) damage resistance and in PhilRice Negros for resistance to tungro through a modified field evaluation. For faster resistance screening for sheath blight (ShB), nine multi-adaptation trial (MAT) lines were evaluated using the micro-chamber method under screenhouse, which was comparable to field conditions.

Results showed that 65% and 7% of rice entries had resistant and intermediate reactions respectively, to blast. For bacterial leaf blight (BLB), 177 (14%) and 450 (36%) entries had resistant and intermediate reactions. For ShB, 4% had intermediate reactions; 42% had intermediate reactions to brown planthopper (BPH) and 36% to green leafhopper (GLH). For SB damage (whitehead), 49% and 21% had resistant and intermediate reactions (Figure 1). In Isabela, 21% of hybrid parent lines showed resistant reactions to blast; 46% had intermediate. For BLB evaluation, 16% and 53% showed resistant and intermediate reactions; for ShB, 10% were resistant and 58% were intermediate. Out of 73 hybrid parent lines evaluated in Negros in 2022 dry season (DS), 51 (61%) and 21 (28%) respectively showed resistant and intermediate reactions to tungro under the modified field method of evaluation.

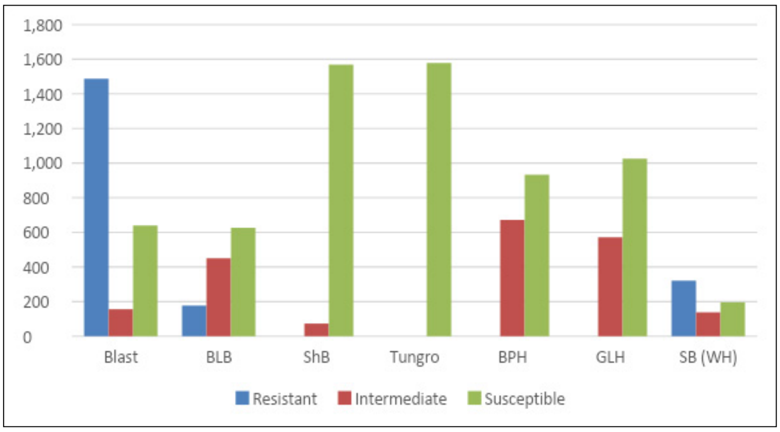


**Figure 1.** Reactions of inbred lines, hybrid parent lines, and germplasm accessions against major diseases and insect pests of rice.

## CORE-FUNDED PROJECT 2

# Characterization of PhilRice Elite Germplasm for Functional Disease Resistance Genes

**Jennifer T. Niones , Eleanor S. Avellanoza, and Anna Marie S. Irang**

This project aimed to better characterize the resistance of PhilRice breeding lines and other rice germplasm as potential sources of resistance genes against rice blast and bacterial leaf blight. It also aimed to elucidate on the genetic variations of rice blast and BLB resistance among PhilRice elite germplasm. Using the differential system, we evaluated 65 parental/donor lines against rice blast and 39 breeding lines for BLB isolates, and estimated the R-genes in these rice genotypes. Thirty-two donor lines showed resistant reactions to the 20 differential blast isolates. Three of the donor lines showed broad–spectrum blast resistance through the use of DNA markers, the Pi9, Pii, and Pib genes were detected in these lines. These lines therefore are good candidates as sources of broad-spectrum rice blast resistance.

Genotyping of BLB resistance using DNA markers detected Xa4 gene in 69% of the evaluated lines, followed by xa5 (8%), Xa7 (8%), Xa21 (5%), and xa13 gene (3%). Two donor lines had Xa8, Xa4, and xa5 genes; line PR40602-B018-28-1-2-2-1 had xa5, xa13, Xa4, and Xa8 genes; one line had Xa8 and Xa21 genes; another had Xa4, Xa8, and Xa21. Donor lines estimated or detected to have multiple Xa genes are good candidate sources for improvement of BLB resistance.

## CORE-FUNDED PROJECT 3

# Ecology and Non-chemical Ways of Managing Rice Pests (ECOWAYS)

**Dindo King M. Donayre, Edwin C. Martin, Evelyn M. Valdez, Leonardo V. Marquez, Ma. Salome V. Duca, Niña Gracel Dimaano, Anna Ma. Lourdes S. Latonio, Jessica Joyce L. Jimenez, and Henesie G. Pascua**

Pests can reduce yields but these can be managed through cultural, physical, mechanical, biological, or chemical methods. This project aimed to improve pest management decision-support and develop sustainable strategies by studying the ecology of major rice pests and their management through non-chemical ways. Specifically, it aimed to monitor the populations of rice bugs through developing and improving traps; determine the dynamics of major diseases of irrigated-lowland rice as influenced by the application of Trichoderma harzianum; determine the ecology and cultural management of selected major weeds of rice; identify and mitigate the spread of multiple herbicide-resistant weeds; and determine the ecology of golden apple snails, ricefield rats, and rice paddy eels as influenced by cultural management techniques.

In the DS, an installed trap at PhilRice CES caught 7-120 rice bug per trap (mean: 47.7 in transplanted rice, 49.7 in direct-seeded rice) at 68 days after transplanting (DAT) or 83 days after sowing (DAS). The same trap installed 30km away from CES (Mapangpang) had low catches due to the very low population of the insect. In the wet season (WS), another setup was placed in nine farmers' fields in Brgy. Mapangpang and four at PhilRice CES. Setting the traps depended on the growth stage—first at flowering, then transferred to other fields 1-2 weeks before harvest.

Bug populations peaked at the flowering to milking stages. At PhilRice where fields were established late, trap catches reached 521 rice bugs per trap up to 182 rice bugs per trap in the larger fields in Mapangpang at the flowering stage.

A two-run field experiment determined the dynamics of major diseases of irrigated lowland rice — RB, SB, BLB, and bacterial leaf streak (BLS) as influenced by Trichoderma harzianum. Two isolates (T5Oi and TMDRi) were applied as follows: (T1) T5Oi applied before seeding, as root dipping for seedlings before transplanting and spraying at 15 and 30 DAT; and (T2) TMDRi applied before seeding, as root dipping for seedlings before transplanting and spraying at 15 and 30 DAT. Fungicide (copper hydroxide) was applied at 15 and 30 DAT (T3) and no treatment (T4) was included as a control check. During the DS, the incidence and severity of sheath blight were 25.7 and 39.8% in T1 plots; 28.2 and 49% in T2 plots; 24.3 and 21.7% in T3 plots; and 36.9 and 37.6% in T4 plots. For BLB: 34.0 and 29.8% in T1 plots; 35.6 and 33.4% in T2 plots; 29.8 and 53.5% in T3 plots; and 33.4 and 52.9% in T4 plots. In the WS, the four diseases above were prevalent; their incidences at different treatments were gathered at 30 and 60DAT.

Another two-run experiment determined the optimum nitrogen rate that will improve the yields of three direct-seeded rice varieties without yield reductions due to interference by the lowland ecotype *Cyperus rotundus*. The experiment involved three popular varieties (NSIC Rc 222, Rc 216, and Rc 160) with *C. rotundus* under four nitrogen rates (0, 60, 120, and 180kg N/ha). Results showed that the high tillering activity of the varieties did not effectively supress *C. rotundus* under flooded conditions. The varieties showed better growth at 100% and 150% of the recommended nitrogen fertilizer rate (120 and 180kg N/ha) despite weed pressure.

Mature seeds of *Echinochloa glabrescens* and *Leptochloa chinensis* were collected in ricefields of Poblacion West, Rizal; Marawa, Jaen; and Sto. Cristo, San Antonio, all in Nueva Ecija. Herbicide resistance-screening indicated possible resistance of both species to bispyribac-sodium, even when applied up to 8x (2L/ha) at the recommended rate. *E. glabrescens* that survived the first screening were planted in clay pots and matured. Seeds were collected and screened again for their resistance to bispyribac-sodium. Screening of F1 plants collected from Rizal survived the 250ml/ha (recommended rate); 500 (2x), 1000 (4x), and 2000ml/ha (8x) the recommended rate were not significantly different from the untreated control when sprayed at the rates of 250 and 500ml/ha. This confirms resistance of *E. glabrescens* from Rizal to bispyribac-sodium. Moreover, even when sprayed at any rate, F1 plants from Jaen and San Antonio were not significantly different from the untreated control. The plants that survived the rate of 8x (2L) will be further evaluated.

In the DS, five treatments (T1-no canalets, T2-0.5m interval, T3-1m interval, T4-1.5m interval, and T5-2m interval) determined the best canalet intervals that will allow more rice seedlings to survive the feeding pressure of the invasive apple snail (IAS). Each canalet, 3cm wide and 4cm deep, was constructed inside a $20m^2$ plot at three days after seeding (DAS) and then rehabilitated at six DAS. Water was introduced at ten DAS to a saturated level and was maintained thereafter. Results showed no significant differences in the number, height, and biomass of surviving seedlings across all canalet intervals, as influenced by the IAS feeding. In the WS, intervals evaluated were (T1) 25m, (T2) 15m, and (T3) 10m. Fields were drained for 20 days to minimize golden apple snail (GAS) damage. Results showed that the treatments did not significantly differ in terms of seedling height and weight.

## EXTRA-CORE PROJECT 1

# Development of a Diagnostic Platform for Forecasting the Effectiveness of Resistance Genes Against Rice Blast

**Jennifer T. Niones, Anna Marie Irang, and Mary Jeanie T. Yanoria**

With the understanding of the gene-for-gene theory, one way to have an effective and appropriate deployment of resistant cultivars harboring rice blast resistance genes is to establish a rice blast AVR gene-based diagnostic platform for real-time pathogen field surveillance and monitoring. Different haplotypes were noted in amplified samples of AVR-Pi9, AVR-Pita, AVR-Pik, and AVR-Pii genes. AVR-Pi9 has 17 haplotypes where variation happens in four polymorphic sites. Eight haplotypes were observed in AVR-Pita, which vary in 30 polymorphic sites. The seven haplotypes observed among samples of AVR-Pik vary in six polymorphic sites. The two haplotypes of the AVR-Pii gene differ in only one nucleotide position. No nucleotide variation was noted among samples of AVR-Piz-t. Virulence differences to IRBLs carrying the cognate R gene were noted among haplotypes of AVR Pita and AVR-Pik.

Based on their disease reaction against 20 standard differential blast isolates (SDBIs), 93 rice germplasms were classified into resistance cluster groups (GC), Ia, Ib, IIa, IIb1, and IIb2. CG II exhibited a broader resistance spectrum to SDBIs than CG I. CG IIa has IRBLs for Pik alleles while Cluster IIb has IRBLs for Pish, Pi9, Piz-5, Piz, and Pita2. More rice blast resistance R genes were detected in CG II using DNA markers for Pik alleles, Pib, Pii, Pia, and Pish. Sequence analyses of amplified fragments of specific R genes showed haplotypes in Pi9, Pia, Pii, Pik, and Pib genes. Pi9 has 2 haplotypes and Pia has 3, with a sequence variation at one nucleotide position. The eight haplotypes observed among Pii samples vary in 18 polymorphic sites. The five haplotypes of the Pik gene differ in 11 polymorphic sites. There were three haplotypes among samples of the Pib gene, which differ in 48 polymorphic sites. Some varieties were found to have haplotypes of Pia, Pik, Pii, Pib, and Pi9 genes that showed susceptibility when inoculated with blast isolates containing the cognate avirulence gene. This confirms the non-functionality of some haplotypes of a specific R gene.

EXTRA-CORE PROJECT 2

# Mechanisms of Rice Insect Pest and Disease Resistance in Traditional Rice Varieties and Development of Genetic Stocks with Novel Sources of Resistance Genes: Component B. Characterizing the Mechanism of Resistance to Rice Blast and Bacterial Leaf Blight in Traditional Rice Varieties

**Jennifer T. Niones, Juliet P. Rillon, Jonathan M. Niones, Teodora E. Mananghaya, and Anna Marie S. Irang**

Traditional rice varieties (TRV) are usually valued for their premium rice grains with excellent eating quality. Most of them have high resistance to various biotic and abiotic stresses, which makes them potential sources of genes useful for rice breeding. The PhilRice Genebank has several TRV accessions with resistance/ tolerance against rice blast and bacterial leaf blight. Before using them for rice improvement programs, there is a need for an in-depth understanding and characterization of resistance mechanisms against different pathogenic strains. The spectrum of host resistance against other pathogenic races and the genetics of disease resistance were determined to develop genetic stocks with introgressed novel resistance genes.

Twelve select BC1F6 Dinorado and 13 select BC1F6 Kalinayan recombinant lines (RILs) with broad – spectrum rice blast resistance were planted in the field. Agro-morphological characterization using 39 qualitative traits in the bioversity descriptors was done on RILs having rice blast resistance genes derived from Dinorado and Kalinayan. The majority of RIL individuals showed similar characteristics in basal leaf sheath green color; absence of anthocyanin coloration; intense green color of the leaf blade (medium green); presence of leaf blade pubescence; auricle color (yellow green); collar light green color; a cleft ligule shape; and absence of culm internode and node anthocyanin color. RIL individuals showed wide variations on flag leaf orientation, lemma and palea color, awn distribution, panicle exsertion, panicle branches, panicle shattering and harvesting, and leaf senescence. A few RIL individuals exhibited unique phenotypic traits. Two RILs have the straw awn color; 1 RIL had glabrous pubescence in lemma and palea; two RILs had brown apiculus color in the spikelet; and 4 RILs had a pigmented (red) pericarp/ caryopsis color.

## EXTRA-CORE PROJECT 3

# Monitoring the Occurrence, Host Plant Specificity, and Management of the Fall Armyworm (Spodoptera frugiperda) in and around Rice Ecosystems in the Philippines

**Evelyn M. Valdez, Genaro S. Rillon, Dindo King M. Donayre, Edwin C. Martin, Eduardo Jimmy P. Quilang, Kennedy B. Dela Cruz, and Ravindra C. Joshi**

The fall armyworm (FAW), a transboundary invasive pest in many countries, is threatening the food, nutrition, and income security of millions of farming households. Native to the tropical regions of North and South America, FAW was first detected in Africa in early 2016. The first record of FAW damage on corn was reported on June 20, 2019 in Piat, Cagayan. It has now spread to all regions. FAW has the corn strain (C-strain) and the rice strain (R-strain). Little is known about FAW damage and host preference for rice.

This project aimed to contribute to the development of a location-specific, sustainable integrated pest management strategies and decision guides in managing FAW in rice. Specifically, it sought to: monitor the presence of FAW in and around rice ecosystems, identify areas where it was observed and understand the spatial and temporal FAW population dynamics;  assess the level of infestation and damage of FAW on rice and other flora in rice and non-rice habitats; determine the diversity of naturally occurring beneficial organisms in rice- and non-rice habitats and their roles in natural regulating mechanisms; identify the alternate host plants records of FAW in rice- and non-rice habitats, and conduct host-plant specificity tests; capacitate local researchers and extensionists in using various CABI Knowledge tools for better FAW risk analysis and management; and develop a location-specific sustainable integrated FAW pest management strategies/decision guide.

Regular FAW monitoring and vegetation analysis were conducted in selected rice-corn growing areas in Pangasinan, Pampanga, and Tarlac. FAW in rice seedbeds was documented at Cagayan State University-Gonzaga on May 24, 2022. Close monitoring of FAW population and damage revealed infestations in nine other Gonzaga barangays and another in Santa Ana. A well-participated one-day webinar was held to assist researchers and extensionists in identifying the potential triggering factors for FAW occurrence in rice in specific areas, and how and why the pest might spread.

## EXTRA-CORE PROJECT 4

# Pest Risk Identification and Management Project (PRIME)

**Eduardo Jimmy P. Quilang, Edwin C. Martin, Leonardo V. Marquez, Arlen A. Dela Cruz, Jomar F. Rabajante, Mary Grace V. Lanuza, Femia R. Sandoval, and Dariel Litorco**

The DA-Bureau of Agricultural Research-funded project falls under the research area: development of localized surveillance, early warning, and forecasting systems for pest outbreaks and epidemics. It aimed to  develop and improve current methods for extracting rice crop parameters, including indicators for crop health and management practices using remotely sensed data; analyze risk factors for pest and disease outbreaks; formulate efficient management strategies and tactics to reduce crop losses; improve the capacity of project partners on remote sensing, and pest and disease risk-mapping and analysis; and develop a sustainability plan for the continued operation of PRIME.

The PRIME PhilRice team is focused on tungro disease and brown planthopper

(BPH) model development, research, capacity building, and support to pest surveillance and sustainability plans. In 2022, the tungro pest risk model was validated in Nueva Ecija, Isabela, Laguna, Albay, and Camarines Sur.

National Usability Assessment of PRIME Products. On March 17, 2022, 34 regional partners from Regional Crop Protection Center (31), and Regulatory Division (3) of the DA-Regional Field Offices assessed and evaluated the pre-semester and monthly bulletins as well as the "Pest Alert." Results showed that the pre-semester bulletin's 'Management of Major Pests' and the 'Commonly Observed Pests' in the region were the most useful and easy-to-understand sections; the information in the "At a Glance" section was the most difficult to understand. Copies or contents of the bulletins are mostly shared with municipal agriculture offices (MAO) (86%), provincial agricultural offices (PAO) (46.7%), and Regional Crop Protection Center (53.4%). Pest Alert is an automated warning system sent through email to notify partners of elevated cases in their areas. According to the assessment, pest alerts were very effective in controlling the damage caused by BPH in Regions 2 and 3 in PRIME monitoring fields during the 2022 dry season (DS). In Region 6, pest alert was used to check the rice grain bug in Antique, and detected the occurrence in Sibalom town.

Capacity Building. A training on immunological detection of tungro viruses via ELISA was carried out at PhilRice CES on March 21-22, 2022. Fourteen staffers from PhilRice and DA-RFO learned about the principles of ELISA, and were taught how to perform ELISA techniques to detect tungro virus in rice. Another training on the use of simulation models for rice BPH and blast was conducted at IRRI on May 16-19, 2022.

Development of PRIME Operations Manual. To ensure sustainability, the PRIME team gathered on June 14-16, 2022 to develop the PRIME Operations Manual, which includes step-by-step instructions, best practices, and guidelines. Volume 1 covers crop health assessment and Rapid Crop Health Assessment protocols. Volume 2 details protocols for early warning and reporting, and mapping of landscape-scale risk.

EXTERNALLY FUNDED PROJECT 1:

# Establishment of Prevention Network for Migratory Pests in Asia Region

**Genaro S. Rillon, Cesjoy Carl B. Encarnacion, Jayvee S. Bruno, and Bueyong Park**

One of the recent severe constraints to rice production in Asian countries is rice planthoppers (RPHs) that transmit viruses. For example, rice grassy stunt virus (RGSV) and rice ragged stunt virus (RRSV) are persistently transmitted by the BPH. The white-backed planthopper (WBPH) can also transmit a newly emerging virus, the Southern rice black-streaked dwarf virus (SRBSDV or RBSDV-2), which is currently problematic in China and Vietnam. In addition, BPH outbreaks and associated viral epidemics have been reported in Bangladesh, Cambodia, China, India, Indonesia, Japan, Korea, Laos, Malaysia, Thailand, and Vietnam.

With the current problem on RPH, this project sought to establish a multilateral strategy for the timely prevention of RPH in the Asia Region. Specifically, it sought to build a cooperative network among 12 Asian countries, develop joint response strategies to manage the RPH migration, share data and technology related to the occurrence of migratory insects, and craft colloborative responses to changes in cultivation patterns and increased trade of agricultural products—which could increase the likelihood of pest inflow and spread in the region.

Monitoring of planthoppers showed  low numbers at PhilRice CES and in Mabini, Sto. Domingo, Nueva Ecija. During the 2022 DS, the highest BPH count collected in a light trap was 823. No WBPH was recorded.