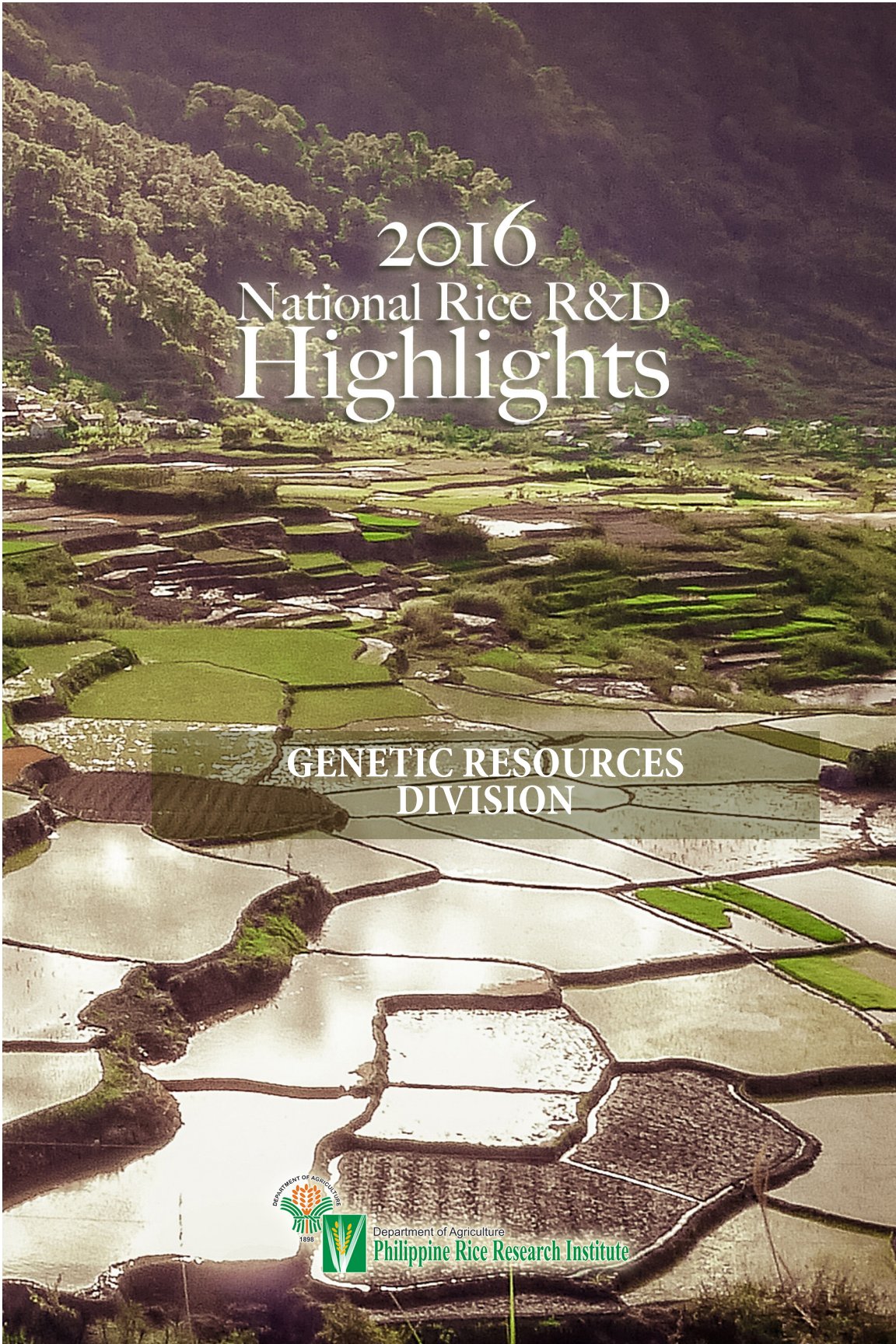


# 2016 National Rice R&D Highlights

## GENETIC RESOURCES DIVISION

Department of Agriculture
Philippine Rice Research Institute

## TABLE OF CONTENTS

# Genetic Resources Division

*Division Head: Xavier Greg I. Caguiat*

## Executive Summary

Genetic Resources Division (GRD) continues to provide support in rice crop improvement. Currently, GRD holds 15, 637 collections and 7,129 of which are assigned as accessions, identifying them as unique among the registered collections. Preservation and documentation of these germplasm is of paramount importance for direct use and may source of useful genes that serve as building blocks for the improvement of rice varieties. The division originally has three core functions: germplasm conservation, characterization (agro-morphological, molecular and biochemical) and evaluation. This year we added one core function which is utilization which could either be direct and indirect usage.

The division ensures the availability of high quality seeds from the diverse germplasm for current and future breeding programs. In order to ensure high quality of seeds are made available. The genebank follows the international standards on various processes such as: seed processing from seed to seed, seed viability testing, seed packaging and seed storage. There are 336 new collections, 330 passport data of new germplasm collections uploaded in the database, 545 rice germplasm accessions' characterization data validated and uploaded in the database, 553 rice germplasm accessions' pest and disease data validated and uploaded under induced method, 810 rice germplasm collections' evaluation data on tungro under field condition validated and uploaded in the database, 592 rice germplasm accession with grain quality data validated and uploaded in the database, 102 rice germplasm accessions' evaluation data under progressive drought condition validated and uploaded in the database, 305 rice germplasm accessions' evaluation data under Zinc deficient soil validated and uploaded in the database, 11 data requests have been catered and provided to PhilRice and non-PhilRice personnel), 79 seed requests served within 3 working days from the database, 11 SMTA's and 3 PMTA-GUD's have been issued to protect intellectual properties or rights over the rice varieties being provided to non-PhilRice staff. PMTA-GUD serves as an attachment to the SMTA for additional conditions on the transfer of breeding lines. In 2016 dry season, exactly 289 entries were characterized while 290 accessions were sown and characterized for 2016WS

The utilization of vast germplasm in breeding programs needs prior information such as the evaluation of the collections against major pests, diseases and response to various abiotic stresses. Two hundred seventy five entries were found resistant to blast while 123 had intermediate reactions.

Aside from long term storage and conservation of germplasm for future generations, utilization of the vast germplasm collection has been always a challenge to any genebank. Aside from strengthening inter-disciplinary approaches to efficiently hasten the evaluation of germplasm for various biotic and abiotic stresses screening, the division aims to continue widen its collaboration in terms of screening of germplasm against emerging pests, diseases, and effects of climate change. The valuable accomplishments of PhilRice genebank with its untapped collection still contains large potential that could be promising in the breeders' pursuit for more resilient, high-yielding, resistance to pests and diseases and tolerance to abiotic stresses that could help increase food production and alleviate hunger in the future.

## I. Conservation, Characterization, and Distribution of Rice Germplasm Resources (GRD 002)

*Project Leader: Marilyn C. Ferrer*

The Genetic Resources Division (GRD) houses the PhilRice Genebank which serves as the national repository of rice germplasm. It provides a safe storage system for the germplasm to facilitate protection of genetic wealth, thus safeguarding Philippine rice germplasms' rich diversity. It supports direct utilization of traditional cultivars and breeding of rice varieties by providing germplasm materials for research as well as parental stocks. GRD collects and conserve rice genetic resources to ensure the future generations of available materials needed to build better rice plants. Rice germplasm must be efficiently harnessed and properly assessed through morpho-agronomic characterization to identify potential donor parents in breeding to meet the demand for rice consumption.

Best management practices are needed for continuity and long-term conservation of rice germplasm. Regeneration is conducted to replenish germplasm with low viability and seed stocks. Viability and storage condition is regularly monitored to ensure viable germplasm conserved. Conservation efforts at different research station of PhilRice were implemented in synchrony with the activities and procedures done at PhilRice Genebank for better management and enhanced utilization. With the advent of the Plant Variety Protection Act, access, exchange and benefit sharing of rice germplasm conserved requires legal instrumentalities such as the Standard Material Transfer Agreement (SMTA) will be instituted for the protection of the Philippine rice genetic resources

**Collecting and acquisition of new germplasm materials (GRD-002-001)**
*MC Ferrer, MC Newingham, MD Duldulao, DO Alfonso, JR Castro, JMZ Nombrere, JB Regalario and XGI Caguiat*

The initial step in all genetic conservation is the collection and assembly of crop germplasm. A Germplasm collection is done to conserve the genetic diversity of crop species and their wild relatives. A systematic approach to germplasm collection program is necessary to insure that the maximum range of diversity of germplasm will be collected in a cost- and time-efficient manner. PhilRice through GRD collects and conserve rice genetic resources. Collecting activities prioritized the underrepresented provinces and tribal area and stored at PhilRice's own Genebank. The collecting activities are closely linked to conservation and use. The wider selection and diversity of materials can be utilized for varietal improvement if more rice germplasm accessions and information available.

**Activities:**

- Priority areas for collections were identified prior to the start of the collecting expeditions based on collection gaps
- Communications with different Municipal Agriculturist of the identified target areas were done to establish contacts in the area
- Passport data were filled up as completely as possible while collecting samples
- Samples were processed shortest time possible prior to drying and storage at genebank

**Results:**

- 336 new collections of rice genetic resources acquired and/or duplicated in PhilRice Genebank (Figure 1) from different part of the Philippines as well as other countries.

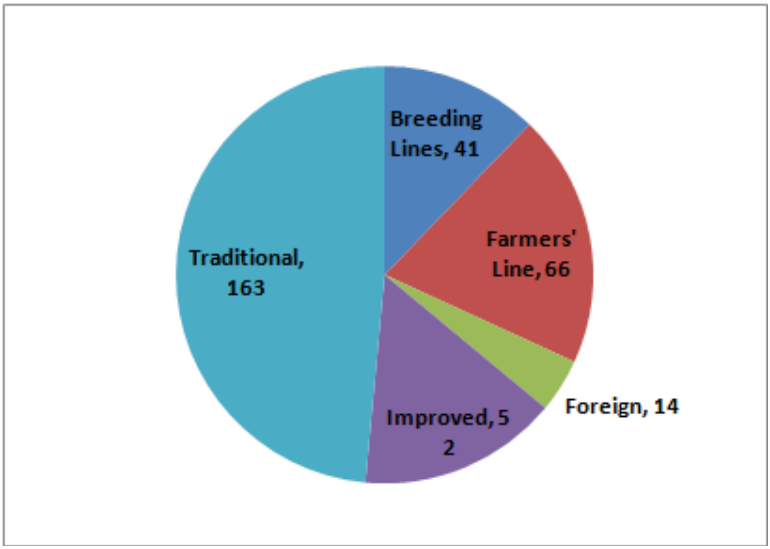



**Figure 1**. Types of rice germplasm acquired in 2016 at PhilRice Genebank.

**Regeneration and conservation of rice germplasm (GRD-002-002)**
*MC Ferrer, MD Duldulao and XGI Caguiat*

The ex situ conservation provides a safe storage system for the germplasm materials under optimal storage conditions that is efficiently managed for the long-term and accessible to users. The facilities of PhilRice Genebank ensure long-term preservation of important rice diversity. However, seeds in Genebank storage tend to lose their viability and get depleted over time. To keep these valuable materials alive, regeneration has to be undergone to maintain their viability and genetic integrity. Regeneration aims to increase the quantity of seed accession and restore the maximum viability of seed collection (Upadhyaya, 2013). Seed multiplication is the best way to revitalize stocks to maintain the genetic integrity of germplasm collection. The study aims to conserve rice germplasm resource for medium and long term storage and rejuvenate low stocks and low viability rice germplasm for conservation and distribution.

**Activities:**

- Accessions with low viability score (less than 85% germination rate) based on results gathered during periodical monitoring and those with low seed stocks (below 120g) were selected for regeneration

- Regeneration of germplasm materials were done during the dry season to reduce insect and disease damages for better quality seeds for storage and distribution

- Regenerated seeds were processed carefully prior to drying and storage at genebank

- Moisture content of each accessions were determined prior to storage and routine viability test were also conducted

**Results:**

*Regeneration*

- Exactly entries (602 Accessions and 265 Collections) were selected for regeneration in 2016 dry cropping season. The germplasm were selected based on the level of viability or germination rate and seed stocks.

- The data obtained can serve as basis of planning for regeneration of rice germplasm to achieve sufficient seed stocks

*Conservation*

- A total of 119 new collections from 2016DS were processed for conservation.

- Regenerated materials from 2015 wet seasons which included 400 accessions/collections were processed for conservation.

**Germplasm distribution and information management (GRD-002-003)**
*MD Duldulao, MC Ferrer, MCV Newingham and XGI Caguiat*

The Genebank Documentation System, also known as GEDS database, was a relational database management system (RDBMS) developed to document, manage, and centralize the large quantities of data of all germplasm conserved in the genebank. This includes germplasm data on passport; agro-morphological characterization; grain quality, biotic and abiotic stresses evaluations; viability conditions; and seed inventories. The GEDS database maintains accurate, reliable and up-to-date rice germplasm information, thus, facilitates ease of data search and retrieval for better access and use of germplasm.

PhilRice genebank regulates the release of seeds that can be used in research, breeding methods and genetic improvements to support the utilization of rice genetic resources. This is accompanied with Standard Material Transfer Agreements (SMTAs) that defines the terms and conditions for use of germplasm agreed upon between PhilRice and receiving party and vice versa. Germplasm data request is offered to rice breeders, researchers, and individuals for their germplasm/ traits of interest.

**Activities:**

- Updating of important rice germplasm data in the GEDS coming from various studies and projects in the division.
- Facilitate acceptance and preparation of SMTA and MTA within and outside PhilRice.

**Results:**

- The GEDS containing important rice germplasm data was updated: passport data (330 new collections), morpho-agronomic characterization data (545 accessions/ collections), grain quality data (592 collections/ accessions), rice tungro field evaluation data (810 collections/accessions), zinc evaluation data (305 collections/accessions), drought evaluation data (102 collections/ accessions), and pest and diseases data (553 accessions).
- Exactly 79 seed requests with a total of 1,101 seed packets covering 580 rice accessions/ collections have been distributed to both PhilRice and non-PhilRice individuals.
- A total of 47 selected Philippine traditional rice varieties were also distributed to 338 farmers during 2016DS and 2016WS Lakbay Palay covering 1,201 seed packets.
- In terms of request for germplasm information, 11 data requests have been catered and provided to PhilRice and non-PhilRice personnel for research purposes.
- 20 SMTA's and 10 PMTA-GUD's have been issued to protect intellectual properties or rights over the rice varieties being provided to non-PhilRice staff. PMTA-GUD serves as an attachment to the SMTA for additional conditions on the transfer of breeding lines.
- To properly document the receipt of rice germplasm, 15 SMTA's and 11 IRRI-OMTA's for the seeds requested by PhilRice researchers were accepted through the GRD Head and is currently being monitored.
- A new system function of the GEDS database has been developed for counting field data entries primarily for morpho-agronomic characterization data.

**Germplasm inventory (GRD-002-004)**
*MC Ferrer, MD Duldulao, JB Regalario, DO Alfonso, JR Castro, JMZ Nombrere, and XGI Caguiat*

Preservation of genetic integrity and prolonging the longevity is the main goal of germplasm conservation. Conservation of plant genetic resources (PGR) is not limited to attaining and physically possessing the materials (collection and storage) but also includes ensuring the existence of these under viable conditions and with their original genetic characteristics intact.

To improve the seed quality of conserved genetic resources, the PhilRice genebank has prioritized the seed identity verification and viability monitoring of its germplasm collection. A detailed inventory system was done to ensure the germplasm's genetic integrity is preserved with sufficient viable stocks through the application of standard conservation techniques. The seed stocks' information on storage conditions such as seedlot, viability, amount, and storage locations are managed through an in-house software, Genebank Database System or GEMS. Results from the study would be an indespensible guide to ensure the preservation of the germplasm's genetic integrity and sufficiency of viable stocks.

**Activities:**

- In 2016DS, stocks for Collection 9046 to 11000 (not yet assigned with accession number) were extracted from different storage location (drying room, medium-term, and long-term storages) for inventory.

- To ensure that the conserved germplasm are same as the original collection, seed identity were verified through cross-checking with available seed files, planting plans and panicle files. Comparison between the seed lot and the seed file was done to verify the identity of the seed lot and the status of the seed quality (i.e. mix, mismatch, infected and etc.) were also noted.

- Proofread/ double checked labels of verified accessions (PRRI000001 to PRRI007129) stored in active set storage.

**Results:**

- Based from the inventory conducted, 2100 rice germplasm matched with seed file, viable and have enough seeds for conservation

**Germplasm characterization (GRD-002-005)**

*XGI Caguiat, MC Ferrer, MD Duldulao, DO Alfonso, JR Castro, JMZ Nombrere and JB Regalario*

Genetic diversity is the foundation of plant breeding programs. Characterization of each germplasm is done to establish genetic identity based on its agro-morphological characters to avoid genetic erosion; classify collection using sound criteria; identify potential traits; develop interrelationship between or among environmental groups of cultivars and estimate range of variation (Upadhyaya et al, 2008). Knowledge of these traits, their genetic and stability under different conditions enhances the value of conserved germplasm.

Standard descriptors for rice of Bioversity International (2007) were used to characterize and identify the materials to efficiently harness, properly assess and identify potential parents in breeding to produce quality traits of the varieties to help meet rice self-sufficiency. Characterization and systematic study of germplasm is not only important in identifying potential donors for crop improvement but also important in protecting the unique traits for present use (Parikh et al. 2012). Over the decades, the germplasm collection in PhilRice-GRD has been systematically characterized for a range of morphological and agronomic traits that facilitate conservation, as well as selection of suitable phenotypes by farmers and breeders.

**Activities:**

- Fifty-eight quantitative and qualitative agro-morphological traits by Bioversity International (2007) were observed and recorded. These characteristics were identified priority in support for breeding and diversity analysis.

**Results:**

- In 2016 dry season, exactly 289 entries were characterized while 290 accessions were sown and characterized for 2016WS.

- The data obtained were uploaded in the germplasm database to be accessible for researchers to serve as basis for selection of target traits for breeding.

**Conservation and management of rice genetic resources in PhilRice Los Baños (GRD-002-006)**

*WBAbonitalla, LVGuittap, TMMasajo, TH Borromeo, Sancho Bon, MC Ferrer and XGI Caguiat*

Germplasm conservation and maintenance at Los Baños is a joint activity of PhilRice Los Baños and UPLB. Materials are processed and stored in the Seed Processing and Seed Storage facility at the branch. Germplasm materials are characterized using the standard descriptors prescribed for rice. Seeds are multiplied and accessions with low viability are rejuvenated. Seed processing and packaging in aluminum sachet is an ongoing activity. Duplicate samples are shared with the germplasm bank at CES. Main users of the collection are breeders at UPLB and the hybrid breeding project at LB branch. The collection should also be available to staff at CES and the branches on request. Continuity and long-term program is essential to conservation and maintenance of germplasm. Germplasm work at PhilRice Los Baños will be implemented in synchrony with the activities and procedures done at CES genebank.

**Activities:**

- The germplasm materials maintained at the station were 2,622 accessions consisting of 60% varietal collections (traditional varieties) and 40% selections and elite line, wide hybridization derived lines, TGMS lines, promising hybrid pollen parents, and highly selected NCT lines are in the collection. Also stored at PhilRice Los Baños are the parental public released hybrids. The accessions are maintained in short-term storage at 15°C and 50% to 60% RH mainly kept in the cold storage room. Long-term conservation is also maintained at -18 °C in an upright three (3) freezers inside the Laboratory. The seeds are currently being processed for medium-term storage in freezers.

- PhilRice LB genebank is currently conserving 2,622 germplasm materials of different classifications. Stored in the cold room are the traditional varieties, breeding lines, elite lines like MET, NCT lines and other wide hybridization lines.

- Slow drying of seeds for processing is continually done using activated silica gels with its corresponding desiccants placed in a sealed glass jars. Regular monitoring and replacement of exhausted silica gels is also done to linger the drying process of seeds. Moisture content of processed seeds has been lowered to about 6%- 8% prior to packaging and storage. The packaging is done at IRRI- GRC using the aluminum foil that is hermitically sealed to prevent moisture absorption from the

environment. Three packets at 10 grams per packet for base collection and 2 packets at 30 grams per packet for active collection were packed for final storage. The base collections were kept at the upright freezer located in the Laboratory room and the active collections were stored in the cold storage facility inside the PhilRice LB hybrid building.

- Seed requests were served to seed requestor like breeders and researcher such as the TGMS breeding group which mainly are for research purposes only

- The facilities at PhilRice Los Baños including the cold storage and freezers are being monitored regularly. The physical condition of the storage rooms are maintained at a temperature ranging from 14°C to 16°C and relative humidity from 40 to 50%. Extended power failure (3 days) can result to temperature rising to 20°C and RH to 90%. Hence, packaging in aluminum packets and having a stand by generating set is much helpful to effectively store and conserve the germplasm.

**Results:**

- A total of 80 accessions were added to the collection of PhilRice Los Baños for 2016. During the dry season (DS), 45 lines were collected whereas 35 materials in wet season (WS). The newly assembled materials were composed of NCT lines and 35 traditional varieties collected and donated. Seed files for each material were currently set aside (Table 1).

- To date, a total of 100 existing materials were manually cleaned and sorted. Viability testing of these accessions was done. Likewise, 200 germplasm materials are tested for viability for this year such as, breeding lines and traditional varieties. Results showed that majority of the lines tested had more than 85% germination rate except in some lines that ranges from 40% to 85%, therefore, accessions having low viability are subject for regeneration this 2017 dry season.

**Table 1.** List of new germplasm materials collected and/or assembled in 2016.

| Accession/ Variety name | Quantity |
|---|---|
| *NCT Line* | 45 |
| *Traditional varieties* | 35 |
| **TOTAL** | **80** |

**Collection, conservation and management of traditional varieties in Mindanao (GRD-002-007)**

*PS Torrena, SJ Labarosa, JM Niones, MC Ferrer, and XGI Caguiat*

The traditional varieties (TRV) are cultivated and popular in the market, consumers and farmers in Mindanao. Many areas in this area are still untouched and undiscovered wherein plenty of traditional, indigenous and even wild rice varieties may be found. The utilization of the traditional and indigenous varieties is of great help in the varietal development. Traditional and indigenous varieties are already adopted and accepted by the local farmers. Improving farmer's traditional and indigenous varieties by introgression of valuable traits/ characters to solved the problem and enhanced the performance, in the particular locations. The farmers adoption and production of this improved traditional variety is quick and easy because the plant type and traits preferred by the farmers is already present and of value-added traits, such as resistance and grain quality. This study aimed to collect, document and conserve traditional germplasm in Mindanao, and the seed duplicates to Genetic Resources Division at PhilRice CES.

**Activities:**

- Collection, documentation and conservation traditional germplasm in Mindanao, and sending of seed duplicates to Genetic Resources Division at PhilRice CES

**Results:**

- A total of 1145 rice germplasm materials (618 traditional varieties and 527 breeding lines and other varieties) were inventoried at PhilRice Midsayap (Figure 2).

- 730 germplasm materials or 63.76% (543 were traditional varieties) from the total collection were duplicated in PhilRice CES Genebank (Figure 3).

- 58 breeding lines, including NERICA lines, were collected and duplicated at PhilRice CES Genebank.

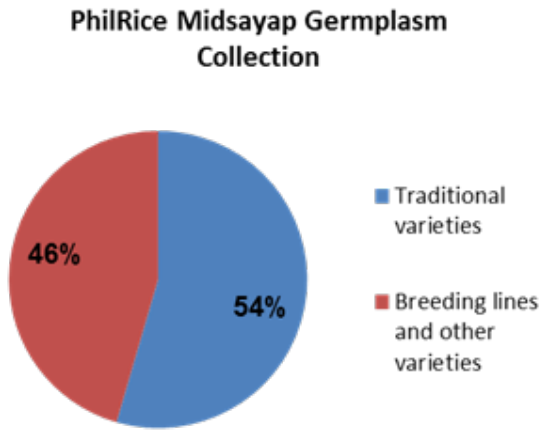



**Figure 2.** PhilRice Midsayap germplasm collection.

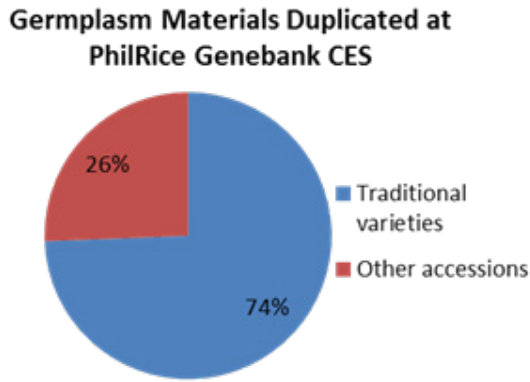



**Figure 3.** Germplasm materials duplicated at PhilRice Genebank.

**Germplasm collection and management in PhilRice Batac (GRD-002-008)**
*AY Alibuyog, JM Solero, NI Martin, BM Catudan, MC Ferrer, and XGI Caguiat*

Although modern high-yielding varieties presently dominate the lowland rice paddies, traditional rice varieties (TRVs) continue to be planted by farmers in diverse ecosystems throughout the country. Farmers plant TRV sowing to their adaptability, resistance to extreme climatic conditions, tolerance to pests, minimal external input requirements excellent grain, and eating quality among others. It is a common practice, though, of farmers growing TRVs to recycle their seeds without any conscious selection and systematic purification process. This resulted to variety mixture and loss of seed vitality. The most serious problem is when seeds of a variety are totally lost in a locality from natural calamities. Unless a move is done to help conserve these traditional rice varieties, they may soon be completely obliterated from the agro-ecosystem. This activity aims help conserve TRVs in northwest Luzon.

**Activities:**

- An air-condition room was maintained in the station to serve as a repository of TRV seeds collected and purified. Periodic viability testing is conducted to these collections.

- Popular TRVs were seed-increased regularly to have sufficient stocks for requesting parties. TRVs with poor germination rate are likewise regenerated to improve the viability level of stored collections.

**Results:**

- From January to June, total of 29 TRVs were added in the collection: 3 from Nueva Era, Ilocos Norte; 14 old collections of DA Ilocos Norte Research and Experiment Center (INREC); 5 from Sugpon and Alilem, Ilocos Sur; 4 from Bangar and San Gabriel, La Union; 1 from Pidigan, Abra; 1 from Davao; and 1 from an unknown donor. To date, PhilRice Batac has a total of 268 collections, including duplicates.

- The 14 TRVs from DA-INREC were processed, cleaned and sent to PhilRice CES for duplication; the remaining 8 new collections are still for processing.

- Of the 268, exactly 254 collections were viability-tested in which only 145 (57%) had good viability while 109 had below 85% viability. From 109, exactly 86 collections were dead (79%).

- A total of 30 TRVs were dried to 6 to 7% MC using silica gel. Overall, 70 TRV of the collections were silica-dried while drying of 6 TRVs is still on-going. Most of the drying was done at PhilRice CES owing to limited silica gel at the station.

- Seeds of 10 most in-demand TRVs (mostly pigmented) were seed increased to 1.5 to 2 kg. Five TRVs had less than 2 kg harvested grain due to typhoon Lawin damage. Likewise, another 12 TRVs were planted for regeneration.

- Twenty-two (22) TRVs were sent to PhilRice Los Baños grain analysis to complete the grain quality data for the TRV catalog being prepared. Grain analysis result is not yet available.

- Securing the Precondition Certification from the National Commission on Indigenous People (NCIP) for the publication of the catalog containing the characteristics and photos of characterized TRVs had been done. Enhancement of the layout of the catalogue is also on-going.

**Germplasm conservation and evaluation of traditional rice varieties in Northeast Luzon (GRD-002-009)**

*JV Galapon, ATIORebong MC Ferrer, and XGI Caguiat*

The importance of a diverse collection of rice germplasm in any breeding program is the foundation of potentially desirable new rice genotypes. An improved variety would not exist without the numerous predecessors that contributed to its development. Thus, the conservation and eventual utilization of traditional landraces as part of a crop's genetic resources is of utmost importance. Northeast Luzon (NE) has a vast collection of rice germplasm waiting to be explored. Discovery of desirable traits for abiotic and biotic stresses from this collection and incorporating them in our rice breeding efforts would greatly benefit our rice farmers. This study aims to identify and collect traditional rice varieties from areas that contain novel rice germplasm not yet conserved; to characterize, conserve on station and submit to GRD collected rice germplasm for future use; and to create a display in rice museum of PhilRice Isabela and database of these collections and publish eventually a compilation of these germplasms for future reference.

**Activities:**

- Collection of traditional rice varieties in Region II and CAR.
- Establishment, characterization (agro-morphological characterization and yield data components)and evaluation of newly collected traditional rice varieties.
- Create a display of these traditional rice varieties in rice museum of PhilRice Isabela (Figure 4).

**Results:**

- In 2016DS, 10 newly collected traditional rice varieties (Table 2) including one special rice variety (NSIC Rc19) that were characterized based on morpho-agronomic (vegetative stage, reproductive stage and harvest and post-harvest stage) and yield data components. Kalong-kalong has the highest yield of 8.45 t/ha among the 10 TRV's characterized. The average yield ranges from 5.09t/ha to 8.45t/ha. The maturity days of the 10 TRV's ranges from 107 to 135 days. Endosperm colors vary from white, red, brown, and variable purple. Six are glutinous, two are intermediate and 2 are non-glutinous.
- The DS2016 seed harvests were packed in a foil envelops with 50 grams each (Figure 5) for conservation and 29 TRV samples

from the previous years were packed and labeled. Fifteen TRV's were prepared for rice museum of PhilRice Isabela (Figure 6).

- Passport, registration data of new and old seed samples and proper labeling of seed files were organized. Germplasm list were updated and encoded

- Seed cataloging and data base was improved on GRD's procedure

- During the wet season 2016 (Figure 7), thirteen newly collected TRVs from Poblacion, Kibungan, Benguet were characterized based on morpho-agronomic characteristics (Table 3).

**Table 2.** Yield data components of traditional rice varieties during the 2016DS.

| ENTRIES | t/ha | Weight of 1000 grains | % Seed Set |
|---|---|---|---|
| Imelda | 8.11 | 29.50 | 74.32 |
| NSIC Rc19 (special rice) | 7.91 | 25.00 | 88.25 |
| Adong | 7.07 | 30.80 | 82.93 |
| Kalong-kalong | 8.45 | 32.50 | 88.16 |
| Chong-ak | 5.15 | 28.00 | 92.31 |
| Dinorado Red | 6.64 | 25.00 | 89.52 |
| Balatinaw | 6.15 | 29.00 | 83.58 |
| Ominio | 7.07 | 27.00 | 82.45 |
| Balatinao | 5.09 | 28.00 | 82.85 |
| Dinorado White | 7.20 | 28.80 | 78.90 |

**Table 3.** Lists of newly collected TRV's from Kibungan, Benguet, 2016 WS.

| ENTRY NAME | | ENDOSPERM | |
|---|---|---|---|
| | | Type | Color |
| 1 | Lasbaken 1 | Glutinous | red |
| 2 | Lasbaken 2 | Glutinous | brown |
| 3 | JMN | Glutinous | brown |
| 4 | Balatinaw | Intermediate | black |
| 5 | Gal-ong | Glutinous | brwon |
| 6 | Malongus | Non-glutinous | white |
| 7 | Kalipago | Intermediate | brown |
| 8 | Lablabi | Intermediate | brown |
| 9 | Bonkitan | Non-glutinous | white |
| 10 | Lamadya | Intermediate | white |
| 11 | Talokitok | Intermediate | white |
| 12 | Kamporo | Intermediate | white |
| 13 | Taiwan | Non-glutinous | white |

**Figure 4.** Traditional rice varieties displayed in PhilRice Isabela's Rice Museum.

**Figure 5.** TRV samples packed in a foil envelope.


**Figure 6.** TRV samples displayed in PhilRice Isabela's Rice Museum.

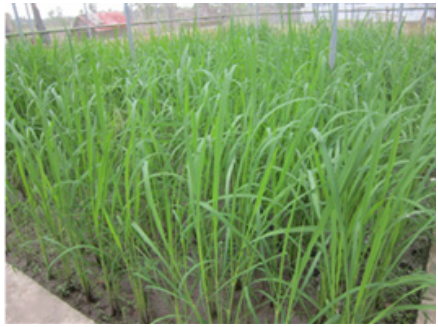


**Figure 7.** Traditional rice varieties at PhilRice Isabela, 2016 WS.

## II. Evaluation of PhilRice Germplasm Collection for Biotic and Abiotic Stresses in Irrigated Lowland and Grain Quality (GRD 003)

*Project Leader: JM Niones*

The vast germplasm stored at PhilRice Genebank possess desirable genes and traits. These may have inherent genes for key traits such as high yield, good eating quality, pest and disease resistance, and tolerance to abiotic stresses. In order to provide breeders with promising rice germplasm, there should be relevant information about these accessions especially on their reaction to various biotic and abiotic stresses. At present, there are few available information on reaction to biotic and abiotic stresses as well as grain quality characteristics. Rice germplasm must be efficiently harnessed and properly evaluated in order to identify potential genetic donors for use as parents in breeding program. This routine project aims to evaluate the vast germplasm in terms of reaction to various abiotic and biotic stresses and to identify high grain quality germplasm of the PhilRice germplasm collection. Data from these evaluation activities would be uploaded in the database.

### Evaluation of PhilRice germplasm collection for biotic stresses (GRD 003-001)

*JP Rillon, GDC Santiago, MSV Duca, MLB Palma, JM Niones, and XGI Caguiat*

Rice germplasm possess useful genes such as resistance to insect pests and diseases. These rice germplasm needs screen against blast, bacterial leaf blight (BLB), sheath blight (ShB), rice tungro virus (RTV), green leafhoppers (GLH), brown planthoppers (BPH) and stemborer. These insect pest and diseases cause severe damage to plants in various stages that eventually affect the yield. This routine study aims to evaluate to reaction of Philippine traditional rice varieties against important insect pests and diseases using artificial and field conditions (if there is a high occurrence). This 2016, 506 PhilRice germplasm accessions were evaluated for resistance to blast, BLB, ShB, RTV, GLH, BPH and SB. Evaluation was done for blast at 30-35 DAS; BLB and ShB at 2 weeks after inoculation; RTV at 3 to 4 weeks after inoculation; GLH and BPH at 10 days after infestation; SB at 35 and 50 DAT for deadheart damage and 10 days before harvest for whitehead damage.

**Activities:**

- Evaluation of 506 PhilRice germplasm accessions against blast, BLB, ShB, RTV, GLH, BPH and SB was conducted under artificial conditions using Standard Evaluation System (IRRI, 2008).

- Evaluation was done for blast at 30 to 35 DAS; BLB and

ShB at 2 weeks after inoculation; RTV at 3 to 4 weeks after inoculation; GLH and BPH at 10 days after infestation; SB at 35 and 50 DAT for deadheart damage and 10 days before harvest for whitehead damage under artificial conditions using Standard Evaluation System (IRRI, 2008).

**Results:**

- 54.3% or 275 out of 506 germplasm accessions showed resistant reaction to blast while 150 entries had intermediate reactions to the disease (Table 4).

- None of the accessions was resistant to BLB, ShB and RTV while 63 accessions had intermediate reactions to BLB.

- Accession number 13817 had intermediate reaction to ShB while accession number 13767, PRRI002941 and PRRI005676 had intermediate reaction to RTV. Accession number 13817 was identified resistant to blast and had intermediate reactions to BLB and ShB. Accession number 14270 and 14083 had intermediate reactions to BLB and ShB.

- 72.7% or 368 accessions out of 506 were evaluated for resistance to BPH under natural field condition. Thirty four entries were resistant to BPH, 123 had intermediate reactions and 211 showed susceptible reactions to BPH damage (hopperburn). Majority of the germplasm accessions had susceptible reactions to GLH and BPH under screenhouse condition.

- 36.2% or 183 out of 506 were resistant to SB while 18 had intermediate and an entry was susceptible to deadhearts.

- 26.3% or 52 out of 197 accessions were infested by BPH at maximum tillering which led to hopperburn hence the accessions did not recover. The remaining 145 entries, 83 were resistant, 28 were intermediate and 34 were susceptible to whiteheads.

**Table 4.** Summary of screening reactions of PhilRice germplasm accessions to major rice diseases and insect pests in 2016.

| Reaction | No. of Accessions | | | | | |
|---|---|---|---|---|---|---|
| | Blast | Bacterial Leaf Blight | Sheath Blight | Rice Tungro Virus | Stemborer | |
| | | | | | DH | WH |
| Resistant | 275 | 0 | 0 | 0 | 183 | 83 |
| Intermediate | 150 | 63 | 1 | 3 | 18 | 28 |
| Susceptible | 58 | 443 | 505 | 503 | 0 | 34 |

## Evaluation of PhilRice germplasm collection for grain quality (GRD 003-002)

*RC de Leon, APP Tuaño, MC Ferrer, JM Niones, and XGI Caguiat*

The value of rice genetic resources stored at PhilRice Genebank could contain high grain quality but these data on grain quality characteristics is still lacking. Grain quality in particular, dictates consumer acceptability and marketability of rice, hence considered an important component in the rice breeding program. This continuing study aims to generate grain quality data of the PhilRice germplasm collection and efficiently provide grain quality data through a computerized database system handled by the PhilRice Genetic Resources Division (GRD).

**Activities:**

- Determination of milling and physical properties such as milled rice recovery, head rice recovery, grain size and shape, and percent chalky grains.
- Analysis of selected physicochemical properties such apparent amylose content (AC) and alkali spreading value.

**Results:**

- 19.6 % or 51 out of the 260 accessions received from GRD had high-AC (>22.0%), 164 were intermediate-AC (17.1-22.0%), 27 accessions were low-AC (10.1-17.0%), and 16 accessions had AC less than 10% (considered as very low AC to waxy) (Table 5).
- Gelatinization temperature (GT) type distribution of 260 samples was as follows:

a. high-AC rices: 16 had intermediate GT (ASV 4-5) and 35 had low GT (ASV 6-7);

b. intermediate-AC rices: none had high GT (ASV 2-3), 107 had intermediate GT (ASV 4-5), and 57 had low GT (ASV 6-7); and

c. low-AC, very low-AC and waxy rices: 23 had high GT (ASV 2-5) and 20 had low GT (ASV 6-7).

- 19.6 % or 51 out of the 260 accessions had short grain size, 134 were medium, 68 were long, and three were extra-long. In terms of grain shape, 53 were bold, 144 were intermediate, and 59 were slender.

- In terms of percent brown rice, 5 were poor, 162 were fair, and 92 were good. In terms of total milled rice, 1 was grade 3, 2 were grade 2, 60 were grade 1, and 196 were premium. In terms of head rice, 11 were grade 3, 9 were grade 2, 14 were grade 1, and 213 were premium.

**Table 5.** Ranges and mean values of grain quality properties of PhilRice Genebank accessions harvested from the GRD regeneration plots, 2015 DS.

| Property | Nonwaxy accessions (n=251) | | Waxy accessions (n=7) | |
|---|---|---|---|---|
| | Range | Mean | Range | Mean |
| Brown rice, % | 74.3 - 81.9 | 79.2 | 75.2 - 78.6 | 77.4 |
| Total milled rice, % | 57.1 - 76.8 | 71.2 | 67.4 - 71.9 | 70.1 |
| Head rice, % | 4 - 74.4 | 61.6 | 63.4 - 69.2 | 66.6 |
| Grain length, mm | 3.5 - 7.7 | 6.0 | 5.4 - 6.8 | 6.2 |
| Grain shape, length/width | 1.5 - 4.5 | 2.5 | 1.8 - 3.0 | 2.5 |
| Apparent amylose content, % | 2.19 - 28.36 | 19.60 | 0.58 - 1.80 | 1.10 |
| Alkali spreading value | 3.2 - 7.0 | 5.4 | 4.6 - 7.0 | 5.8 |

**Evaluation of PhilRice germplasm material in response to progressive drought stress (GRD 003-003)**

*JM Niones, MCN Julaton, RR Suralta, and XGI Caguiat*

The single line-source sprinkler system (LSS) was conceptualized and introduced, to impose and create a continuous variable water application across a research field plot (Hanks et al., 1976; Bauder et al., 1975; Willardson et al., 1987; Hanks et al., 1980). The LSS configuration provides a linearly decreasing irrigation application rate perpendicular to the sprinkler line, thus has been utilized to study crop response to variable amounts of irrigations and to different soil moisture intensities. This study aimed to evaluate and screened PhilRice germplasm collections under different intensities of drought stress using the line source sprinkler system.

**Activities:**

- Germplasm collections were transplanted and conducted in the watertight experimental bed with line source sprinkler system under a rain-out shelter. Each line was planted at 20cm between rows and 45cm between hills in RCBD with two replications. IR64 and KDML 105 served as control genotypes. Fertilizer rate was 120-60-60 kg NPK/ha applied in two splits (basal and maximum tillering stage). Supplemental fertilization of 10kg/ha ammonium sulfate was done at 50DAT to correct sulfur deficiency.

- Draining of water started at 14DAT after the plants have recovered. Soil moisture sensors were placed at both sides of the seedbed at varying distance from line source sprinkler at 10cm, 40cm, 80cm, 120cm, and 160cm, respectively.

- Re-irrigation was done when the soil moisture at 80cm distance was below 30%VMC. Each entry was final sampled and terminated 3 weeks after heading with reference to the hill planted near the line source (10cm).

- Agronomic data (plant height, number of tillers and biomass) and root data (number of nodal roots (NRN), Total Root Length (TRL), Total nodal root length (TNRL), Total Lateral Root Length (TLRL), Root Dry Weight (RDW) were gathered.

**Results:**

- Eight (8) accessions showed less sensitivity to drought which resulted to an increased in shoot dry matter production at ≤15% SMC relative to well- watered (≥22%, SMC). These includes PRRI000148 (Cabachao), PRRI000270 (Bulyhan Kalindol), PRRI000510 (Macabato), PRRI001861 (Macasapi),

PRRI001748 (Ago-oyong), PRRI000469 (Caidol), PRRI002047 (Ginaracia) and PRRI001879 (Minantika) as indicated by sensitivity drought index (SDI) (Figure 8).

- Shoot dry matter increased ranged from 11.9 to 103.8% relative to well-watered (≥22%, SMC). Cabachao had the highest increased (103.8%) while Minantika had least increased (11.9%). IR64 (37.8%) and KDML105 (49.0%) exhibited reduction under different drought stress.

- Eleven germplasm previously identified (2014WS and 2015DS) with potential drought stress tolerance were also validated for root system characteristics under 3 water treatments (CWL, SMF and PDR) using rootbox method in 2016WS. All genotypes had significantly reduced shoot biomass in SMF and PDR. Highest reduction was obtained in Binarit (PRRI000620) 50.5% and Palawan (Coll14240) 63.9% in SMF and PDR, respectively (Figure 9).

- Water stressed showed significant reduced in TRL, and other root traits such as TNRL, TLRL, and S-type LR relative to CWL while significantly increased L-type LR under SMF and PDR. Highest increased was in Duryat (Coll #14278), Binarit (PRRI000620) and Goberno (PRRI006023) ranging from 100 to 182% in SMF and 111 to 131% in PDR (Figure 10).

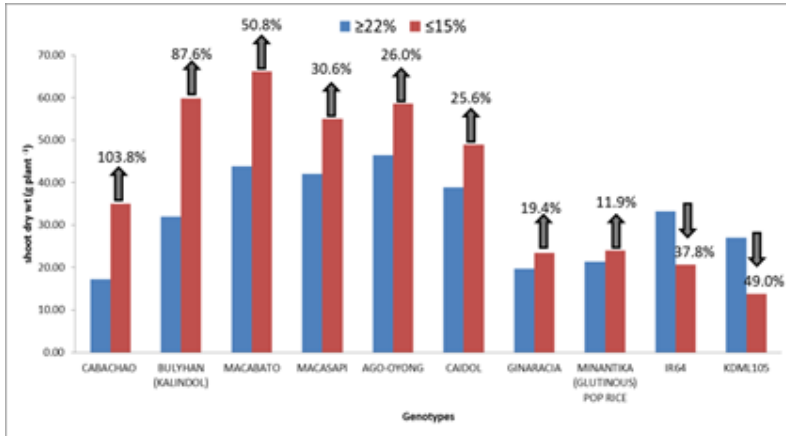



**Figure 8.** Shoot biomass of germplasm with potential drought tolerance evaluated under different intensities of soil moisture, 2016 DS.

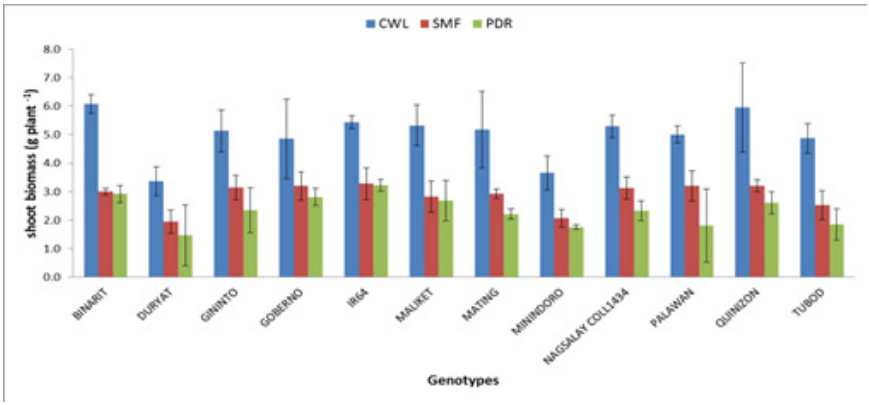



**Figure 9.** Shoot biomass of PhilRice germplasm with potential drought stress tolerance 2014 WS and 2015 DS under rootbox method, 2016 WS.

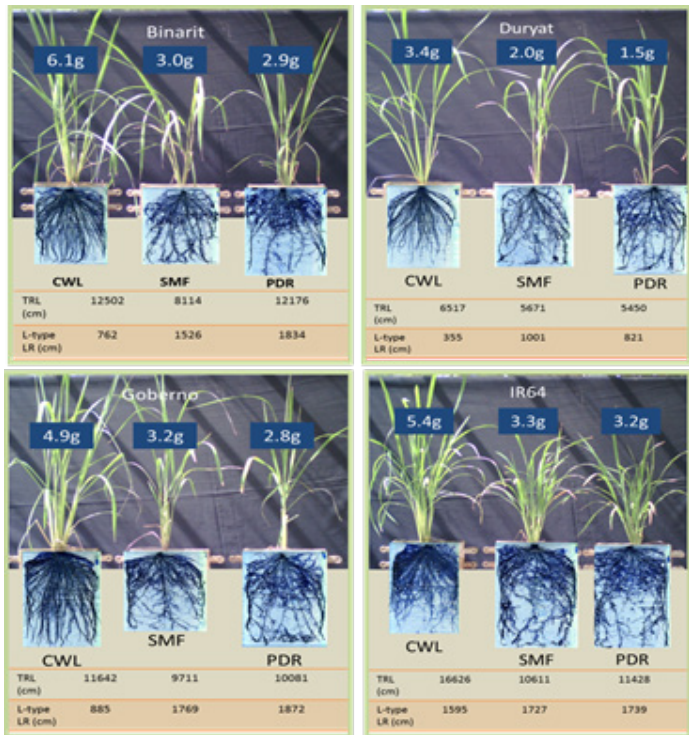



**Figure 10.** Root system developmental response of PhilRice germplasm with potential drought stress tolerance 2014 WS and 2015 DS under rootbox method, 2016 WS.

**Evaluation of Rice Germplasm for Zinc Deficiency Tolerance in Caraga Region (GRD 003-004)**

*HA Jimenez, JB Culiao, JM Niones, and XGI Caguiat*

The biotic and abiotic stresses are most importance factors limits rice production in Caraga region. Low solar radiation, flooding and soil-zinc deficiency are common problem frequently occurred in the region. Zinc (Zn) deficiency was first diagnosed in rice (Oryza sativa) on calcareous soils of northern India (Yoshida and Tanaka, 1969). It is currently a widespread micronutrient deficiency in Caraga Region causing low rice yields on the farmer's field. Zinc deficiency can be corrected by adding Zn compounds to the soil or plant, but the high cost associated with applying Zn fertilizers in sufficient quantities to overcome Zn deficiency places considerable burden on resource-poor farmers and it has therefore been suggested that breeding efforts should be intensified to improve the tolerance to Zn deficiency in rice cultivars (Quijano-Guerta et al., 2002; Singh et al., 2003).

- The DS (January–June 2016) study establishment was cancelled due to El Niño phenomenon. The farmer cooperator planted the area earlier than the normal cropping season.

- Established the study for July-December 2016WS cropping season. Data consolidation and analysis is on-ongoing.

**Evaluation of Rice Germplasm for Rice Tungro Resistance at PhilRice Midsayap (GRD 003-005)**

*PS Torreña, JM Niones, MPA Tejada, MS Ocenar, SJE Labarosa, and XGI Caguiat*

Rice tungro is the most destructive rice disease in Southeast Asia including the Philippines which affects thousands of hectares in the rice production. Rice tungro virus (RTV) infects the plant at any growth stage, but most severe during the vegetative stage where symptoms are more pronounced. In Mindanao, disease infection and other pest infestations contribute to low and unstable yield of rice farmers. The use of RTV resistant varieties is economical and practical on increasing the rice yield. Currently, varieties ARC 11554 (accession no. 21473), Utri Merah (accession no. 16680), Utri Rajapan (accession no.16684), Habiganj DW8 (accession no.11751) and some wild rice are being used as resistant donors in the RTV breeding program at PhilRice. But searching new sources of resistance from our PhilRice germplasm has given a little attention. In this study focused on the screening of PhilRice germplasm collection against rice tungro disease.

**Activities:**

- Rice tungro field screening- A total of 1000 germplasm were evaluated for RTD under natural infection in 2016 with the CHECK variety (IR64).

- RTV rating was conducted at 45 days after transplanting (DAT) and 60 DAT using standard evaluation systems (IRRI SES, 2008).

**Results:**

- 33.8 % or 338 out of 1000 accessions screened for RTV showed resistance at 45 DAT and 39.7% or 397 showed intermediate reaction to RTV, rated moderate susceptible to RBB damage and 213 were rated susceptible. At 60 DAT, 227 showed resistance response and 68 intermediate reaction but only 3 showed less percentage of RBB damage and the rest were rated susceptible (Table 6).

- Eighteen out of 1000 entries were non-germinant and 331 entries were poorly germinated at dry season while 147 entries were non-germinant and 175 entries showed poor germination at wet season.

- At 45 DAT, 14 entries showed resistant to intermediate reaction to RTV infection and at the same time showed moderate susceptible response to rice RBB damage (Table 7).

- Eighteen entries showed resistant to RTV with the most less %RBB damage (Table 7). One hundred ninety five entries survived until 79 DAT with 1 to 10 hills per entry at dry season while wet season there were 34 entries remained up to that DAT.

- All entries screened were heavily damaged by RBB or bugburned at maturity phase (Figure 11). At 60 DAT, 10 entries showed resistant to intermediate reaction to RTV infection and at the same time showed moderate resistant to intermediate response to RBB damage in dry season while in wet season, 7 entries showed resistant reaction to RTV and resistant to moderate susceptible reaction to RBB damage.

**Table 6.** Entries showed less RBB damage at 60 DAT.

| PLOT NUMBER | CULTIVAR NAME | % RTV | RTV RATING | %RBB | RBB RATING |
|---|---|---|---|---|---|
| **DRY SEASON** | | | | | |
| 062 | RADEN KUNING | 49 | INTERMEDIATE | 20 | MODERATE RESISTANT |
| 069 | SAWAH | 50 | INTERMEDIATE | 20 | MODERATE RESISTANT |
| 070 | SAYANG ANAK | 59 | SUSCEPTIBLE | 30 | INTERMEDIATE |
| CHECK | IR64 | 54 | SUSCEPTIBLE | 30 | INTERMEDIAE |
| **WET SEASON** | | | | | |
| 574 | PLB 358 | 33 | RESISTANT | 20 | MODERATE RESISTANT |
| 575 | PLB 359 | 30 | RESISTANT | 30 | INTERMEDIATE |
| 3 | MALINIS 1 | 10 | RESISTANT | 60 | MODERATE SUSCEPTIBLE |
| 11 | CAPITAL | 5 | RESISTANT | 60 | MODERATE SUSCEPTIBLE |
| 20 | ENANNO | 5 | RESISTANT | 60 | MODERATE SUSCEPTIBLE |
| 415 | PINILIK | 10 | RESISTANT | 60 | MODERATE SUSCEPTIBLE |
| 441 | M94-4-1 | 10 | RESISTANT | 60 | MODERATE SUSCEPTIBLE |
| CHECK | IR64 | 30 | INTERMEDIATE | 20 | MODERATE RESISTANT |

Rice tungro virus percent infection [(0-25%: Resistant (R); 26-50%: Intermediate (I); 52-100%: Susceptible (S)]
%RBB – Percent Rice Black Bug Damage [0-10%: Resistant (R); 11-20%: Moderately Resistant (MR); 21-30%: Intermediate (I); 31-60%: Moderately Susceptible (MS); 61-100%: Susceptible (S)

**Table 7.** Entries showed resistant reaction RTV infection at 45 DAT and less RBB damage in wet season.

| PLOT NUMBER | CULTIVAR NAME | RTV % | RTV RATING | %RBB | RBB RATING |
|---|---|---|---|---|---|
| **WET SEASON** | | | | | |
| 807 | BOLIBOD BUNDOK | 13 | RESISTANT | 0 | RESISTANT |
| 422 | MILAGROSA (MALAGKIT) | 6 | RESISTANT | 5 | RESISTANT |
| 197 | LIMANGCA | 8 | RESISTANT | 5 | RESISTANT |
| 248 | IKAT | 9 | RESISTANT | 5 | RESISTANT |
| 041 | CABODBOD | 15 | RESISTANT | 5 | RESISTANT |
| 084 | GRACIA | 14 | RESISTANT | 10 | RESISTANT |
| 509 | IR841-1-1-1-2 (JASMINE) | 14 | RESISTANT | 10 | RESISTANT |
| 344 | LAMPIKET | 15 | RESISTANT | 10 | RESISTANT |
| 988 | P. T. Q. QIM. Q. QIM. Q. MIN. | 8 | RESISTANT | 11 | RESISTANT |
| 416 | NINANGKA | 3 | RESISTANT | 15 | RESISTANT |
| 228 | SABINTAR | 5 | RESISTANT | 15 | RESISTANT |
| 088 | KIMMABATITI | 5 | RESISTANT | 15 | RESISTANT |
| 182 | DECOLA | 8 | RESISTANT | 15 | RESISTANT |
| 336 | FISCAL | 8 | RESISTANT | 15 | RESISTANT |
| 240 | TODYOK | 10 | RESISTANT | 15 | RESISTANT |
| 382 | SALAYUSAY | 13 | RESISTANT | 15 | RESISTANT |
| 431 | M10-2-2-5 | 13 | RESISTANT | 15 | RESISTANT |
| 189 | ISLA | 15 | RESISTANT | 15 | RESISTANT |

Rice tungro virus percent infection [(0-25%: Resistant (R); 26-50%: Intermediate (I); 52-100%: Susceptible (S)]
%RBB – Percent Rice Black Bug Damage [0-10%: Resistant (R); 11-20%: Moderately Resistant (MR); 21-30%: Intermediate (I); 31-60%: Moderately Susceptible (MS); 61-100%: Susceptible (S)

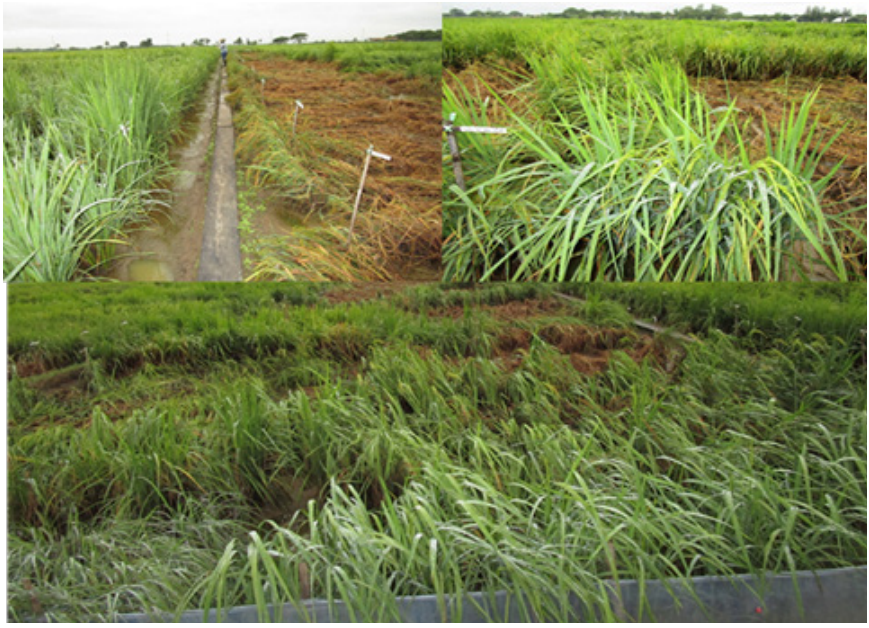


**Figure 11.** Germplasm accessions with hopperburns damage.

**Characterization of new sources of disease resistance genes in PhilRice Genebank accessions (GRD 003-006)**

*JTNiones, JPoblete, MGarcillano, JM Niones, and XGI Caguiat*

Local and indigenous traditional varieties are potential sources of genes useful in improving rice with resistance against various biotic and abiotic stresses. Mass screening of rice accessions from PhilRice Genebank for disease resistance had identified accessions with resistance against important rice diseases. However, before plant breeders can use and exploit these identified disease resistant accessions as potential source of resistance genes, there is a foremost need to characterize the nature and mechanisms of resistance of these rice accessions. Characterizing the mechanism of disease resistance facilitates manipulation, effective transfer of genes to popular varieties and eventual deployment of disease –resistant cultivars. Thus, this means greater opportunity of using and exploiting these lines for breeding and genetic improvement of our rice varieties for resistance to rice diseases. This study aims to systematically analyse the spectra and estimate the resitance genes possibly harboring in these rice blast resistant rice genotypes.

**Activities:**

- Inoculation of rice blast resistant genotypes (rice blast field resistance) with eight rice blast differential isolates. These isolates have a broad spectrum of virulence to known R genes considered in the rice blast differential system.

- Evaluation of disease reaction of these rice accessions when inoculated with eight rice blast differential isolates.

- Gene estimation based on the reaction patterns of 25 kinds of monogenic line harboring 22 R genes to 20 differential isolates from the Philippines (Kobayashi et al. 2007, Telebanco-Yanoria et al. 2008 and Tsunematsu et al. 2000).

**Results:**

- In the first stage of evaluation, we have surveyed the blast resistance in 60 traditional rice varieties (TRV) against eight (8) differential isolates. These 8 differential isolates were used for grouping of varieties and primary gene estimation.

- Among these 15 accessions, we have identified 9 accessions that are resistant to 17 of the differential isolates. Such reaction pattern is different from that of known broad spectrum R genes included in the rice blast differential system (Table 8). Thus it is possible that novel gene/s for blast resistance are present in these Philippine traditional rice varieties.

- These varieties were classified into 11 variety groups (VG) based on reaction patterns to eight differential isolates and gene(s) were estimated by comparing reaction patterns to the differential blast isolates of traditional varieties with those of blast monogenic lines. Broad spectrum resistance index (BSRI) of rice blast resistant genotypes against 8 differential isolates ranges from 0.625 to 1.0. (Table 9).

- Of these 60 TRV, 15 accessions exhibited resistance reaction to 8 of the differential isolates. These 15 lines were further evaluated for their resistance reactions against additional 9 differential blast isolates. Resistance pattern of a particular TRV against the 17 differential isolates that cannot be attributed to any of the 24 major R genes considered in the differential system was assumed to be conferred by an “unknown” R gene/s.

**Table 8.** Blast resistance spectra of selected traditional rice varieties against 17 differential blast isolates from the Philippines.

| ACCESSION NO. | COLLECTION NO. | ACCESSION NAME | Differential blast isolates | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | PO6-6 | IK81-25 | B90002 | M39-1-3-8-1 | Ca89 | BN209 | M101-1-2-9-1 | BNIII | V85O256 | M36-1-3-10-1 | C923-49 | JMB84610 | 43 | Ca41 | M64-1-3-9-1 | IK81-3 | JMB8401 |
| PRRI000001 | 1984 | HINAMOG | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R |
| PRRI000020 | 2003 | SAN JUAN | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R |
| PRRI000038 | 2021 | BINARIRE | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R |
| PRRI000044 | 2027 | CABOYO | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R |
| PRRI000065 | 2048 | KASAYA | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R |
| PRRI000216 | 2199 | BESBESYAG | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R |
| PRRI000234 | 2217 | CARAVANTO | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R |
| PRRI000292 | 2275 | INUWAK | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R |
| PRRI000482 | 2465 | CAYANGA | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R | R |

**Table 9.** Blast resistance spectra of selected traditional rice varieties against eight differential blast isolates from the Philippines.

| ACCESSION NO. | COLLECTION NO. | ACCESSION NAME | Differential blast isolates | | | | | | | | BSRI | Estimated genes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Ca89 | IV39-1-3-8-1 | BNIII | PO6-6 | BN209 | IV101-1-2-9-1 | IK81-25 | B90002 | | |
| PRRI000001 | 1984 | HINAMOG | R | R | R | R | R | R | R | R | 1 | unknown genes |
| PRRI000020 | 2003 | SAN JUAN | R | R | R | R | R | R | R | R | | |
| PRRI000024 | 2007 | ENANNO | R | R | R | R | R | R | R | R | | |
| PRRI000038 | 2021 | BINARIRE | R | R | R | R | R | R | R | R | | |
| PRRI000044 | 2027 | CABOYO | R | R | R | R | R | R | R | R | | |
| PRRI000065 | 2048 | KASAYA | R | R | R | R | R | R | R | R | | |
| PRRI000216 | 2199 | BESBESYAG | R | R | R | R | R | R | R | R | | |
| PRRI000226 | 2209 | GINARACIA | R | R | R | R | R | R | R | R | | |
| PRRI000234 | 2217 | CARAVANTOS | R | R | R | R | R | R | R | R | | |
| PRRI000292 | 2275 | INUWAK | R | R | R | R | R | R | R | R | | |
| PRRI000304 | 2287 | MACARANIAG | R | R | R | R | R | R | R | R | | |
| PRRI000443 | 2426 | BALLUKOK | R | R | R | R | R | R | R | R | | |
| PRRI000466 | 442 / 2449 | MOKUL | R | R | R | R | R | R | R | R | | |
| PRRI000474 | 2457 | BARAO | R | R | R | R | R | R | R | R | | |
| PRRI000482 | 2465 | CAYANGA | R | R | R | R | R | R | R | R | | |
| PRRI000493 | 2476 | GIRES 1 | R | R | R | R | R | R | R | R | | |
| PRRI000022 | 476 / 2005 | BINAGSAC | S | R | R | R | R | R | R | R | 0.875 | *Pii, Pib, Pita, Pita-2* |
| PRRI000176 | 2159 | DINALORES | S | R | R | R | R | R | R | R | | |
| PRRI000207 | 2190 | ZIONGZO | S | R | R | R | R | R | R | R | | |
| PRRI000387 | 2370 | KABODIT | S | R | R | R | R | R | R | R | | |
| PRRI000671 | 1539 | SALIMPOPOY | S | R | R | R | R | R | R | R | | |
| PRRI000674 | 1549 | FORTUNA | S | R | R | R | R | R | R | R | | |
| PRRI000788 | 863 | BE-3 | S | R | R | R | R | R | R | R | | |
| PRRI001943 | 3215 | P2-7-2 (BINIDING (IR68)) | S | R | R | R | R | R | R | R | | |
| PRRI003236 | 3995 | PINALWA | S | R | R | R | R | R | R | R | | |
| PRRI003404 | 4205 | WAGWAG V3 | S | R | R | R | R | R | R | R | | |
| PRRI000675 | 1550 | KAMOROS | S | R | R | R | R | R | S | R | 0.75 | *Pib, Pi20, Piz-t,* unknown gene |
| PRRI001184 | 2586 / 3501 | PSB Rc40 (CHAYONG) | S | R | R | R | R | R | S | R | | |
| PRRI001188 | 2590 / 3508 / 10963 / 11261 / 11837 | PSB Rc68 (SACOBIA) | S | R | R | R | R | R | S | R | | |
| PRRI002169 | 4196 | KAMROS | S | R | R | R | R | R | S | R | | |
| PRRI000003 | 1986 | MALINIS 1 | S | R | R | S | R | R | R | R | 0.75 | *Pita-2, Pib, Pi20(t), Piz-t, Pita,* unknown |
| PRRI001037 | 1861 | M5 | S | R | R | S | R | R | R | R | | |
| PRRI001038 | 1860 | M45 | S | R | R | S | R | R | R | R | | |
| PRRI001890 | 223-A | PINDINGA B | S | R | R | S | R | R | R | R | | |

Legend: BSRI- Broad spectrum resistance index

## III. Genetic Resources Research (GRD 005)

*Project Leader: XGI Caguiat*

The project was focuses to provide basic and advance information on molecular data, current diversity status and accelerate discovery of novel traits from the vast germplasm accessions conserved at PhilRice Genebank. The studies under this project focuses on development of multiple founder lines , exploration of landraces for CMS diversification, utilization of next-generation sequencing for in silico gene discovery, and survey of ethnobotanical studies on rice with medicinal use. Broad range diversity analysis using various types of marker systems and different bioinformatics softwares would be employed in order to fast track trait discovery. Another promising prospect for this project is the development of core collection that represent current diversity of the entire collection, biotic stress resistance, abiotic stress tolerant and superior grain and eating quality traits.

### MAGIC (Multi-parent Advanced Generation Inter Crosses) in PhilRice Genetic Resources (GRD 005-001)

*XGI Caguiat, TE Mananghaya, VG Dalusong, RP Mallari, and R Baybado*

Multi-parent Advanced Generation Inter Crosses or MAGIC is an experimental method in which genetic markers are linked to quantitative trait loci (QTL) (IRRI, 2011). MAGIC populations are established by several rounds of intercrossing multiple founder lines and the resulting populations are, hence, genetically diverse, essential for the detection of multiple QTLs at the same time. The focus of the study is to determine potential founder lines in the rice germplasms conserved at PhilRice genebank. Selection of founder lines to be included in the MAGIC population will be done with the breeders and in consideration with unique agronomic traits suitable to the need of rice farmers in the Philippines. Phenotyping as well as molecular characterization of the founder lines will be explored by establishing the traits and methodologies as well as appropriate genetic marker systems for the molecular analysis.

**Activities:**

- Selection of founder lines to be included in the MAGIC population will be done with the breeders and in consideration with unique agronomic traits suitable to the need of rice farmers in the Philippines.

- Phenotyping as well as molecular characterization of the founder lines will be explored by establishing the traits and methodologies as well as appropriate genetic marker systems for the molecular analysis.

**Results:**

- Phenotypic and molecular evaluation of 8 MAGIC founder lines to biotic and abiotic stresses; and grain quality.

- Due to poor phenotypic acceptability, proponents decided to re-select the 8 founder lines in 2017.

**Exploration of Landraces for CMS Diversification (GRD 005-003)**
*IG Pacada, TMM Pascual, C Blazer, R Marzan, E Corpuz, A Bildua, and XGI Caguiat*

Wild abortive (WA) type of cytoplasm has been used extensively in identifying and developing new maintainer lines and breeding rice F1 hybrids. To date, most of PhilRice maintainer lines converted into male sterile has WA cytosterility source. However, single source of male sterile cytoplasm maybe disastrous in case of sudden outbreak of pest and diseases specifically if the susceptibility is associated with a CMS-inducing factor. Furthermore, cytoplasmic influences yield and agronomic characters, hence, diversification of cytoplasmic source play an important role in improving crop productivity. This study aimed to develop new sterile cytoplasm source using nucleus substitution approach.

**Activities:**

- Generate inter sub-specific and nucleus substitution crosses and identify potential CMS source based in pollen fertility/ sterility.

**Results:**

- 3 F1 crosses, from inter-sub-specific crosses, exhibited male sterility (evaluation/validation is in progress).

**Complete genomic DNA sequencing of selected Philippine traditional varieties for in silico gene discovery (GRD 005-004)**
*XGI Caguiat, RP Mallari, D Alfonso, and J Regalario*

Genomic DNA sequencing is a biotechnology tool for discovering genes coding for traits including resistance to pests and diseases, tolerance to abiotic stresses, grain quality. With the revolution of molecular tools and fast-paced evolution of DNA analysis technology, it becomes a common measure for gene discovery in plants especially rice. Philippine traditional rice varieties currently conserved in PhilRice Genebank have immense genetic diversity and potential novel genes for rice genetic improvement. This study will generate genomic sequence information of selected Philippine

traditional varieties and identification of potential novel genes using in silico gene discovery. Molecular analysis and phenotyping of rice germplasm helps in identification of novel genes. Trainings and memorandum of agreement with collaborators will be useful in handling data analysis. The discovery of genes and potential source of germplasm in local and indigenous traditional rice varieties will mean opportunity for commercialization of rice science advancement in the Philippines.

**Activities:**

- Genomic DNA sequencing was done by outsourcing the services.
- Whole genome sequences were analyzed using workstation in Philippine Genome Center-Core Facility for Bioinformatics that resulted to variant call data which would be analyze using bioinformatics.

**Results:**

- Five (5) Philippine traditional varieties were selected.
- Whole genome sequence of 3 TRVs were obtained from GINA in BAM and FASTQ format and 1 from Illumina.

**Ethnoguided survey and collection of Philippine medicinal traditional rice varieties (GRD 005-006)**

*FGE Manuel, R Mallari, D Alfonso, DG Esmero, and XGI Caguiat*

The need to discover and conserve natural sources of medicine and other high value products is becoming increasingly important. Ethnoguided approaches involving ethnobotany and ethnomedicine have been reported as significant tools for elucidating the roles of plants in basic health care system of many societies. In the Philippines, rice has always been a strong pivot in the culture and traditions of Filipinos and agriculture based research. However, the ethnomedicinal attributes of rice especially those of traditional varieties remain scarce and underexplored. To date, no baseline catalogue describing the rice varieties used for ethnomedical treatment exits. This study aims to collect and conserve traditional rice varieties and gather information from local communities concerning their use of rice in folk medicine. Ethnoguided survey was held using semi-structured interviews with knowledgeable locals as our key informants.

**Results:**

- Germplasm collected (DALINO, MARAGAYA, INOWAK, KINILALA, KARIKIT, GAPON GAPON, TRES MARIAS, GAPON GAPON, BIHOD, TANG CO, PILIT TAPUL, DINORADO, BULAWAN, HINUMAY, KUTIBOS, MAKAITOT)

- 1 scientific publication: Cabanting RM and LM Perez. 2016. An ethnobotanical study of traditional rice landraces (Oryza sativa L.) used for medical treatment in selected local communities of the Philippines. J Ethnopharmacol. 2016 Oct 11.

## IV. Optimization of Germplasm Conservation Procedures (GRD 007)

*Project Leader: Imelda Lyn G. Pacada*

Characterization and evaluation of germplasm is linked to utilization. Low utilization of conserved germplasm is due to lack of documentation and inadequate description of the collections. Developing a system that can provide quick information on what is conserved in the genebank will facilitate the genebank curator and researcher in germplasm management and enhanced gene pool utilization, respectively.

### Development of reference collection digital database and germplasm query software (GRD 007-001)

*IG Pacada, MC Ferrer, MD Duldulao, and XGI Caguiat*

Traditionally, reference collection or seed file (duplicate of what is conserved at genebank), is located in an organized box. However, conserving, documenting, evaluating and securing long-term maintenance of reference collection is not simple. The development of virtual seed file provides back up and long term preservation. In addition, this can be coupled by software with the capability of digitizing available seed file and storing its grain characteristic information. This study aimed to create digital database of all available seed file, and develop germplasm query system for quick retrieval information base on seed file grain dimension.

**Activities:**

- Develop a digital reference collection and germplasm query software and 1 digital reference collection database established, and one rice germplasm query software developed.

**Results:**

- Rice germplasm query optimized for 1:1, while for 1:N germplasm query find & match is in progress).

- Delayed output due to ff:
  - Improved GUI of the software, Increased scanned resolution from 300 to 600 dpi
  - Fixed default ruler
  - Changed background from white to black

**Classification of rice germplasm (japonica/indica) into ecotypes using morphological, biochemical, and molecular tools**

*MC Ferrer and XGI Caguiat*

Exploitation of new germplasm played important role in rice breeding. This is due to its diverse background and its potential source for generating novel adapted allele combinations which can be used for genetic improvement by various breeding programs. Significant prerequisite of utilizing germplasm for improvement is to accurately identify their ecotypes whether they are belong indica and japonica group. In this way, it provides baseline information for a breeder to design appropriate breeding approach when they utilize them. Among the physiological and morphological characteristics, the grain shape and grain phenol reaction have been widely used as conventional tools for classifying rice varieties into Japonica and Indica types.

Activities:

- Classify the PhilRice germplasm into indica and japonica-types using KOH test.

Results:

- 500 germplasm collections classified into japonica and indica types in 2016.

## V. Conservation of Genetic Resources in the Rice Environment (GRD-008)

*Project leader: JT Niones*

Recognizing the impact, importance and potential utilization of microbial, invertebrates and plant resources from the rice environment, PhilRice has been studying, evaluating and promoting the use of beneficial microbes ranging from fungi, bacteria and actinomycetes either as potential biological control agent of specific rice pest or as plant growth promoter. Pure isolates of rice pathogens are regularly cultured and utilized in the evaluation of rice plant breeding materials for disease resistance. Moreover, PhilRice has recently renewed its interest in Azolla technology and other N-fixing systems in support to the organic agriculture program.

Along with the increasing collection of these beneficial microbial and non- microbial resources at PhilRice, is the pressing concern to provide a reliable and safe preservation and storage protocol for these genetic resources. Physiological or genetic damage to economically important strains could potentially result in considerable loss of investment in a research and product development program.

The project aims to: (1) develop conservation and preservation strategies for beneficial microbes, invertebrates and plant resources from the rice environment to ensure their physiological and genomic integrity and quality, for research and development, and public utilization purposes; (2) to establish management system that facilitates record-keeping, utilization, distribution and exchange of these genetic resources.

### Conservation of Philippine azolla species and hybrids (GRD-008-001)

*CLC Mondejar, GO San Valentin, JT Niones, and XGI Caguiat*

The adoption of modern high-yielding varieties and commercial fertilizers had greatly increased rice production in the Philippines. However, increased rice production could not be achieved by application of inorganic fertilizers alone, but it requires soil management for desirable soil processes related to soil health. There is also a need for alternative technology that is affordable to resource-poor farmers which contributes to sustainable productivity and at the same time environmentally safe. Organic fertilizers offer such an option. For centuries, Asian farmers maintained relatively high yields using mineral nutrients produced on the farm before the invention of chemical fertilizers. These are the aquatic fern azolla and other leguminous plants for green manures.

Nitrogen-fixing agents in soil and water are natural “fertilizer factories’. These promote the growth of the plants. N2-fixing activity is

an important strategy for sustaining rice production. Biological nitrogen fixation technologies are also important for long-term maintenance of soil fertility. The technologies are environmentally safe. It benefits such fertilizer savings, improved soil properties, reduced pests and diseases, and reduced environmental pollution.

PhilRice has the capability to continue R&D activities on azolla and other N-fixing systems in support to the organic agriculture program. As leader of rice research and development in the Philippines, PhilRice in 2013 initiated the recovery of the original accessions and continues the selection and hybridization to develop superior strains. With PhilRice sustaining research projects on azolla, it tries to fulfill its goal in making bio-fertilizers a stable part of the rice farming system and in making the dream of sustainable agriculture in the Philippines a reality.

**Activities:**

- Figure 12 shows the workflow in PhilRice Los Baños Azolla Nursery.
- Collection of azolla from different parts of the Philippines.
- Conservation and maintenance of different accessions of azolla.
- Identification of superior strains based on the specific traits such as prolific spore producing, heat tolerant and fast-growing.

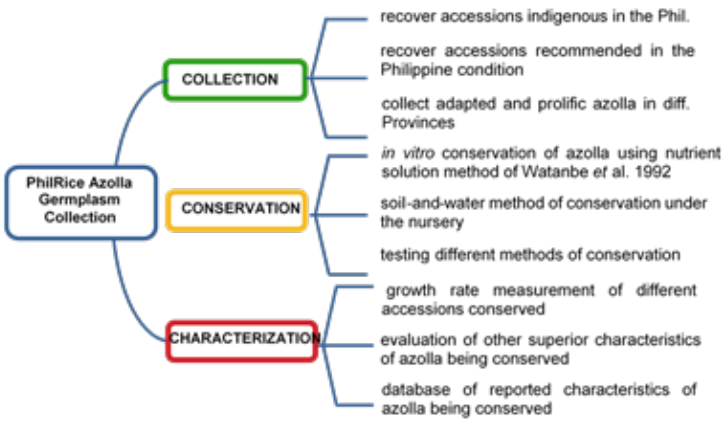



**Figure 12.** The framework of the workflow in PhilRice Los Baños Azolla Nursery.

**Results:**

- The conservation and maintenance of 98 accessions consist of azolla newly collected from different parts of the Philippines.
- Identified superior strains i.e. prolific spore producing, heat tolerant and fast-growing, and indigenous azolla strains.
- During the field day at PhilRice Los Baños, a total of 50 farmers were given spores of prolific spore producing azolla. The PhilRice Los Baños caters also its collaborating institutions i.e. Romblon State University (RSU) and UPLB by distributing fresh azolla biomass for R&D activities.
- A total of 21 individuals consist mainly of farmers and heads of NGOs were given fresh biomass of prolific spore producing azolla as starting material for cultivation.

**Conservation and management of biocontrol agents (GRD-008-002)**
*GF Estoy Jr, BM Tabudlong, JT Niones, and XGI Caguiat*

Entomopathogenic fungi as biocontrol agents provide an alternative pest control measures reducing rice pest population below damaging level. During pest outbreaks, there is a great demand for the production of high quality inoculum of these biocontrol agents (BCAs).

Through PhilRice-funded projects, several strains of Metarhizium anisopliae, Beauveria bassiana and Paecilomyces sp. were isolated and proven to be effective in reducing rice insect pests such as white stemborer, rice black bug, brown planthopper and rice bug. The study aims to evaluate different conservation techniques for these entomopathogenic fungi. This study is being conducted at PhilRice Agusan.

**Activities:**

- Conservation and maintenance of different strains of entomopathogens.
- Evaluation of the viability of entomopathogens stored under different preservation methods.

**Results:**

- Pure culture of fungal biocontrol agents were isolated and maintained in the laboratory to have a continuous source of the fungus for the efficacy tests conducted in the laboratory.

- The fungi, Beauveria bassiana, Metarhizium anisopliae and Paecilomyces sp. were isolated and mass produced in potato dextrose agar slant. To have an effective and economical method of conservation of biological control agent, four (4) preservation techniques for fungal biocontrol agents were tested namely potato dextrose agar slant, mineral oil, granulated form and powder form.

- Ten (10) strains of each B. bassiana: Bb01, Bb02, Bb21, Bb22, Bb27, Bb33, Bb42, Bb41, Bb49 and Bb52 and 12 M. anisopliae: Ma01, Ma03, Ma05, Ma06, Ma15, Ma16, Ma17, Ma19, Ma20, Ma116, Ma210, Ma211 and one (1) Paecilomces sp. fungal biocontrol agents are maintained in mineral oil in the laboratory (Table 10).

- Different conservation techniques of the fungal biocontrol agents resulted in 108 conidia mL-1 concentration after 3-12 months in the laboratory (Figure 13). The fungus remained viable in the preservation methods (Table 11). Efficacy of this conservation method will be evaluated. Passport data and information of each fungal cultures collected is completed and available in MS Excel format.

**Table 10.** Conidial concentration of Beauveria bassiana and Metarhium anisopliae after 3 and 6 months preserved on different preservation methods.

| Preservation Methods | Conidial Concentration | |
|---|---|---|
| | 3 months | 6months |
| a.*Beauveria bassiana* | | |
| Potato dextrose agar | 4.7 x 108 conidia $mL^{-1}$ | 4.5 x 108 conidia $mL^{-1}$ |
| Mineral oil | 2.5 x 108 conidia $mL^{-1}$ | 2.1 x 108 conidia $mL^{-1}$ |
| Granulated form | 2.0 x 108 conidia $mL^{-1}$ | 1.8 x 108 conidia $mL^{-1}$ |
| Powder form | 1.7 x 108 conidia $mL^{-1}$ | 8.9 x 107 conidia $mL^{-1}$ |
| b.*Metarhizium anisopliae* | | |
| Potato dextrose agar | 6.5 x 108 conidia $mL^{-1}$ | 6.0 x 108 conidia $mL^{-1}$ |
| Mineral oil | 4.3 x 108 conidia $mL^{-1}$ | 4.0 x 108 conidia $mL^{-1}$ |
| Granulated form | 3.5 x 108 conidia $mL^{-1}$ | 3.1 x 108 conidia $mL^{-1}$ |
| Powder form | 4.5 x 108 conidia $mL^{-1}$ | 2.4 x 108 conidia $mL^{-1}$ |

**Table 11.** Viability of different strains of Beauveria bassiana and Metarhium anisopliae on different preservation methods.

| Fungal Biocontrol Agents | Fungal Growth | |
|---|---|---|
| | After 8 months | After 12 months |
| *Beauveria bassiana* | viable | viable |
| *Metarhizium anisopliae* | viable | viable |
| *Paecilomyces sp.* | viable | viable |

**Figure 13.** Different methods of preservation techniques for fungal biocontrol agents in the laboratory.

**Conservation and management of microbial agents (GRD 008-003)**
*JT Niones, JA Poblete, MC Garcillano, and XGI Caguiat*

The role and impact of microorganisms on agronomically important crops depend on their interaction with their host plant. Negative interaction of microorganisms with their host resulted to diseased plants and significant crop loss while positive host- microorganism interaction can improve crop nutrition and the ability of crops to resist biotic and abiotic stress. With the increasing awareness of the undesirable human and environmental effects of the use of inorganic fertilizers, herbicides and pesticides, PhilRice through its R&D programs had long recognized that beneficial microbes provide an alternative strategy to combat limiting soil nutrient and the destructive effects of weeds and pests on crops.

Maintaining and preserving fungal cultures are not only essential on systematics and biodiversity studies but also in ensuring the quality of microbial agents especially for commercialization and public utilization purposes. Preservation methods of potentially important isolates for agrobiological applications have to be optimized early in the development process of a product so as to avoid potential economic and scientific loss in the event of deterioration of a production strain.

The study aims to preserve biological important microbial isolates such as plant growth promoters and biological control agents against rice pathogens developed through PhilRice- funded projects. Moreover, virulent isolates of major rice pathogens are also being preserved and maintained at the laboratory.

**Activities:**

- Conservation and maintenance of different strains of microbial agents.
- Evaluation of the viability and pathogenicity of rice pathogens as well as a biological control agent stored under different preservation methods.
- Evaluation of the viability, IAA production, ACC-deaminase and P-solubilization activity of a plant growth promoting microorganism stored under different preservation methods.

**Results:**

- In different storage conditions, two strains of Trichoderma sp., one isolate of a plant growth promoting bacteria, Streptomyces mutabilis and 13 isolates of rice bacterial leaf blight pathogen, Xanthomonas oryzae pv. oryzae, were

evaluated in terms of culture viability, virulence and stability of their biologically important physiological traits.

- After two years of storage in filter paper, mineral oil, and 10% glycerol and a year of storage in MicrobankTM, fungal spores of Trichoderma sp. did not differ against the periodically sub-cultured control in terms of viability and mycelial colony size (Figure 14). Fungal spores stored at filter paper, 10% glycerol, mineral oil and MicrobankTM have retained their virulence against the Rhizoctonia solani pathogen.

- After two years of storage in a soil-based carrier at room temperature, S. mutabilis maintained viable colony forming units (CFU) comparable with the periodically sub-cultured control. Cultures stored for one year at MicrobankTM maintained its viability and have higher CFU compared with the control. IAA production (Figure 15), ACC-deaminase (Figure 16) and P-solubilization (Figure 17) activity of S. mutabilis were maintained when the organism was stored under the aforementioned storage conditions.

- On the other hand, S. mutabilis stored in carbonized rice hull (CRH) and soil-based carrier stored at the refrigerator, and CRH stored at room temperature were not viable (Table 12).

- Thirteen (13) isolates of the bacterial leaf blight pathogen, Xanthomonas oryzae pv. oryzae (Xoo) from two sources, stock culture and infected leaves, maintained their viability (Figure 16) and high CFU (Figure 17) after one year of storage in MicrobankTM. (Table 13).

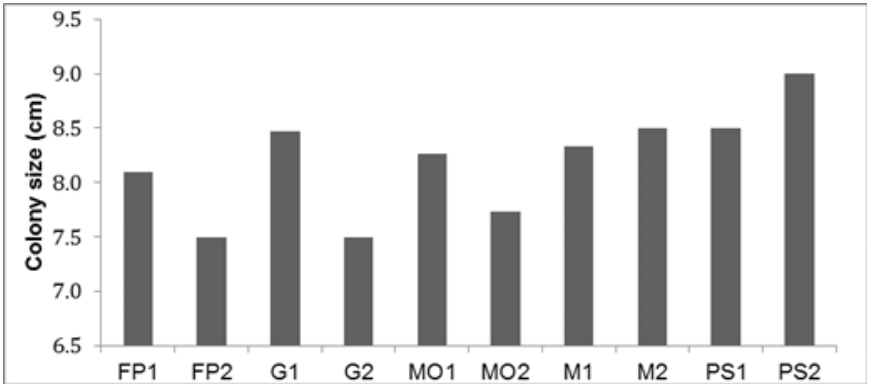



**Figure 14.** Colony size (cm) of Trichoderma sp. 1 & 2 after subjected to different storage conditions. Measurement was taken 3 days after placing spores of Trichoderma sp. in fresh PDA medium. The microtubes containing fungal spores in filter paper (FP), in 10% glycerol (G), in mineral oil (MO) were all stored in -80°C freezer for two years, and MicrobankTM (M) was stored in -80°C freezer for one year. The control (PS) has been regularly sub-cultured in PDA medium every 1 to 2 months.

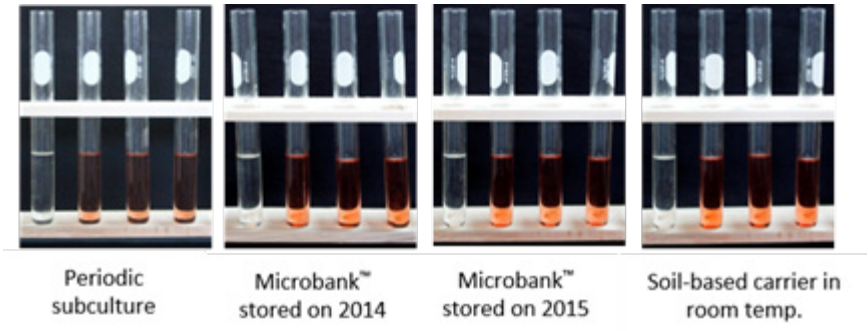



**Figure 15.** Effect of different storage conditions on the indole-3-acetic acid (IAA) production activity of Streptomyces mutabilis. To measure IAA production, test cultures were grown in arginine- glycerol- salt (AGS) broth supplemented with tryptophan. After 7 days of incubation, the cultures were centrifuges and the IAA in supernatant was added with Fe-H2SO4 reagent. Pink to red color indicated positive reaction. Test tube in extreme left, in each picture panel, is AGS broth only (negative control).

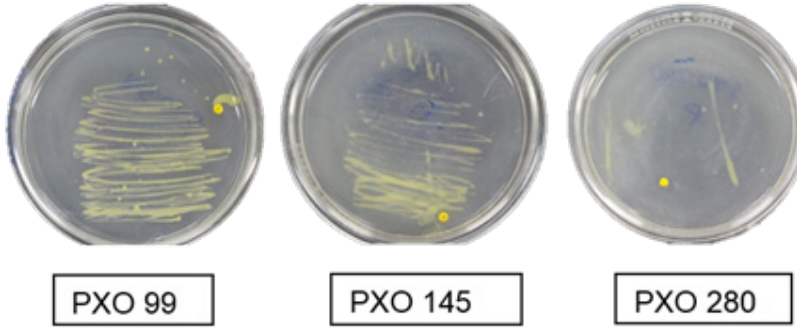



**Figure 16.** Effect of different storage conditions on the 1-aminocyclopropane-1-carboxylate (ACC) deaminase activity of Streptomyces mutabilis. To test ACC-deaminase activity, the isolates were grown using the nitrogen-free Dworkin and Foster's salts minimal agar medium (Dworkinand Foster, 1958). The plates were incubated at 28+/-2°C in the dark for 7 days. Growth and sporulation of the isolates are indicators of ACC utilization and production of ACC deaminase.

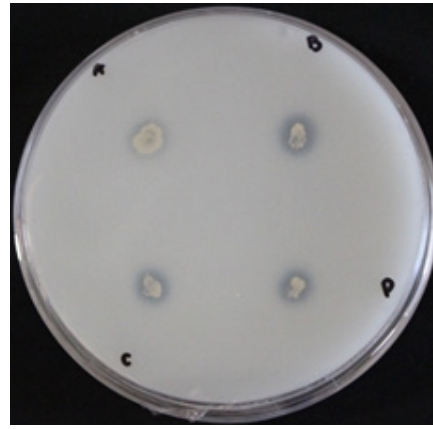


**Figure 17.** Effect of different storage conditions on the Phosphate solubilizing activity of Streptomyces mutabilis. The isolates were grown on solid media containing precipitated tricalcium phosphate. The bacterial isolates were inoculated on the surface of the agar. The presence of clearing zone around the bacterial growth as indication of P-solubilization and was noted after 7 days incubation period.

**Table 12.** Effect of different storage on the population of Streptomyces mutabilis.

| Treatment | Average Colony Forming Units at $10^5$ dilution |
|---|---|
| Control (Periodically sub-cultured) | 32 |
| Microbank™ (stored on 2014) | 27 |
| Microbank™ (stored on 2015) | >300 |
| Soil based carrier (Room temperature) | 12 |
| Soil based carrier (Refrigerated) | 0 |
| Carbonized rice hull (Room temperature) | 0 |
| Carbonized rice hull (Refrigerated) | 0 |

*Data were collected from 3 replications/treatment.

**Table 13.** Viability and Colony Forming Units of Xoo after storage on MicrobankTM at -80°C after one year.

| | DATE STORED | | VIABILITY UPON REVIVAL | | COLONY FORMING UNITS AT 10^9 DILUTION | |
|---|---|---|---|---|---|---|
| Race | From stock culture | From infected leaf | From stock culture | From infected leaf | From stock culture | From infected leaf |
| PXO 363 | 12/3/2015 | 12/4/2015 | Viable | Viable | 0.3 | 14 |
| PXO 112 | 12/3/2015 | 12/4/2015 | Viable | Viable | 0.9 | 3 |
| PXO 339 | 12/3/2015 | 12/4/2015 | Viable | Viable | 88 | 4 |
| PXO 71 | 12/3/2015 | 12/4/2015 | Viable | Viable | 73 | 2 |
| PXO 280 | 12/3/2015 | 12/4/2015 | Viable | Viable | 10 | 29 |
| PXO 99 | 12/3/2015 | 12/4/2015 | Viable | Viable | 24 | 16 |
| PXO 341 | 12/3/2015 | 12/4/2015 | Viable | Viable | 31 | 10 |
| PXO 79 | 12/3/2015 | 12/4/2015 | Viable | Viable | 1 | 6 |
| PXO 347 | 12/3/2015 | 12/4/2015 | Viable | Viable | 5 | 9 |
| PXO 145 | 12/3/2015 | 12/4/2015 | Viable | Viable | 2 | 5 |
| PXO 86 | 12/3/2015 | 12/4/2015 | Viable | Viable | 2.1 | 16 |
| PXO 340 | 12/3/2015 | 12/4/2015 | Viable | Viable | 27 | 1.4 |
| PXO 349 | 12/3/2015 | 12/4/2015 | Viable | Viable | 14 | 1.4 |
| PXO 79 (control) | Periodically sub-cultured | | Viable | | 107 | |

## Abbreviations and acronymns

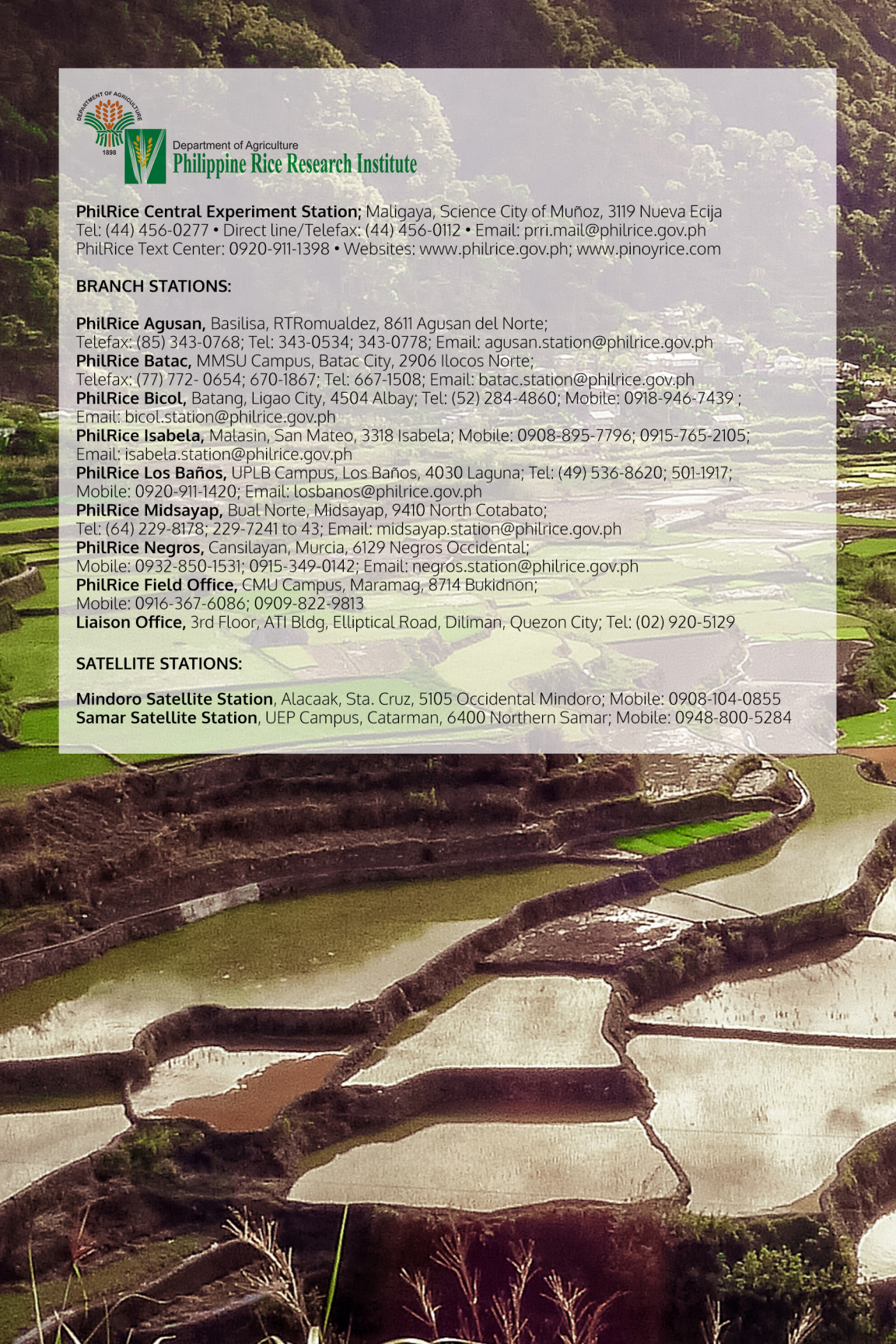
ABA – Abscicic acid
Ac – anther culture
AC – amylose content
AESA – Agro-ecosystems Analysis
AEW – agricultural extension workers
AG – anaerobic germination
AIS – Agricultural Information System
ANOVA – analysis of variance
AON – advance observation nursery
AT – agricultural technologist
AYT – advanced yield trial
BCA – biological control agent
BLB – bacterial leaf blight
BLS – bacterial leaf streak
BPH – brown planthopper
Bo - boron
BR – brown rice
BSWM – Bureau of Soils and Water Management
Ca - Calcium
CARP – Comprehensive Agrarian Reform Program
cav – cavan, usually 50 kg
CBFM – community-based forestry management
CLSU – Central Luzon State University
cm – centimeter
CMS – cystoplasmic male sterile
CP – protein content
CRH – carbonized rice hull
CTRHC – continuous-type rice hull carbonizer
CT – conventional tillage
Cu – copper
DA – Department of Agriculture
DA-RFU – Department of Agriculture-Regional Field Units
DAE – days after emergence
DAS – days after seeding
DAT – days after transplanting
DBMS – database management system
DDTK – disease diagnostic tool kit
DENR – Department of Environment and Natural Resources
DH L– double haploid lines
DRR – drought recovery rate
DS – dry season
DSA - diversity and stress adaptation
DSR – direct seeded rice
DUST – distinctness, uniformity and stability trial
DWSR – direct wet-seeded rice
EGS – early generation screening
EH – early heading
EMBI – effective microorganism-based inoculant
EPI – early panicle initiation
ET – early tillering
FAO – Food and Agriculture Organization
Fe – Iron
FFA – free fatty acid
FFP – farmer's fertilizer practice
FFS – farmers' field school
FGD – focus group discussion
FI – farmer innovator
FSSP – Food Staples Self-sufficiency Plan
g – gram
GAS – golden apple snail
GC – gel consistency
GIS – geographic information system
GHG – greenhouse gas
GLH – green leafhopper
GPS – global positioning system
GQ – grain quality
GUI – graphical user interface
GWS – genomwide selection
GYT – general yield trial
h – hour
ha – hectare
HIP - high inorganic phosphate
HPL – hybrid parental line
I - intermediate
ICIS – International Crop Information System
ICT – information and communication technology
IMO – indigenous microorganism
IF – inorganic fertilizer
INGER - International Network for Genetic Evaluation of Rice
IP – insect pest
IPDTK – insect pest diagnostic tool kit
IPM – Integrated Pest Management
IRRI – International Rice Research Institute
IVC – in vitro culture
IVM – in vitro mutagenesis
IWM – integrated weed management
JICA – Japan International Cooperation Agency
K – potassium
kg – kilogram
KP – knowledge product
KSL – knowledge sharing and learning
LCC – leaf color chart
LDIS – low-cost drip irrigation system
LeD – leaf drying
LeR – leaf rolling
lpa – low phytic acid
LGU – local government unit

LSTD – location specific technology development
m – meter
MAS – marker-assisted selection
MAT – Multi-Adaption Trial
MC – moisture content
MDDST – modified dry direct seeding technique
MET – multi-environment trial
MFE – male fertile environment
MLM – mixed-effects linear model
Mg – magnesium
Mn – Manganese
MDDST – Modified Dry Direct Seeding Technique
MOET – minus one element technique
MR – moderately resistant
MRT – Mobile Rice TeknoKlinik
MSE – male-sterile environment
MT – minimum tillage
$mtha^{-1}$ - metric ton per hectare
MYT – multi-location yield trials
N – nitrogen
NAFC – National Agricultural and Fishery Council
NBS – narrow brown spot
NCT – National Cooperative Testing
NFA – National Food Authority
NGO – non-government organization
NE – natural enemies
NIL – near isogenic line
NM – Nutrient Manager
NOPT – Nutrient Omission Plot Technique
NR – new reagent
NSIC – National Seed Industry Council
NSQCS – National Seed Quality Control Services
OF – organic fertilizer
OFT – on-farm trial
OM – organic matter
ON – observational nursery
OPAg – Office of Provincial Agriculturist
OpAPA – Open Academy for Philippine Agriculture
P – phosphorus
PA – phytic acid
PCR – Polymerase chain reaction
PDW – plant dry weight
PF – participating farmer
PFS – PalayCheck field school
PhilRice – Philippine Rice Research Institute
PhilSCAT – Philippine-Sino Center for Agricultural Technology
PHilMech – Philippine Center for Postharvest Development and Mechanization
PCA – principal component analysis
PI – panicle initiation
PN – pedigree nursery
PRKB – Pinoy Rice Knowledge Bank
PTD – participatory technology development
PYT – preliminary yield trial
QTL – quantitative trait loci
R - resistant
RBB – rice black bug
RCBD – randomized complete block design
RDI – regulated deficit irrigation
RF – rainfed
RP – resource person
RPM – revolution per minute
RQCS – Rice Quality Classification Software
RS4D – Rice Science for Development
RSO – rice sufficiency officer
RFL – Rainfed lowland
RTV – rice tungro virus
RTWG – Rice Technical Working Group
S – sulfur
SACLOB – Sealed Storage Enclosure for Rice Seeds
SALT – Sloping Agricultural Land Technology
SB – sheath blight
SFR – small farm reservoir
SME – small-medium enterprise
SMS – short message service
SN – source nursery
SSNM – site-specific nutrient management
SSR – simple sequence repeat
STK – soil test kit
STR – sequence tandem repeat
SV – seedling vigor
t – ton
TCN – testcross nursery
TCP – technical cooperation project
TGMS – thermo-sensitive genetic male sterile
TN – testcross nursery
TOT – training of trainers
TPR – transplanted rice
TRV – traditional variety
TSS – total soluble solid
UEM – ultra-early maturing
UPLB – University of the Philippines Los Baños
VSU – Visayas State University
WBPH – white-backed planthopper
WEPP – water erosion prediction project
WHC – water holding capacity
WHO – World Health Organization
WS – wet season
WT – weed tolerance
YA – yield advantage
Zn – zinc
ZT – zero tillage

## List of Tables

## List of Figures

## List of Figures



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