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2017
National Rice R&D
Highlights

GENETIC RESOURCES DIVISION

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Genetic Resources Division

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Executive Summary

The Genetic Resources Division (GRD) houses the PhilRice Genebank. It safeguards huge and diverse rice germplasm collections, which is critical in supporting the goal of a rice- secured Philippines. PhilRice Genebank is a national repository and it leads efforts on ex-situ conservation and management of rice genetic in accordance with International Genebank standards. These germplasm materials are important genetic resources for direct-use, breeding, and genetic and physiological studies towards the development of rice varieties.

GRD is composed of two units: germplasm conservation and seed technology. Germplasm conservation unit leads the conservation and management of rice genetic resources of indigenous traditional Philippine cultivars including improved varieties, mutant lines and elite breeding lines of PhilRice, farmers' selections, rice genetic materials from other breeding and research institutes, foreign introductions, and wild rice relatives. The unit focuses its activities on genetic diversity research as well as germplasm collection, conservation, management, dissemination, and utilization in support to PhilRice rice breeding and development activities.

Meanwhile, the seed technology unit assesses and ensures high quality seed for seed growers and farmers and monitors regular seed quality testing on buffer seed and carry over seed lots of the previous cropping. It also screens and evaluates packaging materials, storage conditions, and seed treatment that will prolong seed quality. It also conducts compact technology demonstration of newly released inbred and hybrid varieties including different types of crop establishment.

Major accomplishments of the Division include the collection and conservation of new genetic resources, characterization, regeneration, and evaluation of collections/ accessions, and responding to seed and data requests. PhilRice genebank maintains and conserves 16,222 rice germplasm accessions. Six hundred twenty-six new genetic resources were collected from local and international sources. This collection increases our chances of finding novel genes and parental for the Institute's varietal development research efforts.

The interface of Germplasm Management System (GEMS) database management system was enhanced and improved. GEMS is a relational database management system developed to document, manage, and centralize the large quantities of data of all germplasm conserved at the

PhilRice Genebank. The GEMS data system were updated with 3,854 rice germplasm accessions' characterization and evaluation data. These include germplasm data on passport, morpho-agronomic characterization, grain quality, pest (BPH, GLH, and SB) and diseases (RTV, blast, BLB, and sheath blight), abiotic stresses evaluations, viability conditions, and seed inventories. GEMS maintains accurate, reliable, and up-to-date rice germplasm information for better access search and retrieval of germplasm.

I. Conservation, Characterization, and Distribution of Rice Germplasm Resources

Marilyn C. Ferrer

Rice genetic resources are foundation of sustainable rice production. Its preservation is of paramount importance as germplasms are repository of useful genes for plant scientists to solve future problems. These are the building blocks in rice breeding program for development of new varieties to address sustainable development and meet the needs of the continuously growing population. Their efficient conservation and use is critical to safeguard food and nutrition security, now and in the future. The threat of losing these valuable materials makes conservation efforts increasingly more urgent and important. Thus, the need to conserve these important germplasms has been addressed by PhilRice with the establishment of the Genebank.

The Division aimed to collect Philippine landraces and traditional rice germplasm that are continuously cultivated by the farmers together with the background information and traditional knowledge applied for local germplasm; conserve rice germplasm resource for medium and long term preservation; and rejuvenate/replenish low stocks and low viability rice germplasm for distribution and conservation. It also aimed to maintain an accurate, reliable and up-to-date rice germplasm information stored in the central database of PhilRice genebank in support to the management and utilization of rice genetic resources; ensure the germplasm's genetic integrity is preserved and to prolong the viability of stocks through the application of standard conservation techniques; and characterize rice germplasm materials based on the standard descriptors for rice by Bioversity International for efficient selection in breeding programs. Furthermore, conservation efforts implemented in different PhilRice branch stations were in synchrony with the activities and procedures done at PhilRice Genebank for long term and efficient germplasm conservation management.

In 2017, 626 rice germplasm materials were collected. Majority of these collections are of Philippine origin, in which 63% are traditional cultivar or landraces, 23% farmer's line, while the rest are unclassified. On the other hand, 132 rice germplasms were acquired from different countries. Six hundred fifty-seven entries were regenerated while 696 germplasm collections were morpho-agronomically characterized. Variations in characters were observed in different rice collections. Some of the traditional rice varieties exhibited interesting characteristics such as short plant height, long panicle, and early maturity.
Conserved germplasm totalling 3,651 have enough seeds and high viability and are readily available for distribution. The germination test results showed that 53% of the conserved germplasm have high viability (81-100%). One percent of the tested germplasm has low viability, which will be prioritized in the next regeneration plan, while 6% need to be immediately subjected to embryo rescue to ensure survival.

GEMS, which contains important rice germplasm data was updated: passport data (626 new collections), characterization data (464 collections/ accessions), rice tungro field evaluation data (622 collections/accessions), zinc evaluation data (865 collections/accessions), and pest and diseases data (418 accessions/ collections). Standard Material Transfer Agreement (SMTA) was issued to protect intellectual properties or rights over the rice varieties being provided to clients while PhilRice MTA-Germplasm under Development (PMTA-GUD) serves as an attachment to the SMTA for additional conditions on the transfer of breeding lines.
PhilRice Midsayap had collected 111 rice germplasm. Currently, the station had 1,271 (PMES 1271) germplasm collections listed in the database and conserved in the genebank. On the other hand, PhilRice Batac had collected 295 germplasm, mostly TRVs from upland, highland, irrigated- lowland, submerged, and saline-submerged areas. PhilRice genebank also had duplicates of the 279 collections of PhilRice Batac for future use and safe-keeping.

PhilRice Isabela and Los Baños characterized the morpho-agronomic traits of different varities. PhilRice Isabela analyzed and compared the performances of the traditional rice varieties in the dry and wet seasons. It was found that the percent seed set of traditional rice varieties during the wet season is significantly greater than the dry season harvest. Moreover, the yield and weight of 1,000 grains is comparable in both seasons. The traditional rice varieties also have longer maturity period than the inbred and hybrid varieties in the lowland irrigated ecosystem. PhilRice Los Baños conducted characterization, multiplication, and regeneration of 411 rice accessions. High phenotypic diversity was showed in morpho-agronomic characterization. High viability was also noted from the viability test.

Collection and Acquisition of New Germplasm Materials
Teodora E. Mananghaya, XGI Caguiat, MC Ferrer, MC Newingham, M Duldulao, JBM Alvariño, D Alfonso, J Castro, JMZ Nombrere, JB Regalario

Germplasm collection is a vital source of novel genes that are useful in different breeding programs to increase crop productivity. This study aimed to collect Philippine landraces and traditional rice germplasm that are continuously cultivated by the farmers and to gather background information on traditional knowledge applied for local germplasm. Areas of collection were identified based on the collection gaps and collecting activities prioritized the underrepresented provinces and tribal areas. Close coordination with the regional DA offices, LGUs, and upland technicians were conducted to identify farmers prior to collection. Collecting mission is guided with Global Positioning System (GPS) to generate accurate georeferenced data such as latitude, longitude, and elevation of germplasm origin. The gathered passport data was uploaded in the database.

GRD had collected 626 rice germplasms across and introductions from other countries. Currently, PhilRice Genebank stores 16,298 rice collections of which 7,129 were found unique and assigned with accession number. Traditional rice varieties constitute 47.22% of the collection while the rest are improved lines and wild types. Germplasm collections has represented all 81 provinces in the Philippines and other countries. The proximity of the collection sites, farmer's donations, presence of regional agriculture research consortiums and PhilRice branch stations, and their recent deployment of upland technicians are among the factors that contributed to the number of germplasm collected. Continuous collection of germplasm are important to preserve these valuable genetic resources.

Regeneration and Conservation of Rice Germplasm
Marilyn C. Ferrer, M Duldulao, JM Nombrere, JR Castro, XGI Caguiat, JM Niones

The long-term preservation of rice genetic resources is the principal aim of every genebank. The ex-situ conservation provides a safe storage system for these germplasm materials under optimal storage conditions that is efficiently managed and accessible to users. To date, PhilRice Genebank conserves 16,222 collection of rice germplasm. Genebank facilities ensure the long-term preservation of this important rice diversity. Regeneration of genebank collections is necessary due to decreasing seed viability as well as diminishing amount of seeds overtime due to active distribution. Seed multiplication is the best way to revitalize stocks to maintain the genetic integrity of germplasm collection. The study aimed to conserve rice germplasm resource for medium and long term storage and rejuvenate low

stocks and low viability rice germplasm for conservation and distribution. Exactly 657 entries were selected for regeneration in DS 2017. Result showed that only 585 germinated while only 559 produced enough seeds (<.100g). Meanwhile, 834 accessions/collections (768 of which are from 1991 to 2013 seed stocks while 66 are 2016 new collections) were regenerated during DS 2016 and processed for conservation. An average of 66.7% increase in viability were noted after regeneration. Most of the materials conserved have high viability (>96.7%). Ninety percent produced enough seeds (<.100g) while the 10% (83) have insufficient seed, which will be prioritized in seed multiplication in DS 2018.

Germplasm Distribution and Information Management
Jonathan M. Niones, MD Duldulao, MC Ferrer, MCV Newingham, JMZ Nombrere

Efficient utilization of germplasm pre-requires a properly characterized, evaluated, and documented workable database system so that any germplasm carrying desired characteristics could be easily retrieved and used in breeding programs. This is supported through the PhilRice Genebank's GEMS (Germplasm Management System). GEMS database run as a stand-alone database focused for internal use in the genebank operations and acts as the central repository of all integrated data on passport, morpho-agronomic characterization, grain quality, pests, diseases, and abiotic stress reactions. It also supports genebank day-to-day operations from seed registration, inventories, and monitoring of quantity and quality of seeds; therefore, guiding regeneration and distribution. Uploading of vast rice germplasm data in the GEMS database from the studies and projects in the division were continuously conducted. Available data consists of morpho-agronomic characterization (90.8%), pests (23.5%), diseases (31.0%), abiotic stresses (14.2%), and grain quality (32.6%) of the total accessions that were characterized and evaluated. To bridge the gap of under-utilized germplasm, PhilRice Genebank continuously provides seeds to breeders, researchers, and stakeholders. Most germplasm were utilized in breeding and genetic studies (51%), farmers' adaptability trials (31%), special rice project (7%), and undergraduate theses (11%). To date, morpho-agronomic characterization and evaluation to different biotic and abiotic stresses are being done to complete the genotypic and phenotypic profile of the rice germplasm. Its web-based version is also being developed for broader dissemination of information to breeders, researchers, and stakeholders.

Germplasm Inventory

Marilyn C. Ferrer, MD Duldulao, JM Nombrere, JR Castro, DO Alfonso, J Regalario, XGI Caguiat, JM Niones

Genebanks play a crucial role in the conservation and use of biodiversity. 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 acquiring and physically possessing the materials (collection and storage) but also includes ensuring the existence of these under viable conditions with their original genetic characteristics intact. Thus, a detailed inventory system comprising seed stocks' information on storage conditions such as seedlot, viability, amount, and storage locations are managed through an in-house software called Genebank Database System or GEMS. Among the 7,124 accessions from the active storage, 5,311 accessions matched the original seed files. Moreover, 3,651 have enough seeds and high viability, which are readily available for distribution. Two hundred seventy-three have high seed stocks but with low viability; 127 have low seed stocks but high viability; 376 have low stock and low viability; and 884 in base storage need to be prioritized in the next regeneration plan to ensure survival. Results from the study will be an indespensible guide to ensure the preservation of the germplasm's genetic integrity and sufficiency of viable stocks.

Germplasm Characterization

Marilyn C. Ferrer, XGI Caguiat, M Duldulao, JM Nombrere, D Alfonso, JR Castro, J Regalario, JM Niones

Assessment of agro-morphological diversity among rice germplasm is important in any genetic resources management and crop improvement. Discovery of desirable traits from traditional rice varieties (TRVs) and incorporating these traits in rice breeding efforts would greatly benefit rice farmers as it will help them produce better rice even in changing environmental conditions. This study provided information on morphological characterization of TRVs used to establish each accession's genetic identity, identified varieties with desirable traits for direct utilization and potential donors for crop improvement, and assessed the extent of genetic diversity of the collections. Six hundred ninety-six germplasm accessions/collections were planted during WS 2016-2017 for morpho-agronomic characterization using 58 traits and following the standard descriptors list for cultivated rice.

Variations in characters were observed based on multivariate statistical analysis. Results showed that number of tillers ranged from 5 to 41, in which PR3A has the most number of tillers. Plant height varied from 4 to 182.9 cm. The majority of the varieties were >142 cm tall with an average height of 109.6 cm. The 100 seed weight observed ranged from 1.2 to 3.66 g, in which Kanukot was observed to have lightest grain weight (1.2 g) while MILFLOR 6-2 had the heaviest grain weight (3.66 g). The traditional rice varieties mentioned in the study exhibited interesting characteristics, which should be further explored for farmers' benefits and breeders' varietal improvement programs.

Conservation and Management of Rice Genetic Resources at PhilRice Los Baños

Wendy B. Abonitalla, LV Guittap, MC Ferrer, TM Masajo, TH Borromeo, S Bon

Characterization, seed multiplication, and rejuvenation or regeneration of rice genetic resources are common field operations when handling plant genetic resources. Maintaining viability and longevity is tedious and critical as it involves many efforts and resources. Hence, the study aimed to conserve and keep safe germplasm collection and working materials in variety development and to seed increase and/or regenerate germplasm materials ensuring the maintenance of genetic integrity and diversity. It also characterized and evaluated the germplasm collection to facilitate effective utilization; identified accessions with important desirable traits often sought by plant breeders; and developed sound seed and data retrieval system useful to the breeders in collaboration with CES Genebank. In DS 2017, 411 accessions were selected based on the viability test/ germination test conducted in WS 2016. The criteria of selection for the planting materials were the following: accessions with inadequate seeds and without characterization data and accessions with lower quality (<85% germination rate). Morphological traits were thoroughly characterized to determine the uniqueness of each accessions. Results showed high genetic diversity implying that the materials stored in the Los Baños Genebank are unique. Some accessions are purple-base while others are green. There are also accessions with purple or red caryopsis. In terms of its pubescence type, some are glabrous while others are pubescent. There were 200 rice accessions tested for viability. Traditional and improved varieties were tested. One hundred accessions were manually cleaned and sorted. Drying of newly harvested seeds is ongoing using the silica gels. Harvested seeds had 6-8% MC, which is the standard requirement for a long-term conservation at IRRI- GRC drying room facility. Materials are packed and stored at the Genebank's 3-upright freezers using the hermetically sealed aluminum foil.

Collection, Conservation, and Management of Traditional and Indigenous Rice Cultivars in Mindanao
Pernelyn S. Torreña, JM Niones, HJC Candalia, MS Ocenar, XGI Caguiat, MC Ferrer

This study aimed to collect, document, and conserve rice germplasm in Mindanao. From 2016 to 2017, 126 germplasm collections were added in the database. Most of the collections came from upland areas (86%) and the rest from rainfed and/or irrigated lowland. Germplasm collected with only few seeds (20 g and below) were prioritized in germination test and were seed increased in screenhouse and/or field condition. Germplasm collections with at least 1 kg seeds available were divided and duplicates were sent to PhilRice CES Genebank.

Germplasm Collection and Management at PhilRice Batac
Anielyn Y. Alibuyog, JM Solero, NI Martin, BM Catudan

The Philippines is still a very rich genetic source of TRVs, which may serve as valuable resource in developing new varieties. These varieties, however, are rapidly lost with the advent of modern agriculture. Hence, conservation is recommended. The study aimed to collect and conserve germplasm in Northwest Luzon, process and conduct inventory of collections, purify, and seed increase for distribution to farmers. Twenty-three TRVs from Ilocos Norte, Ilocos Sur, Abra, and La Union were added in the collection. These were registered and encoded in the database along with their passport data. Seeds were cleaned, tested for viability, and their seed moisture content were recorded. The station has 295 germplasm, which were mostly obtained from the uplands (187) and irrigated areas (87). Few were collected from submerged and saline-submerged fields.

Upon request, three farm managers and PhilRice CES researchers were provided with Red Rice, Ballatinaw, BIO-rice, and pigmented rice. To cater seed requests, seed increase and generation of 59 varieties were continued during WS.

Germplasm Conservation and Evaluation of Traditional Rice Varieties in Northeast Luzon
Jerome V. Galapon

This study aimed to collect, document, evaluate, and conserve traditional rice varieties from Cordillera Administrative Region and Region II. The performance of the traditional rice varieties in dry and wet season were analyzed and compared. Results showed that only the % seed set of TRVs during the wet season is significantly greater than dry season. The yield and weight of 1,000 grains is also comparable in both seasons. During DS 2017, Bongkitan registered the highest yield with 9.88 t/ha followed by Kamporo with 9.21 t/ha. The weight of 1,000 grains ranged from 23 g to 28 g. The percentage of seed setting ranged from 81.08% to 95.72%. In WS 2017, Kalipago registered the highest plant height with 192.2 cm followed by Lasbaken with 185.2 cm. Kamporo registered the highest number of productive tillers (15) followed by Lablabi and Taiwan (14). Likewise, Talakitok registered the highest yield at 12.54 t/ha followed by Bongkitan (9.53 t/ha) and Kamporo (9.46 t/ha). These traditional rice varieties have longer maturity period than the inbred and hybrid varieties in the lowland irrigated ecosystems.

II. Evaluation of PhilRice Rice Germplasm
Xavier Greg I. Caguiat

Results of this project will help the Institute in achieving its vision of a rice-secure Philippines and in improving the competitiveness of the Philippine rice industry amidst challenges on climate change. It is directly linked to two of the six major R&D strategic outcomes in the new strategic plan: increased productivity, cost-effectiveness, and profitability of rice farming in a sustainable manner and advanced rice science and technology for future sources of growth.

The project highlighted the importance of rice germplasm stored in the Genebank through various screening against biotic and abiotic stresses including grain quality traits. During DS 2017, 113 rice germplasm collections from PhilRice Genebank were evaluated for blast, bacterial leaf blight, sheath blight, and tungro reactions. Ninety-two entries showed resistant reaction to blast while 14 entries were susceptible to the disease. No resistant reactions to bacterial leaf blight, sheath blight, and tungro were observed. Among the germplasm accessions, 106 had intermediate reaction to bacterial leaf blight while 5 had intermediate reaction to sheath blight. Accession numbers 15322, PRRI001410, PRRI001360, and PRRI002100 showed resistance against blast and had intermediate reactions to bacterial leaf blight and sheath blight. Among the 194 rice germplasm accessions evaluated during WS 2017, 107 showed resistant to blast 32 had an intermediate reaction, while 55 were susceptible to the disease. Susceptibility to bacterial leaf blight was recorded in 146 accessions while 48 was observed with intermediate reaction. The reactions to sheath blight were intermediate in 22 accessions and susceptible in 172 accessions. Field screening was also conducted against natural infection of rice tungro virus (RTV). Six hundred twenty-two entries in DS 2017 and 957 entries in WS were screened for RTV's natural infection under field conditions. In DS 2017, result showed that 19 of the 622 entries showed resistance against RTV both at 45 and 60 days after transplanting (DAT) while more than 50% of the entries were rated intermediate to resistant against RTV at 45 and 60

DAT. Validation and verification is needed to further confirm their resistance.

The 305 rice samples from DS 2017 collections and accessions were screened for grain quality. Grain quality dictates consumer acceptability and marketability of rice making it an important component in the rice breeding program. The alkali spreading value ranged from 2 to 7 and majority had intermediate gelatinization temperature. Thirty-two samples had good milling recovery having fair-good brown rice, Grade 1-premium milled rice, and Grade 1-premium head rice recovery, Grade 1-premium chalky grains, long-extra long grain length, slender grain shape, and intermediate amylose content.

Eight selected germplasm from 2016 LSS (line source sprinkler) experiment was evaluated for root system developmental responses under various water stressed conditions. Drought significantly reduced biomass production on all genotypes except for Ibarraki. Among the selections, Ibarraki showed a good response to drought stress neither on fluctuating soil moisture or progressive drought as indicated by the increased in shoot biomass production relative to CWL (control) counterpart. Malagkit 1 and Mimis also exhibited relatively good response due to less decreased in biomass production compared to their CWL counterparts.

Evaluation of PhilRice Germplasm Collection for Biotic Stresses
Juliet P. Rillon, MLB Palma, KMB Guarin

The increase in the demand for rice caused farmers to increase their production by continuous application of chemical inputs such as fertilizer and pesticide. However, it triggered the outbreaks of serious diseases that are now considered major constraints to rice production. Thus, it is necessary to identify rice lines that can serve as parent source for new resistant lines. To determine the reactions of the rice germplasm collections from PhilRice Genebank against blast, bacterial leaf blight, sheath blight, and tungro, 113 TRVs and 194 rice germplasm accessions were evaluated in 2017. Blast occurrence were assessed 30-35 days after sowing. Bacterial leaf blight and sheath blight infestations were checked 14 days after inoculation while tungro incidences were inspected 45 and 60 days after transplanting. Data showed that 107 accessions were resistant against blast and 32 had intermediate resistance. Fifty-five rice germplasm accessions were susceptible to the disease. The reaction to bacterial leaf blight was intermediate in 146 accessions while 48 accessions were susceptible to the disease. Twenty two accessions expressed an intermediate reaction to sheath blight while 172 were identified to be susceptible. Resistant reaction to tungro was observed in 1 rice germplasm accessions while 191 expressed susceptibility to the disease.

Evaluation of PhilRice Germplasm Collection for Grain Quality
Amelia V. Morales, XGI Caguiat, MC Ferrer, EH Bandonill, BO Juliano

Grain quality evaluation plays an important role in the rice breeding program. Other than yield, genotype also influences resistance to pests and diseases, agro-morphologic characteristics, and grain quality. Three hundred five rice collections and accessions were screened for grain quality. Majority of the samples had excellent grain quality. Out of 305 samples, 32 samples had high milling recovery, low amount of chalky grains, long-extra long grain length, slender shape, and intermediate amylose content. Fourteen glutinous and 33 pigmented rice samples also had excellent grain quality. The screening provided grain quality data through computerized database system that serves as one of the basis in selection for parent materials in breeding.

Evaluation of Germplasm Material in Response to Progressive Drought Stress
Jonathan M. Niones, RR Suralta, MCJ Cabral, LM Perez

Maintaining high yield under drought due to water scarcity is one of the major challenges in rice breeding. Root plasticity plays key role in maintaining crop productivity under abiotic stress. The Philippines has diverse genetic resource materials, which can be potential sources of gene(s) for tolerance to water stress. This study aimed to evaluate and characterize the root system development and response of germplasm using rootbox system under three water stresses. Three water treatments were imposed consisted of continuously waterlogged (CWL), soil moisture fluctuation (SMF), and progressive drought (PDR). In CWL, the rootbox were submerged in water until termination period (45 DAS). However, in SMF (transient waterlogged to drought), the rootbox were first submerged in waterlogged for 17 days. Thereafter, the water was withheld to progressive drought at 10% (w/w) maintained until termination. In PDR, the soil was saturated until 3 DAS; thereafter, it was allowed to dry and maintained at 10% SMC (w/w) until 45 DAS. Eight selected germplasm from 2016 LSS (line source sprinkler) experiment was thoroughly evaluated for root system developmental responses under various water stressed conditions. Among the selections, Ibarraki showed a good response to drought stress neither on fluctuating soil moisture or progressive drought as indicated by the increased in shoot biomass production relative to CWL (control) counterpart. The increased in biomass production of Ibarraki may be attributed to the promotion of total lateral root length (TLRL) under SMF (225%) and PDR (261%), which consequently contributed to the increased in TRL both water stress condition. Major roots component traits such as Total Root Length, total nodal root length, TLRL, and number of nodal root had highly significant contribution to the increased in shoot biomass production in a water stresses environment.

Evaluation of Rice Germplasm for Zinc Deficiency Tolerance in Caraga Region
Henry A. Jimenez, JB Culiao, JD Tangog, GF Estoy, Jr., JM Niones, LM Perez

Biotic and abiotic stresses are among the factors affecting rice production in Caraga region. Abiotic factors including low solar radiation, flooding, and soil-zinc deficiency are the region's most important concerns. Using tolerant varieties is an efficient and sustainable management option to solve these problems. Genetic variability in tolerance to stresses exists, which can be explained by physiological mechanisms underlying certain adaptations to unfavorable conditions. These will serve as bases in varietal selection and development of improved rice varieties. PhilRice germplasm materials (approximately 7,101 TRVs) from PhilRice CES were evaluated by batches for tolerance to zinc deficiency. Augmented row column and zinc deficiency rating following the Standard Evaluation System (SES) for Rice manual were used as experimental design. The germplasm material identified with potential tolerance to zinc deficiency were validated. In January-June 2017, 865 Rice Germplasm plus 4 Check varieties (IR-64 & NSIC Rc 122 – susceptible; NSIC Rc 222 and NSIC Rc 240 – tolerant) were treated without zinc sulfate and fertilizer to evaluate the germplasms' tolerance to soil zinc deficiency. Results showed 41 (4.74%) tolerant rice germplasm including: Kamoros, PSB Rc 50 (Bicol), LI-486-1, PLB 313, PLB 588, PLB598, D2-110-3, TCF4-115, P9-4-4 (Bongkitan), Raminad, Dinorado, Series, Brown Rice, Burdagol (Pilit), Kabus-ok, Malagkit (Puti), Batolinaw, Pinkitan, Japanese Pearl, Malagkit, Pangpadan, IR50404, Raeline 1, Raeline 2, B-3, Ngarabngab, Pokpoklo, Tukon-Tukod, Talipugo, Waray, IR87707-445-B-B-B L14DS-71 #71, Kalipapa, Remilitis, and IR10Ar83. Two hundred twelve (24.51%) of the rice germplasm had intermediate tolerance; 189 (21.85%) were moderately susceptible while 423 (48.90%) were susceptible. In July-December 2017, 640 rice germplasm and 4 check varieties (IR64, NSIC Rc 122, NSIC Rc 222 and NSIC Rc 240) were also screened and evaluated without zinc oxide, zinc sulfate, and fertilizer to test the performance of the entries without intervention. Results showed that 18 (2.81%) rice germplasm accession has tolerance to soil zinc deficiency with good to excellent phenotypic performance; 152 (23.75%), moderately tolerance to soil zinc deficiency; 202 (31.65%), intermediate tolerance to soil zinc deficiency; 249 (38.91%), moderately susceptible; 16 (2.5%), susceptible; and 3 (0.47%), low germination after sowing.

Evaluation of Rice Germplasm for Tungro Resistance in PhilRice Midsayap
Pernelyn S. Torreña, JM. Niones, MPA Tejada, MS Ocenar, LM Perez

This study aimed to provide information on the field reaction of PhilRice germplasm materials with resistance against rice tungro virus (RTV). The study was conducted at PhilRice Midsayap Experiment Station, Bual Norte, Midsayap, Cotabato. Six hundred twenty-two germplasm entries and 957 germplasm entries were screened in the dry season and wet season, respectively, against RTV through natural infection under field conditions. Result showed that 19 rice germplasm entries showed resistance to RTV both at 45 and 60 DAT with less rice black bug (RBB) damage. Nineteen entries were found to have good phenotypic acceptability even under the presence of RTV and high RBB population. Among the entries screened in the DS 2017, 30 germplasm entries were recorded to flower, but only IRBLB-B and IRBLKM-T5 reached up to 50% flowering.

In the WS 2017 screening against RTV, more than half of the germplasm entries was rated resistant to intermediate against the target pathogen at 45 and 60 DAT. Less RBB damage was observed in this cropping season than in DS 2017. Eight hundred nineteen entries were recorded to reach flowering and 318 of those entries reached up to 50% flowering. Out of 957 entries screened, 90 entries were recorded to have high susceptibility to bacterial leaf blight (BLB). Even with the presence of RBB and BLB in the field, 35 entries showed good phenotypic acceptability for this cropping season.

III. Genetic Resources Research
Jonathan M. Niones

DNA fingerprinting and Genomic DNA sequencing is a biotechnology tool for discovering genes coding for traits including resistance to pests and diseases, tolerance to abiotic stresses, and grain quality. With the revolution of molecular tools including the fast-paced evolution of technology for DNA analysis, DNA sequencing becomes a common measure for gene discovery in plants including rice.

Philippine TRVs stored in PhilRice Genebank have immense genetic diversity and potential reservoir of novel genes for rice genetic improvement. With the advent of intellectual property rights and ownership of rice particularly germplasm under development, there is a need to discover local sources of genes/traits for breeding and genetic improvement of rice varieties for resistance to pests and disease, tolerance to abiotic stresses, and good grain quality. The discovery of such genes and potential source germplasm in local and indigenous traditional rice varieties will mean opportunity for commercialization and advancement in Philippine rice science. This project is composed of two studies: 1) Complete Genomic DNA Sequencing of Selected Philippine Traditional Varieties for In-Silico Gene Discovery, and 2) Molecular Characterization and Genetic Analysis of Nutritional Components of Philippine Indigenous Pigmented Rice Germplasm (NutrientRice).

The complete genomic DNA sequencing of selected Philippine traditional varieties (PTRV) for In-Silico Gene Discovery using the Next Generation Sequencing (NGS) combined with bioinformatics is an efficient molecular tool in characterizing, discovery of novel traits, and unlocking the potential of vast PhilRice genebank accessions. Bocao, a PTRV, was subjected to whole genome sequencing using Hi Seq 2000. Paired end results generated as much as 23GB of data per read and GC content of 42% with the total sequences generated 23,806,185 bases in 20 notable regions.

The study, NutrientRice or molecular characterization and genetic analysis of nutritional components of Philippine Indigenous Pigmented Rice Germplasm, aimed to identify rice accessions containing high nutrient and antioxidant traits with good grain quality and possible genetic donors for the healthier rice breeding program. Genetic diversity and population structure analysis of 600 pigmented rice accessions generated two main clusters, which were further confirmed in the 389 pre-selected unique genotypes. The accessions were assigned to subpopulations using the Bayesian algorithm. Five hundred twenty-nine SNPs were selected to perform the structure analysis with a length burning period of 50,000 and 100,000 MCMC replications.

Conservation and management of biocontrol agents was also studied. Conservation strategy of biocontrol agents was developed, in which 10 strains of B. bassiana and M. anisopliae were preserved and conserved in oil from potato dextrose agar. The efficacy of these 2 biocontrol agents was also tested on white stemborer, rice bug, and rice black bug.

Complete Genomic DNA Sequencing of Selected Philippine Traditional Varieties for In-Silico Gene Discovery
Xavier Greg I. Caguiat, TE Mananghaya, VG Dalusong, RP Mallari

The availability of robust molecular technology enables fast and efficient trait discovery in crops. The cost and fast turnaround of data attracts end user to venture in utilization of such novel technology in unlocking the potential of vast Genebank accessions. This study aimed to assess and validate presence of stress-resistance and novel traits in the Philippine traditional varieties from the Genebank using Next Generation Sequencing (NGS) combined with bioinformatics. Preliminary data identified several accessions and Bocao was identified as having drought tolerance trait

subjected to whole genome sequencing using Hi Seq 2000. The huge amount of data generated as much as 23GB per read and GC content of 42%. Sequences generated 23,806,185 bases with 20 notable regions. This information will be further analyzed using bioinformatics pipelines that could lead to elucidation of the drought tolerance genes present in Bocao. The ability of NGS and bioinformatics to validate phenotype data could lead to donor parent identification for pre-breeding and breeding for drought and other stresses in rice.

Conservation and Management of Biocontrol Agents
Gerardo F. Estoy Jr and Belen M. Tabudlong

Preservation techniques of different fungal biological control agents were conducted in the laboratory from January to June 2017 to develop management strategies to conserve and preserve biocontrol agents and to evaluate the efficacy of these conservation strategies for the control of some major rice insect pests. Different fungal isolates previously collected in the field were passed through the insect hosts and later purified in the laboratory. Strains of Metarhizium anisopliae and Beauveria bassiana were successfully conserved and preserved in oil form and remained effective and viable up to 18 months. Some of the isolates remained viable for 4 years in oil form stored at refrigerator. Additionally, B. bassiana stored in 6 months in oil was effective against white stemborer with 43-100% mortality while M. anisopliae caused 60-86%, 56-93%, and 70-86% mortality in white stemborer, rice bug, and rice black bug, respectively.

IV. Seed Quality Assurance in PhilRice Seed Stocks

Susan R. Brena

Good quality seeds are the basis of crop productivity, which possesses important genetic characteristics for successful rice production. Therefore, PhilRice-produced seeds, regardless of seed class, must have high quality.

Four studies were implemented under this project: 1) Field inspection of seed production areas at PhilRice CES; 2) Seed testing of buffer stock and carry over seed lots; 3) Assessing the seed quality, purity, and genetic identity of hybrid parental lines of public hybrids produced at PhilRice; and 4) Utilization of SSR markers for seed purity testing in TGMS hybrids.

Internal field inspection adhered to the Administrative Order issued of the Department of Agriculture, which is normally done by designated seed inspectors. However, to have the highest quality seeds at PhilRice, an internal field inspection is done by GRD's Seed Technology Unit. Breeder seed production (BS) areas of the Plant Breeding and Biotechnology Unit and the foundation and registered seed production of the Business Development Division were all inspected in DS and WS. In DS, 13 breeder seeds (BS), 17 foundation seeds (FS), and 14 registered seeds (RS) of inbred varieties were inspected. Under BSP, NSIC Rc 194 and NSIC Rc 300 had less than 100% field purity at final inspection. Under Foundation Seed Production (FSP), NSIC Rc 398 and NSIC Rc 402 were rejected owing to observed mixtures of different varieties. In WS, 25 BS, 18 FS, and 12 RS inbred varieties were inspected. Under BSP, three varieties were rejected, NSIC Rc 406, NSIC Rc 476, and NSIC Rc 478 owing to different plant canopy orientations and different grain shapes observed during crop growth.

Seed purity and viability testing are regular activities of the unit which serves as the internal seed quality control of the institute for determining the quality of seed produced after harvest and during storage. In DS, 12 BS varieties were tested for varietal purity after threshing, drying and cleaning; however, only five deemed pure and passed as BS after threshing and cleaning. After cleaning, varieties tested for varietal purity were classified as BS (5); FS (1); RS (2); and CS (4). None of the varieties under FSP passed as FS after varietal purity determination. Among 5 varieties planted under RSP, 3 varieties were classified as RS after seed cleaning. Seven among the 22 BS varieties planted in WS were submitted after threshing and seed cleaning. Only NSIC Rc 25 was considered BS after seed cleaning. Despite the very high field purity of the varieties planted, down grading to lower seed classes were experienced in the seeds produced at PhilRice owing to mechanical mixtures incurred during postharvest operations.

The following were tested for viability and seed vigor testing: 251 bags of hybrid parental lines; 238 bags, F1 (Mestiso 20); 876 bags, breeder; 555 bags, foundation; and 76 bags, registered seed stock. Parental lines produced at PhilRice Los Baños had higher germination rates of ≤90% however; parental lines (PRUP TG101) produced at PhilRice Negros had only 85% and 87% viability and vigor, respectively.

It is estimated that yield is reduced up to 100 kg/ha for every 1% impurity in the hybrid seed. Assured genetically pure seed can provide the full potential of hybrid seeds. It is important to conduct grow out test prior to parental line distribution for use by the hybrid seed growers and researchers. Only parental lines with 97% and higher genetic purity were distributed based on grow-out test. Identification of an off–types in Grow-out Test (GOT) was based on observation of color, height, and heading of flowers. Seventy-five and 42 seed lots were analyzed for DS and WS, respectively. In DS 2017, 23 BS seed lots were evaluated; 11, FS; and 41, F1 hybrids. In WS 2017, 11 BS seed lots were analyzed; 9, FS; and 22, hybrids. All BS seed lots of parental lines tested in DS 2017 had more than 98% genetic purity. Likewise, all FS seed lots had higher than 97% genetic purity. Parental lines produced in DS were tested for genetic purity in WS and showed more than 98% genetic purity in GOT.

The assessment of genetic purity of the rice hybrids in conventionally GOT is based on a particular morphological trait. However, traditional GOT is time consuming, demands space, and has environmental dependence. Microsatellites or simple sequence repeat (SSR) markers are considered for application in genetic purity and diversity studies due to their multi-allelic nature, high reproducibility, co-dominant inheritance, abundance, and extensive genome coverage and simple reproducible. Leaf samples were collected from each treatment 21 days after seeding. The parental line produced from different seed lots of WS 2016 and DS 2017, were evaluated for genetic purity through the DNA analysis using the SSR markers. Identification of off type was based on the markers RM 1, RM 127, and RM 511. Seed purity analysis using SSR markers tested 12 seed lots (DS) and 9 seed lots (WS). Six BS seed lots of PRUPTG102 produced from PhilRice LB and six FS of PRUPTG102 from Negros were evaluated. Among the DS entries, 97-100% genetic purity was observed in 8 seed lots. In WS 2017, 100% purity was obtained in 3 seed lots, 99% in one seed lot, 98% in 2 seed lots, 97% in 1 seed lot.

Internal Field Inspection of Seed Production Areas

Rachel C. Ramos and Alpha Grace Ferriol

Internal field inspection examines the purity of BS, FS, and RS seed production areas of the Plant Breeding and Biotechnology Division (PBBD) and Business Development Division (BDD) of PhilRice CES. Generally, field inspection starts 20 days after transplanting, at maximum tillering, onset of flowering (most important period to remove off-types), and two weeks before harvest. Although these are prescribed period for inspection, rouging should be done for as long as there are off-types observed in the field. The field under each seed class planted per variety was inspected in three replications. For breeder seed production (BSP), 20 x 25 hills were pegged with bamboo sticks. For foundation seed production (FSP) and registered seed production (RSP), 32 x 32 hills were pegged with bamboo sticks. There were 500 and 1,024 plants pegged in an area for BSP and FSP/RSP, respectively. Three pegged areas per variety were inspected. This routine was done to ensure seeds' high purity. Moreover, Bureau of Plant Industry conducted laboratory certification. During DS 2017, 13 BS, 17 FS, and 14 RS varieties were inspected. In BSP, NSIC Rc 194 and NSIC Rc 300 had less than 100% field purity at final inspection while in FS production, NSIC Rc 398 and NSIC Rc 402 were rejected owing to mixture of different variety. During WS 2017, 25 BS, 18 FS, and 12 RS were inspected. In BSP, NSIC Rc 406, NSIC Rc 476, and NSIC Rc 478 were rejected owing to many types of plant canopy orientation and different grain shapes.

Seed Testing of Buffer Stock and Carry Over Seed Lots

Rachel C. Ramos and Alpha Grace Ferriol

Seed purity and viability testing are routine activities of the unit, which serves as the Institute's internal seed quality control for determining the quality of seed produced after harvest and during storage. This may include carry over seed lots of previous cropping and buffer stocks. This routine study was conducted as part of the PhilRice internal seed quality control spearheaded by the Seed Technology Unit under Genetic Resources Division.

During varietal purity testing, 500 g sample of a particular variety were taken at random after different postharvest operations (after threshing, drying, and cleaning) to assess the presence mixtures. The determinants of off-types were grain shape, color, width, and presence and absence of awns. In DS 2017, among 12 BS varieties tested for varietal purity after cleaning, only five deemed pure and passed as BS, 1 variety passed as FS, and 5 varieties passed as CS. On the other hand, among 15 varieties tested after cleaning, only 6 varieties were deemed pure and passed as BS, 5 passed as FS, and 3 as RS. Viability and vigor tests were conducted to assure high quality seeds with 85% or higher be procured by the seed growers. In seed viability testing, in between paper germination was used with 400 seeds randomly taken from a seed lot. Four replications was used in germination with 100 seeds per replicate. For vigor testing, 400 seeds from the same seed lot were subjected to accelerated ageing (4200C for 3 days). After ageing, seeds are germinated following the in between paper method. Two hundred fifty-one bags of parental lines, 238 F1 bags (Mestiso 20), 876 BS bags, 555 FS bags, and 76 bags of registered seed stock were subjected to viability and vigor testing. Parental lines produced by PhilRice LB had higher germination rates of ≤90%. However, parental lines (PRUP TG101) produced at PhilRice Negros had only 85% and 87% viability and vigor, respectively.

Assessing the Seed Quality, Purity, and Genetic Identity of Hybrid Parental Lines of Public Hybrids Produced at PhilRice

Susan Brena

It is important to conduct GOT prior to parental line distribution for use by the hybrid seed growers and researchers. Parental lines with 97% and higher genetic purity are distributed. At this genetic purity level, minimal off-types are observed in the field when the parental lines are planted. This study evaluated the genetic purity of various seed through GOT. Identification of an off–type was based on observation of color, height, and heading of flowers. GOT conducted in 75 seed lots were analyzed in DS 2017 and 42 seed lots were analyzed for the WS 2017. Entries in DS 2017 were 23 BS seed lots; 11 FS seed lots; and 41 CS seed lots. In WS 2017, 11 seed lots were planted to BS; 9, FS; and 22 CS. Results showed that 25 over 40 hybrids produced in the WS 2016 failed to meet the standard for genetic purity. All the parental lines tested in the DS 2017 complied the >97% genetic purity. In WS 2017 GOT, all of the F1 M19, all the BS, and 6 foundation lines have the genuineness of the seed. One important aspect of a good quality seed is the higher genetic purity. Admixtures in the rice seeds may diminish the value of the crop. This study confirmed that some hybrid and their parental lines are contaminated. The results validated the seed purity of produced hybrid seed and parental line tested in 2017.

Utilization of SSR Markers for Seed Purity Testing in TGMS Hybrids

Susan Brena

Microsatellites or simple sequence repeat markers are considered in genetic purity and diversity studies due to multi-allelic nature, high reproducibility, co-dominant inheritance, abundance and extensive genome coverage, and simple reproducible. The parental line produced were evaluated for genetic purity through the DNA analysis using the SSR markers. Identification of an off-type was based on the markers RM 1, RM 127, and RM 511. Seed purity analysis using SSR markers in 2017 studied the 12 seed lots tested for DS 2017 and 9 seed lots tested for WS 2017. Entries in DS 2017 included 6 BS of PRUP TG102 produced from Los Baños and 6 FS of PRUP TG102 from Negros. In DS 2017, 8 seed lots achieved genetic purity ranging from 97 to 100% genetic purity while 4 seed lots attained minimum genetic purity. In WS 2017, 3 seed lots obtained 100%; 1 seed lot, 99%; 2 seed lots, 98%; and 1 seed lot, 97%. Minimum genetic purity was recorded at 96% and 92% from two seed lots. Five entries had 100% seed purity while 5 entries had a minimum seed purity of less than 97%. The entries of parental lines TG102 M and PRUP TG102 of rice hybrid Mestiso 20 produced were studied for seed purity analysis at molecular level using SSR marker. RM 1, RM 127, and RM 511 clearly distinguished seeds with impurities.

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

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We are a government corporate entity (Classification E) under the Department of Agriculture. We were created through Executive Order 1061 on 5 November 1985 (as amended) to help develop high-yielding and cost-reducing technologies so farmers can produce enough rice for all Filipinos.

With a "Rice-Secure Philippines" vision, we want the Filipino rice farmers and the Philippine rice industry to be competitive through research for development in our central and seven branch stations, coordinating with a network that comprises 59 agencies strategically located nationwide.

We have the following certifications: ISO 9001:2008 (Quality Management), ISO 14001:2004 (Environmental Management), and OHSAS 18001:2007 (Occupational Health and Safety Assessment Series).

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