
# 2019
## PHILRICE R&D HIGHLIGHTS

# RICE FARM MODERNIZATION AND MECHANIZATION PROGRAM

# Contents

PROGRAM

# Rice Farm Modernization and Mechanization (RFMM)

*Division head: Jasper G. Tallada*


## Executive Summary

The mechanization and modernization of rice farming are key strategies to achieve affordable and available food for the Filipinos in the current DA's 10-point agenda. The Rice Farm Modernization and Mechanization (RFMM) Program has an overarching goal to develop mechanization technologies for rice production and post-production operations including renewable energy systems. The program primarily contributes to Outcomes 1, 2, 3, and 5 of the PhilRice Strategic Plan 2017-2022. To modernize farming, the Program creates smart information technologies founded on electronic sensing and control, and intelligent information systems and applications to provide efficient decision guides and deep industry insights.

Three projects were implemented on all sequential farming operations from irrigation and land preparation to harvesting and rice processing with integration of information and control technologies at PhilRice CES. These projects were: (1) Mechanization of rice and rice-based farming; (2) Post-production and renewable energy technologies for improved rice and rice-based farming; and (3) Modernized rice farming through precision technology and intelligence information systems.

Project 1 developed final prototypes of the three-row motorized weeder, multi-crop reduced till planter (MCRTP), gear transmission tractor, cutter-bar rice combine, and the pedal cum electric motor driven brown rice mill which are now at pre-commercialization stage with the accreditation of manufacturers in strategic locations. Project 2 included the incorporation of the automated furnace control of the upgraded flatbed dryer which achieved better operational performance and fuel efficiency; concept-validated producer gas-fed single cylinder non-retrofitted diesel engine that obtained high fuel replacement rates for water pumping and electric power generation; and the rice-hull gasifier engine pump system that can now operate continuously for at least eight hours. Project 3 enhanced the RiceIntel, an intelligent executive information which is continuously populated with enormous rice industry information and derived insights to sustain decision making. Aside from the AgriDoc apps, downloadable from Google App store now included *Binhing Palay* (for rice varieties) and

*eDamuhan* for weed identification and control. Unmanned aerial vehicles (UAVs) were further explored for seeding, fertilizing and spraying field trials at the FutureRice and REMD Farms, and for the three-dimensional mapping in partnership with New Hope Corporation. These technologies reduced drudgery, decreased costs of farming to realize higher net incomes, reduced losses for higher food conversion efficiency, created new avenues of entrepreneurship with brown rice, and improved farm management by employing advance sciences on instrumentation and control, artificial intelligence, and decision sciences. Two seminars on drone technology were participated by 79 individuals (38% women) and a capability building on gasification technology was attended by 42 individuals (24% women).

# Mechanization of Rice and Rice-based Farming

*EG Bautista*

The project developed machines for land preparation, crop establishment, and crop care to lower production costs while attaining higher rice yields by ensuring optimal crop production practices. Outputs included the boat tiller for laboy soil, a multi-crop till planter for corn, rice, and mungbean to help farmers in crop diversification, a gear transmission for multiple purposes to reduce acquisition cost of machines, and a mechanical weeder for row planted rice.

Two prototypes of a riding-type boat tiller for shallow and waist-deep mud fields were developed to ease the burden of land preparation and which can also be used by women. The prototypes with metal and plastic floaters for shallow and deep mud fields, respectively, were pilot tested. The boat tiller that used metallic floater achieved an average forward speed of 5.23km/h, fuel consumption of 1.54li/h, and had an actual field capacity of 2.72ha/day at 65% efficiency.

The performance of the multi-crop reduced till planter (MCRTP) was tested for corn establishment in Pangasinan (Region 1), Isabela (Region 2), and Nueva Ecija (Region 3). Higher yields (330 – 5,320kg/ha) were obtained from MCRTP-seeded compared with farmers' practice. The production cost was reduced to 32-82% and the total output-input energy ratio was 8.34-14.76, which were higher than the FP in all regions. Based on farmers' feedbacks, the MCRTP could be further improved and modified to address issues on the wide range of planting distances (12-35cm) and missing hills.

A power tiller with gear transmission and pivot mechanism prototype with 7hp reduction-type air-cooled diesel engine was field tested with land preparation attachments such as rotavator, harrow, and riding-type leveler Actual field capacities using the mentioned attachments were 0.12ha/h, 0.22ha/h, and 0.28ha/h, respectively. It had an average speed of 2.42kph and average field efficiency of 76%. Necessary modifications were made to address accumulation of weeds to the depth wheel and resistance of the rotavator attachment while turning to the headland. With this promising performance, the prototype is ready for pilot testing in farmers' field. Moreover, a transplanting attachment had undergone functionality test and is ready for field testing in the coming cropping season.

A gender-neutral three-row portable mechanical weeder was developed using local materials for its parts (handle, weeding rotator, mud guard, and skid), and using a 4-stroke single cylinder engine (of the traditional grass-cutter). The improved prototype had a weeding capacity of up to 1.5ha/day and efficiency of 71%, and is now ready for pilot testing.

## Improvement and Pilot Testing of Lightweight Riding-Type Boat Tiller for Shallow and Waist-Deep Mud Conditions

*AS Juliano, JB Bedonia, JA Ramos, EG Bautista, MJC Regalado, JP Miano, and KC Villota*

Two prototypes of a riding-type boat tiller; one with metal body and another with plastic body were developed and improved for land preparation in shallow and waist-deep mud fields. The metal-body boat tiller for shallow field equipped with 7hp reduction-type air-cooled diesel engine was field tested and the prototype had an average forward speed of 5.23kph, fuel consumption of 1.54li/h, actual field capacity of 0.34ha/h (2.72ha/day), and field efficiency of 64.98%. On the other hand, the metal-body boat tiller for shallow field was pilot tested in San Luis, Aurora and after three passes, it had actual capacities of 0.45-0.55ha/h with efficiencies ranging from 69.5% to 76.4%, average forward speed of 6.95kph and diesel fuel consumption of 1.7li/h of operation. It showed promising performance with the fast completion of a well-prepared field ready for leveling. The riding-type boat tiller (with metal body) for shallow field was demonstrated to more than 200 participants during the October 3-4, 2019 Lakbay Palay at the FutureRice Farm (Figure 1). Positive feedbacks, particularly on its fast operation compared to hand tractor and comfortability, were gathered. On the other hand, during testing of the riding-type boat tiller with plastic body and revised parts in deep or laboy field (Figure 2), the machine could run and till the field in a short distance, but it has difficulty to move forward again when the soil was tilled. After necessary improvements, the prototypes were recommended for pilot testing in the farmer's field.

*Figure 1. Demonstration of the boat tiller with metal body during 2019 WS Lakbay Palay*

*Figure 2. Actual testing of the prototype with plastic body in laboy field*

## Pilot-testing of Multi-Crop Reduced Till-Planter for Improving Labor Productivity, Cost, and Energy Efficiencies for Rice and Rice-Based Crop in Rainfed Upland Condition

*MJC Regalado, KS Pascual, ML Rafael, and AT Remocal*

This study aimed to evaluate the performance of the multi-crop reduced till planter (MCRTP) in terms of its energy efficiency, labor productivity, and cost effectiveness at the farmer's field. After undergoing field trials at PhilRice CES, the MCRTP was pilot-tested for corn seeding in three regions, namely: Regions 1 (Pangasinan), 2 (Isabela), and 3 (Nueva Ecija) under different biophysical conditions (Figure 3). Results showed that higher yields (330-5,320kg/ha) were obtained using MCRTP compared with farmers' practice or FP in all regions. The MCRTP had yielded more kilograms of corn per man-day by 4-48% at 153-239 kg/day as compared with FP due to higher yields with fewer labor-days per ha. The unit production cost of MCRTP was reduced by 32-82% at P2.51-4.42/kg of corn. The overall energy ratio was 8.34-14.76, which was higher by 3-48% than FPs across regions. Based on the result, MCRTP could be a better option to improve labor productivity, energy and cost efficiencies while having good yield in rainfed lowland corn cultivation. The economic analysis of owning and operating a multi-crop planter through custom hiring by farmers' association was also found to be viable. However, some modifications need to address problems on the wide range of plant distances (12-35cm) and missing hills based from farmers' feedbacks (Figure 4).


*Figure 3. Corn planted at 15 DAS using MCRTP in (a) Sta. Maria, Pangasinan, (b) Aurora, Isabela, and (c) Muñoz, Nueva Ecija*

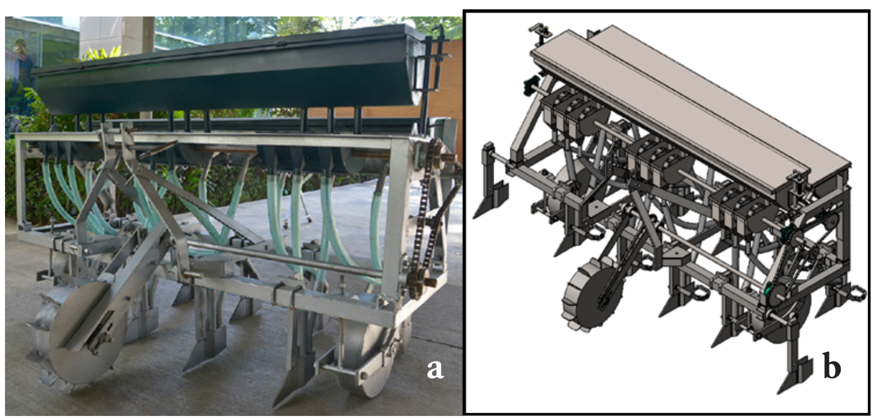


*Figure 4. (a) Existing prototype of multi-crop reduced till planter (b) Improved prototype multi-crop reduced till planter*

## Development of Gear Transmission Power Tiller with Pivot Mechanism for Multiple Farm Operations

*AS Juliano, JB Bedonia, JA Ramos, and JP Miano*

The study aimed to develop a power tiller with gear transmission and pivot mechanism made of locally available spare parts to be fully adopted by lowland and upland farmers to make them competitive in producing rice and rice-based crops. The design for farm operations was conceptualized based on the imported power tiller with gear transmission used by PhilRice. Using computer-aided design (CAD), details of parts were made as guide for fabrication (Figure 5). A machine prototype was fabricated by shop technicians at the PhilRice manufacturing shop using common tools, equipment, and locally-available materials. The prototype with 7hp reduction-type air-cooled diesel engine was tested in the field using three different attachments for land preparation; rotavator, harrow, and riding-type leveler to gather data and assess its performance (Figure 6). In using the rotavator attachment, the machine had a forward speed of 2.43kph, actual field capacity of 0.12ha/h, and field efficiency of 75%. With the harrow, the forward speed was at 2.43kph with actual field capacity of 0.22ha/h at 75.86% field efficiency. With the riding-type leveler, the prototype had a forward speed of 2.41kph, actual field capacity of 0.28ha/h, and field efficiency of 77.78%. Based on the promising performance of the machine, the prototype is ready to be pilot tested in farmer’s field. Feedbacks were gathered from select attendees of the October 3-4, 2019 Lakbay Palay at the FutureRice farm where a demonstration of the machine was conducted. The encouraging feedbacks showed the usefulness of the prototype in multiple farm operations and convenience to use due to the pivot mechanism. Moreover, a prototype with rice transplanter attachment was fabricated and had favorable performance when subjected to functionality test to determine workability of all parts of the machine (Figure 7). Hence, the machine with rice transplanter attachment is ready for field testing to evaluate its performance for crop establishment.

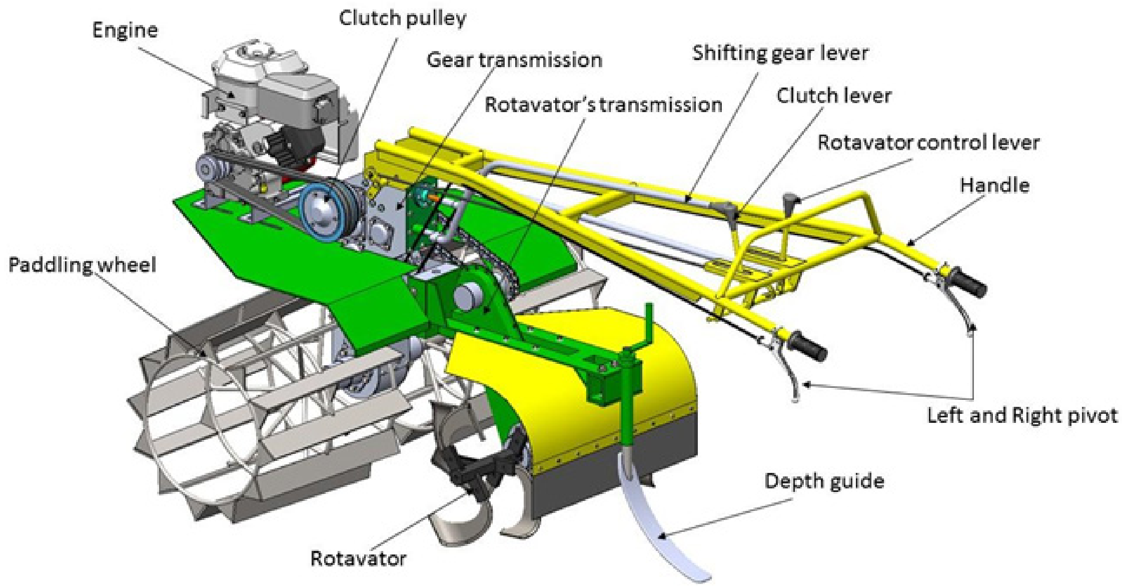


*Figure 5. Updated CAD drawing of the prototype with rotavator attachment*


*Figure 6. Testing of the prototype using rotavator, harrow, and riding-type leveler attachment*


*Figure 7. The fabricated prototype with rice transplanter attachment (left) while undergoing functionality test (right)*

## Development and Pilot Testing of Local Mechanized Weeder for Straight Row Planted Rice Crop

*EG Bautista, AS Juliano, JEO Abon, ES Espique, and PR Castillo*

Weeds, unwanted plants found in fields, compete with main crops for growth resources, decrease crop quality, raise production costs due to increased cultivation and hand weeding, and considerably reduce crop yields. Weeding is one of the most laborious operations in rice farming. The management of weeds should be done using a combination of preventive, chemical, and mechanical means such as mechanical weeders. Mechanical weed control compared with manual weeding is less labor-intensive, controls the weeds, and keeps the soil surface loose ensuring soil aeration and water intake capacity. However, existing mechanical weeders quite need improvement. Hence, PhilRice developed a gender-neutral mechanized weeding machine made from locally available materials with the following details: three-row weeding machine using a 4-stroke single cylinder gasoline engine similar to that of a grass-cutter (Figure 8), with a handle, weeding rotator (wheel), mud guard, and skid. After a series of tests (Figure 9), the prototype had initial weeding capacity of up to 1.5ha/day and efficiency of 71% with zero damaged plant. Improvements made based on testing results included shortened main frame from 56cm to 46cm for ease of operation; increased diameter of weeding rotator from 25cm to 40cm and decreased width from 17cm to 10cm to avoid damaged plants; adjustable rotator up to 30cm planting distance; improved position, angle, length, curve/bend of rotator blade to increase weeding efficiency and for the machine to run smoothly; and reduced skid from double to single attached at the center for ease of handling and operation. Fabrication of three pilot test prototypes are ongoing.

*Figure 8. Three-row local mechanized weeder*

*Figure 9.  Field testing of the prototype*

PROJECT 2

# Post-Production and Renewable Energy Technologies for Improved Rice and Rice-Based Farming

*JA Ramos*

This project has seven components focusing on reducing drudgery and input cost of farm operations, managing postharvest losses, and preserving quality of product in rice and rice-based farming. An increase in yield and a decrease in postharvest losses must be achieved for increased farm income. Postharvest losses are 16% of the total production where harvesting, drying, and milling account for 95%. From 16%, there is a need to reduce postharvest losses to 12%. Improving the harvest and postharvest operations and management, facilities, and equipment as key components of this project can contribute significantly to this target of reducing postharvest losses. Mechanical harvesting can reduce harvesting losses up to 2% and 0.5% reduction from manual harvesting. Proper time of harvest with appropriate drying technique and storage reduces the total postharvest losses and improved quality of rice in milling and head rice recovery. Hence, with efficient and appropriate technologies, more can be recovered when postharvest losses are cut down.

Improvement of the rice hull gasifier engine pump system (RHGEPS) focused on minimizing attention time and human intervention and making operation time continuous. A char-discharging mechanism was incorporated to make the reactor continuous type. During testing, problems were addressed by simplifying the design of char scraper and discharger and incorporating a primary gas cooler to absorb heat and partly trap impurities from producer gas before passing to other parts of the system. Subsequent tests conducted resulted to an average water discharge of 6.3L/s operated continuously for 8h.

The design and proof-of-concept prototype for a combined producer gas and diesel-fed non-retrofitted single cylinder 10hp compression ignition engine was successfully developed for the first time in the Philippines. Current iteration for the single cylinder model yielded breakthrough results in overall performance. Results showed that on the average, the producer gas could replace 65% of diesel consumption at full load, whether the system was configured for electricity generation or water pumping application.

The stripper and cutter bar combine harvesters were improved increasing the field capacity of the stripper combine to 1.5ha/day and 2.5ha/day for cutter bar combine. Recorded field efficiencies ranged from 60 to 71% and 64 to 81% for stripper and cutter bar combine harvesters, respectively. Two farm machinery manufacturers were accredited for the fabrication of pilot test units. Both prototypes are expected to be ready for field testing in the coming 2020 DS.

A prototype of auto-feed rice hull furnace and a monitoring system for heated air were developed, constructed, and installed to a 6-ton capacity flatbed dryer. Modifications were employed after encountering problems during test runs and desirable results were obtained. The control system for rice hull feeder and temperature monitoring for plenum were integrated in one mobile application which could be viewed and configured remotely through smart phone. Three batches of freshly harvested paddy were dried using the new drying system resulting to a mean drying air temperature of 43.8°C, moisture reduction rate of 1.51%, and an average rice hull consumption of 25kg/h.

A pilot-scale microwave heating system (MHS) with a throughput capacity of up to 50kg of brown rice per hour in semi-continuous operation was designed. It had a horizontal configuration with a grain hopper and a loader that evenly dispensed a thin layer of brown rice onto food-grade, microwave-safe conveyor belt moving through a heating chamber consisting of a series of magnetrons situated above the belt. Two batches of NSIC Rc 160 brown rice were stored and microwave-treated for comparative evaluation.

A two-season validation of rice postharvest management protocol at farmer's field was completed. Dry season results suggested that on-time combine harvesting minimized the losses to 0.97% and drying the combine-harvested crop using flatbed dryer and hermetically storing it using PhilRice SACLOB also kept physical grain losses at a minimum of 1.2-1.7%. Moreover, on-time, combine-harvested, flatbed-dried, and SACLOB-stored samples had the highest milling recovery at 67.59%.

## Improvement and Pilot Testing of Rice Combine Harvesters

*JA Ramos, CJM Tado, MJC Regalado, AS Juliano, EG Bautista, RS De Gracia Jr., and ML Dela Cruz*

Two machines, the stripper and cutter bar combine harvesters, facilitate cutting, threshing, cleaning, and bagging of crop in one operation. Continuous field tests with necessary improvements were conducted to assess and refine the performance of both prototypes. Test runs in 2019 DS increased field capacity of 1.5ha/day of the stripper combine with new stainless stripper teeth and 2.54ha/day for cutter bar combine (Figure 10). Field efficiency recorded for stripper and cutter bar combine harvesters ranged from 60-71% and 64-81%, respectively. With further modifications and improvement, the machines were expected to attain the allowable performance indicators prescribed in the existing standards for rice combine harvesters. Fabrication of two pilot test units of cutter bar combine began in June 2019 and is nearing completion. Both units are expected to be ready for field test run in the 2020 DS.

*Figure 10. Actual field operation of stripper combine (left) and cutter bar combine (right)*

## Pilot Testing and Automation of Rice Hull Gasifier Engine-pump System

*JP Miano, AS Juliano, JA Ramos, and JG Tallada*

Farmers relying on pumping ground water in irrigating crops are affected by the increasing fuel costs. With the development of rice hull gasifier engine-pump system (RHGEPS), farmers can save as much as 30–40% of fuel cost for irrigation because it uses rice hull biomass as alternative fuel to run an engine pump set. To assess the readiness of this technology for commercialization, the machine was pilot tested at a farmer's field for one cropping season. At the end of the season, the farmer-cooperator gave positive feedback in terms of machine performance. To make the system more acceptable, attention time and human intervention should be minimized and operating time made continuous. To address this concern, the machine's reactor was re-designed and incorporated with a char discharging mechanism to make operation continuous. During tests, problems were observed and fine-tuned by simplifying the design of the char scraper (Figure 11a) and discharger. Due to continuous operation, heat also accumulated at different components of the system affecting its function resulting to stoppage of operation and frequent cleaning of system components. A primary gas cooler (Figure 11b) was incorporated to absorb heat and partly trap impurities from producer gas before passing to other parts of the system. With this improvement, subsequent tests conducted to optimize its operation resulted to minimized interval of changing the bed filter and cleaning of carburetor. Performance tests at open water and shallow tube well sources (Figure 12) using different suction fan speeds and char discharging duration and interval were conducted. The system was able to run continuously for eight hours with average water discharge of 8.2L/s for open water source and 6.3L/s for shallow tube well source. For the shallow tube well source, the system was operated using 3-inch pulley at 10-minute char discharging duration and 15-min discharging interval. The modifications significantly minimized human intervention and attention time during operation. As part of pilot testing of the batch-type unit in Visayas, a technical staff of PhilRice Negros was trained in the operation and maintenance of the system. Moreover, the unit initially deployed in PhilRice Mindoro was being modified to retrofit with continuous-type reactor and will be pilot tested in Mindanao.

*Figure 11. (Left) Simplified char scraper; (Right) primary gas cooler*

*Figure 12. Performance testing of the rice hull gasifier engine pump system (RHGEPS) at open water source (left) and shallow tube well source (right).*

## Design, Development, and Pilot Testing of a Non-Retrofitted Diesel Engine Co-Fueled with Producer Gas from Rice Husk

*AT Belonio, JG Tallada, JA Ramos, JJA Batanes, and JA Dela Cruz*

PhilRice has been working on alternative fuels to run internal combustion engines commonly used by farmers in their farms. One of these is the conversion of rice husk into combustible gas by partial combustion in a fixed-bed and moving-bed reactors. The technology was proven to work well with spark ignition engine providing power for stationary agricultural machines. However, the use of gasifier as an alternative is constrained with the use of gasoline engines as most farmers prefer diesel engines as prime mover for farm machines. Design and prototyping of a non-retrofitted diesel engine co-fueled with producer gas from rice husk was completed. Current iteration of the single cylinder model yielded breakthrough results in terms of overall performance. The gasifier system was powered by a 30-cm diameter moving bed down draft reactor with an average of 7.4kg/h rice husk consumption (Figure 13). The producer gas passed through series of filtration starting from dry scrubbing made of metal tubes sprinkled by cool water; then, through a series of pre-cut PVC pipes inside a cylindrical tank, and ultimately to a box-type fiber filter. The gas now in ambient temperature was forced via a ring blower to the engine intake. Engine internal parts were not modified, only the intake to facilitate entrance of ambient air. Diesel fuel was still necessary to start and supplement the engine operation. Producer gas could now be introduced gradually via ball valves. On the average, the producer gas could replace 65% of diesel consumption at full load, whether the system was configured for electricity generation or water-pumping application. The technology had undergone series of endurance tests and performed at operational specifications even up to 12h of straight operation where higher diesel replacement of up to 75% was achieved.

*Figure 13. Rice husk gasifier system for single cylinder diesel engine currently being tested in San Rafael, Bulacan*

## Improvement of Flatbed-Type Mechanical Dryer

*JA Ramos, JG Tallada, and ML Dela Cruz*

Various paddy drying technologies have been widely introduced in the country and one that is available is the flatbed dryer, a fixed bed batch-type grain dryer which is currently being improved at PhilRice. The flatbed dryer needed a more efficient paddy drying system through automation with less human interference. The new design provided mechanisms for automatic feeding of rice hull and auto unloading of char. The prototype of auto-feed rice hull furnace (Figure 14) was constructed and installed to a 6-ton capacity flatbed dryer along with a monitoring system for heated air installed at the plenum. Modifications focusing on varied grate inclination, dimensions, and selection of appropriate materials were made on the furnace after test runs. The setup with an on-off push button switch as control now used electronic components such as limit switch, arrays, and mobile device in which feeding duration and interval could be accessed and configured. Moreover, a temperature-based control system was integrated to the furnace to enable the operator to set the temperature condition at the plenum at a desired level appropriate for drying. The control system was integrated in one system application which could be installed to a mobile device for remote viewing and configuration. Nine sensors were distributed uniformly inside the plenum to cover the entire chamber for accurate reading of temperature. Before drying tests, functionality of each component of the dryer was checked. In 2019 WS, three batches (2.5-3t/batch) of freshly harvested NSIC Rc 160 paddy were dried using the new drying system (Figure 15). Results showed that the new system achieved drying capacity of 493kg/h with heated air temperature ranging from 40-50°C and average of 43.8°C. The mean moisture reduction rate was 1.51% with an average rice hull consumption of 28kg/h of operation.

*Figure 14. Fabricated prototype of rice hull furnace*

*Figure 15. Paddy drying test*

## Development of a Microwave Heating System for Shelf-Stable Brown Rice

*MJC Regalado, JG Tallada, JA Ramos, JJA Batanes, and ML Dela Cruz*

A pilot-scale microwave heating system (MHS) with a throughput capacity of up to 50kg of brown rice per hour in semi-continuous operation was developed to enhance the shelf-life and preserve the quality of brown rice (Figure 16). The MHS design has a horizontal configuration with a grain hopper and a loader that evenly dispense a thin layer of brown rice onto food-grade, microwave-safe conveyor belt with endless loop to move the brown rice through a heating chamber consisting of magnetrons situated above the belt. Fabrication and assembly of the prototype microwave heating conveyance system was developed at the REMD shop. Various MHS components had undergone rigid microwave radiation leakage tests and material endurance tests of the food-grade wide belt. Two batches of Rc 160 brown rice were microwave-treated and stored for comparative evaluation (Figure 17). These samples were evaluated for their physical and chemical attributes every quarter.

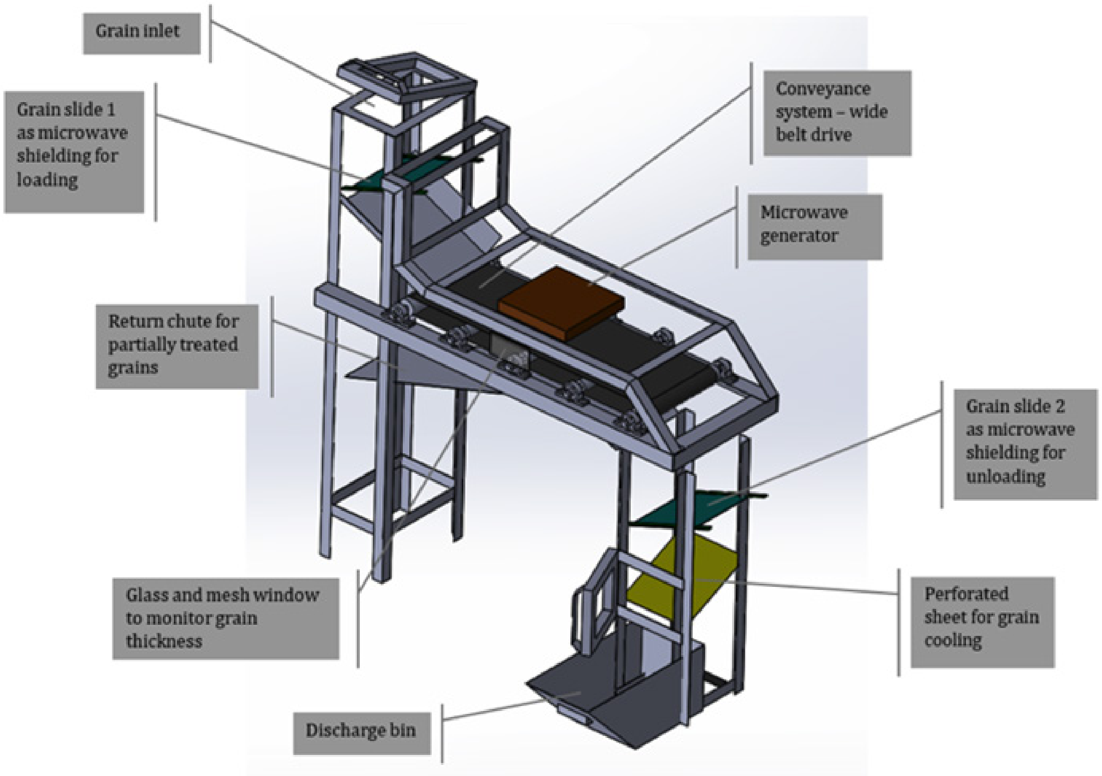


*Figure 16. Conceptual design of the pilot-scale brown rice microwave heating system prototype*

*Figure 17. Brown rice samples treated using commercially available microwave oven with different grain layer thickness and time of exposure*

# Improvement and Pilot Testing of Portable Brown Rice Machine for Household Use

*PR Castillo, AS Juliano, JA Ramos, JP Miano, MM Rañeses, and SC Andales*

Brown rice has health-promoting properties like more dietary fiber, micronutrients, and antioxidants that help prevent diabetes, cancer, and cardiovascular diseases. It promotes weight loss with healthy bowel movement and increased metabolic function. While high-income earners can easily afford brown rice, it is not accessible to low-income earners as it is relatively high-priced and found only in supermarkets. If palay will be processed at rural household level, brown rice will become available and accessible that could contribute to rice self-sufficiency. Hence, PhilRice developed a gender-neutral brown rice machine with a simple design. This easy-to-operate and affordable machine could provide the daily requirements of a family of five members (equivalent to 1kg uncooked brown rice). The prototype has a pair of 4-in diameter rubber roll huller with the whole assembly mounted in a frame with seat and pedals, commonly found in bicycles and with 0.5hp electric motor as alternative prime mover (considered for older persons), so the user had an option to exercise or not (Figure 18a). Dog clutch (Figure 18b) was fabricated and placed between the momentum weights attached to the 12-in pulley used to connect and disconnect two rotating shafts. After a series of tests and refinements, the improved prototype had the capacity to produce brown rice at 1.83kg/h of operation with 74.15% average dehulling recovery after two passes using manual power, and the operator burning 80-240 calories/hour.  Powered by 0.5hp electric motor, the mill had an initial capacity of 2.08kg/h with 78.6% dehulling recovery. Fabrication of four pilot test prototypes is ongoing. Pilot testing in households covered by PhilRice Los Baños, Isabela, Bicol, and Agusan will be done to get feedback from users to further improve the performance and acceptability of the prototype.

*Figure 18.  Improved prototype with electric motor (left) with dog clutch (right)*

## Field Validation of Rice Postharvest Management Protocol for Reduced Losses and Improved Rice Quality

*MJC Regalado, JA Ramos, TC Juganas, MM Rañeses, and JR Waliwar*

Validating rice postharvest management protocol at farmer's field will help in making rice postproduction operations more efficient, minimize postharvest losses, and improved paddy and milled rice quality. This study aimed to validate the best management practices, conduct workshops to present field validation result, and produce a Rice Techno Bulletin on the improved rice postharvest management protocol. The study was conducted during 2019 DS and WS at farmer's field in Villa Cuizon, Brgy. Bantug, Science of Muñoz, Nueva Ecija. Dry season results showed that on-time combine harvesting had the lowest harvest losses of 0.97% (Table 1). This was relatively lower than the losses acquired from manual harvesting/threshing 5 days early, on-time, and 5 days late of 2.0%, 2.39%, and 3.3%, respectively. Drying the combine-harvested crop using flatbed dryer (Figure 19) and hermetically storing it using PhilRice SACLOB kept physical grain losses at minimum of 1.2-1.7%, which was lower than those obtained with sun-drying and ambient storage (2.3-2.7%). Moreover, moisture content of the SACLOB-stored grains was kept on optimum range of 13%-14% during the storage period and fissured grain percentage were lower compared to the samples stored in pallet. On-time, combine-harvested, flatbed-dried, and SACLOB-stored samples had the highest milling recovery at 67.59%, while five days early harvested samples, whether manually harvested or combine-harvested, had the lowest milling recovery values at 60.45% and 60.81%, respectively. Samples harvested five days early also obtained the highest head rice percentage (67.32%) than samples harvested on-time using combine harvester, while the lowest head rice percentages were obtained from samples harvested manually on-time (36.68%). All things considered, harvesting on-time using combine harvester, mechanical drying using flatbed dryer, and storage using PhilRice SACLOB will reduce total postharvest losses and improve processed product quality in terms of milling recovery and head rice. Workshops will be conducted and the Rice Techno Bulletin will be updated and finalized after completing the last set of data by first-half of 2020.

Table 1. Influence of Harvest Date and Method on Harvest Loss (2019 DS)

| Harvest Date | Total Harvest Losses (%) | |
|---|---|---|
| | Combine Harvester | Manual Reaping & Mechanical Threshing |
| 5 days early | 0.98 | 2.00 |
| On time | 0.97 | 2.39 |
| 5 days late | 2.05 | 3.30 |

*Figure 19. Mechanical (flatbed) drying of combine harvested samples (2019 DS)*

**PROJECT 3**

# Modernized Rice Farming through Precision Technology and Intelligence Information Systems

*NL Caballong*

The use of strategic intelligence through electronics and intelligence information technology to different rice stakeholders, especially men and women farmers can achieve modernized rice farming operations. The project is composed of five technology-specific studies, focusing on intelligence information systems (RiceIntel), mobile application tools (RApps), Internet of Things (RIoT), robotics (RoboRice), and drone technology (R-Drone). However, the robotics study was temporarily put on hold. The RiceIntel's digital portal provides fast high-level information to PhilRice top management for executive planning and monitoring. It consolidates and organizes data from different internal and external databases. It provides information on rice situation and rice area per national, regional, and provincial levels; list of PhilRice partner agencies; and research mappings, among other things and are formatted in tables, histogram, line graphs, bar graphs, and vector overlays. In 2019, more datasets and improvement on the dashboard interface (enhanced layout and graphics) were integrated. The portal was launched to the PhilRice Intranet for top management users for Beta testing.

On the study RApps, three mobile application tools for specific rice farming operations were developed. These were AgRiDOC App, for rice farm operation management; *eDamuhan* App, for weed identification and management; and *Binhing Palay* App, for appropriate rice seed variety selection. Improvements and new functions were added this year. Data analytics as of December 4, 2019 showed that the *Binhing Palay* App had the most number of sessions at 59,837 with active and new users at 6,950 and 5,022, respectively. The AgriDoc App had 9,903 sessions with 2,951 active users, and 2,707 new users.

Under RIoT, instrumentation and actuator devices were developed for showcase at the FutureRice Farm and for rapid deployment for PhilRice operations. Some of the prototypes under development (since 2018) were for the following functions: automated drip irrigation, irrigation gate control, water quality monitoring, air quality monitoring, warehouse microclimate monitoring, insect monitoring, and rice paddy monitoring. For 2019, environment monitoring of seed warehouses using a microclimate monitoring system for air temperature and relative humidity transmitting data wirelessly to a cloud database server was implemented at PhilRice. Graphical trends can be visualized either using a smartphone or the web in real time. A first prototype of an automatic irrigation canal sluice gate controlled using commands sent from smartphone was developed. The solar-powered device was enabled by an open-source microcontroller-based motorized linear actuator. A system of network of insect recognition devices for monitoring insect presence and migration was conceptualized.

Lastly, the R-Drone study explored and developed rice farming applications on the use of different drone technologies. New agricultural drones for direct-seeding, herbicide spraying, and fertilizer application were pilot-tested and promoted in several locations in Luzon and Visayas. During the preliminary testing, the use of an agricultural drone direct-seeding and herbicide spraying reduced time from 5h to 30min/ha but with the same effectiveness as manual. The project partnered with New Hope Corporation, an agricultural drone technology provider in conducting this study. All these endeavors contributed to exploring advanced science and technology as source of growth.

## Intelligent Information System for Rice RDE planning (RiceIntel)

*RF Barroga, NL Caballong, and PAA Alday*

Aiming to contribute to Outcome 7 of the PhilRice strategic plan (strengthened institutional capability), this study developed an intelligence information system for use by PhilRice top management in planning and monitoring the institute's programs and interventions. The final output was an operational digital platform providing fast high-level rice situation information, relevant research data, and ground partner directory for target users. Presented information were in the form of tables, histogram, line graphs, bar graphs, maps, geographical points, and vector overlays. In 2019, the dashboard layout and graphics were enhanced with the color palette finalized for the provincial-level areas of coverage of each PhilRice station for uniform identification (Figure 20). A function was developed to allow adjustments of transparency of vectors of administrative boundaries to improve viewing of the base map (Figure 20). Histogram maps of rice situation data of regions and provinces were now automatically generated. Datasets from PRISM (yield estimates and rice area), NCT sites, PhilRice projects, and seed utilization requirement (e.g., Bicol) were added. Important map layers such as PRISM planted rice area, PAGASA climate type, BSWM soil type, UPLB rice suitability, DENR-FMB critical watersheds, and NAMRIA land cover were collected and integrated to the dashboard interface. To start the Beta-testing phase, the RiceIntel was now loaded to the PhilRice Intranet for access and evaluation of top management and other identified key personnel. A function for sending feedbacks and message to the developers was incorporated in the interface for faster evaluation.

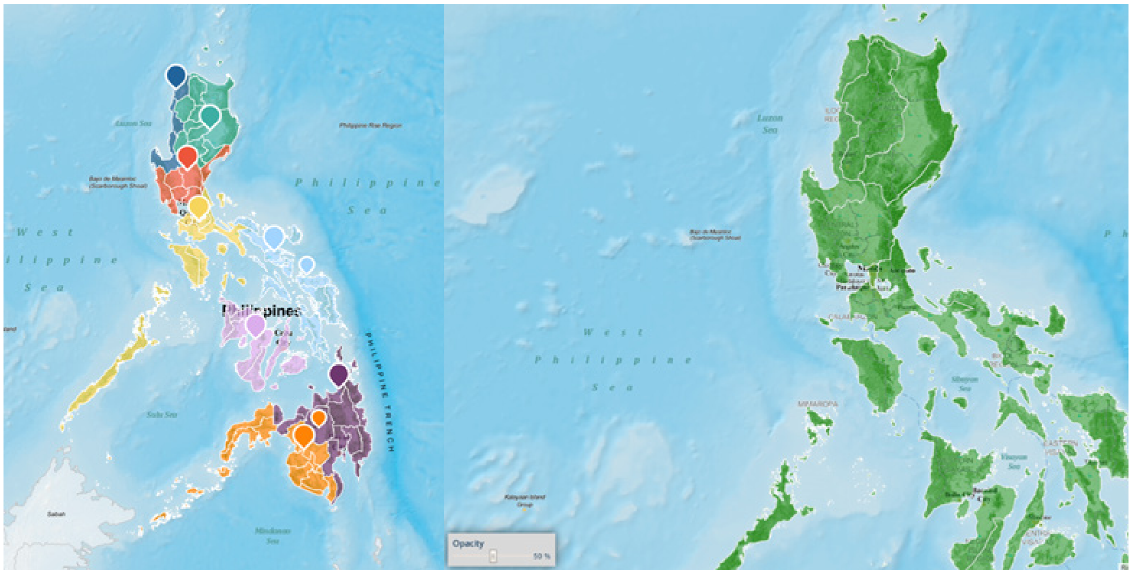

*Figure 20. Color palette scheme for provincial-level areas of coverage of each PhilRice station (left); administrative boundary overlay opacity adjustment function (right)*

## Mobile Application Tools for Rice-Based Farming (RApps)

*NL Caballong, PAA Alday, EM Dicen III, MJC Sotto, DKM Donayre, and EC Martin*

Based on the Rice-Based Farming Household Survey (RBFHS) conducted by the PhilRice Socioeconomics Division (SED) in 2016-2017, 95% of the respondent-household owned at least one smartphone. With this scenario, the potential of smartphone technology as another medium for agricultural knowledge delivery can be maximized. This study developed three smartphone application tools (i.e., app) for rice farming-households, extension workers, researchers, and other stakeholders in managing farm operations (AgRiDOC App), weed management (*eDamuhan* App), and seed variety selection (*Binhing Palay* App). In 2019, several improvements were done for each app. The seasonal transition function of the AgRiDOC App was improved. An activity page for herbicides profile (Figure 21) and top-promoted rice varieties (Figure 22) had been added to *eDamuhan* App and *Binhing Palay* App, respectively. Users can utilize the herbicides profile for options for weed management. Profile of each active ingredient and appropriate rate and timing of spraying were also provided. The cloud-based analytics services of the three apps continuously monitored their utilization. Results showed that 63% of all active and new users were male while 37% were female. Majority were between 25-34 years old. The *Binhing Palay* App had the greatest usage recorded with 6,950 active users, followed by *eDamuhan* App with 4,040 active users, and AgRiDOC App with 2,951 active users. The apps were demonstrated and promoted to extension workers, farmers, and students in events and seminars throughout the country.

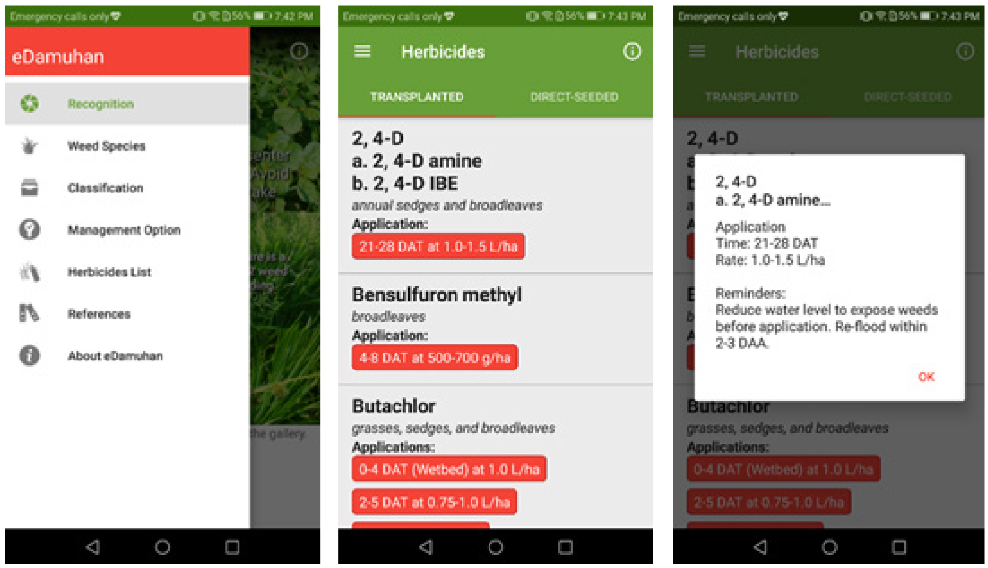


*Figure 21. eDamuhan App herbicides list activity page screen interface*

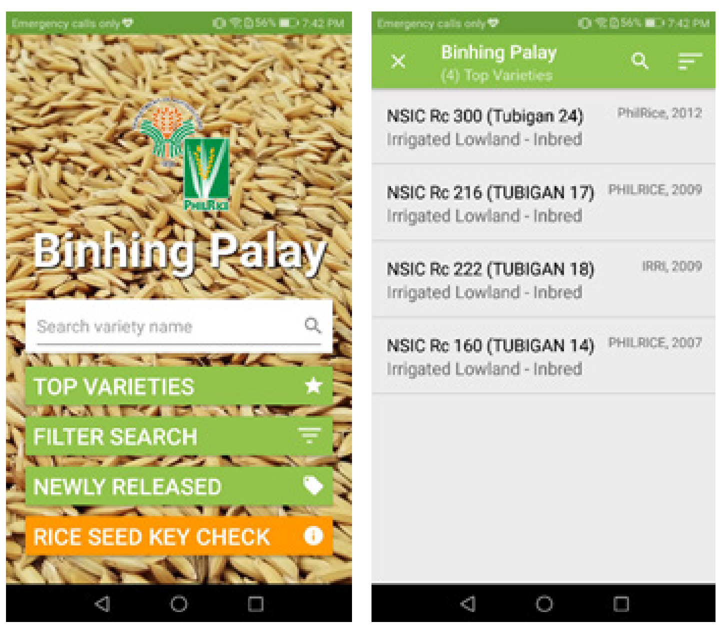


*Figure 22. Binhing Palay top varieties activity page interface*

# Internet of Things (IoT) Technology for Smart Rice-Based Farms (RIoT)

*NL Caballong, JG Tallada, PAA Alday, EM Dicen III, and MJC Sotto*

Simply put, an Internet of Things (IoT) system is a network of devices (sensors and actuators) connected to the Internet which can be controlled or monitored via a remote interface through a mobile and web application software. This study aimed to develop IoT system models for rice farming. It hoped to build the FutureRice Farm as a model of a modernized IoT-enabled farm in actual operation (FutureRIoT). Two new components, the automated water gates systems and light trap with insect recognition device, were added to the overall design of the FutureRIoT system and existing device prototypes were improved. An automated water gate prototype was developed and installed at the farm. The light trap was initialized with artificial intelligence training server and electronics and hardware design. The existing rice paddy monitoring device had a newly improved prototype with sensors for monitoring rice plant height and water temperature (Figure 23). It will be mass fabricated and installed in 2020. It has also undergone microclimate (air temperature and relative humidity) sensor upgrade. Aside from the FutureRIoT, a new IoT system was also developed to monitor microclimate at seed warehouse (Figure 24). For now, the system assisted in improving the warehouse design by providing data for analysis. A component for remotely controlling warehouse ventilation mechanisms (e.g. fans, humidifiers, and windows) which can be accessed thru a web and mobile dashboard by warehouse managers was added. This system at CES will be duplicated at the branch stations. Furthermore, RIoT outputs were presented to students, training and conference participants, guests, and visitors in events and occasions, particularly during the Lakbay Palay, Federation of Plant Science Societies of the Philippines Conference, and PhilEASNet AFFNR symposium, to increase awareness on the possibility of improving productivity using advanced ICTs.

*Figure 23. The upgraded rice paddy monitoring device prototype*


*Figure 24. The microclimate sensing device installed at the CES seed warehouse (left) and the remote dashboard at the office showing real-time microclimate readings (right).*

## Applications of UAV Systems in Rice Farming (R-Drone)

*RF Barroga, NL Caballong, PAA Alday, EM Dicen III, MJC Sotto, JG Tallada, DKM Donayre, EC Martin, OE Manangkil, WV Barroga, RC Braceros, WB Collado, RV Bermudez Jr., and SD Cañete*

This study explored and developed rice farming applications on the use of different drone technologies. Precision agricultural drones capable of spraying liquids and spreading granular fertilizer and rice seeds were tested in 2019 DS and WS. The drone equipment and operation were provided by New Hope Corporation through a Memorandum of Agreement. Three experiments on the use of drones for granular fertilizer application, pre-emergence herbicide spraying, and direct seeding were conducted in partnership with researchers from ASPPD, CPD, and PBBD, respectively. Result showed promising potential in substituting manual operation with drones in the abovementioned rice farming operations. Preliminary results showed that using a drone in spraying reduced operation time from 5h (manual) to 30min/ha. Technology demonstration in actual field using precision drones for direct seeding and pre-emergence herbicide application were established at the FutureRice farm (Figure 25), REMD area, and DA-WESVIARC in 2019 WS. Yield data gathered in the FutureRice and REMD trials was 5.5t/ha, which was above average using manual direct-seeding method. The DA-WESVIARC setup, on the other hand, was discontinued due to lapses in land preparation that contributed to low penetration of seeds resulting to bird infestation. Separate experiments were also conducted to pilot test the drone for fertilizer application in 2019 DS. For drone-aided direct seeding, results showed that the drone broadcast treatment had higher average grain weight and average estimated yield compared to manual application. However, the fertilizer broadcasting using drone was halted due to the corrosive property of Urea and the observed limitation of the drone tank for broadcasting several bags of fertilizers. Moreover, promotion and awareness campaign activities were organized at PhilRice Isabela, Apayao, Ilocos Norte, and Iloilo which were attended by PhilRice researchers, rice farmers, cooperative leaders, LGU agriculture officers, and extension workers (Figures 26-27).


*Figure 25. Rice, grown by drone techno-demonstration plot at FutureRice farm*

*Figure 26. Drone flight demonstration in San Nicolas, Ilocos Norte*


*Figure 27. Mr. Nicky Ye of DJI demonstrating drone technology at PhilRic*

# Abbreviations and acronyms

AYT - Advanced Yield Trial
ABE - Agricultural and Biosystems Engineering
AEW - Agricultural Extension Worker
ATI – Agriculture Training Institute
AESA - Agro-ecosystem Analysis
AC - Amylose Content
BLB - Bacterial Leaf Blight
BLS -Bacterial Leaf Streak
BCA - Biological Control Agent
BS - Breeder Seeds
BPH -Brown Planthopper
BPI - Bureau of Plant Industry
CGMS - Cytoplasmic Genic Male Sterility
COF - Commercial Organic Fertilizer
CDA - Cooperative Development Authority
DAS - Days After Sowing
DAT - Days After Transplanting
DF - Days to Flowering
DM- Days to Maturity
DAR - Department of Agrarian Reform
DA-RFOs - Department of Agriculture-Regional Field Offices
DoF - Department of Finance
DOLE - Department of Labor and Employment
DTI - Department of Trade and Industry
DSR - Direct-seeded Rice
DS - Dry Season
FBS – Farmers' Business School
FC - Farmers' Cooperative
FSM - Farming Systems Models
FAA - Fish Amino Acid
FGD - Focused Group Discussion
FSP - Foundation Seed Production
FRK - Farm Record Keeping
GABA - Gamma-aminobutyric Acid
GT - Gelatinization Temperature
GAD - Gender and Development
GYT - General Yield Trial
GCA - Genetic Combining Ability
GIS - Geographic information system
GEMS - Germplasm Management System
GAS - Golden apple snail
GL - Grain length
GQ - Grain quality
GW - Grain Weight
GY - Grain Yield
GLH - Green Leafhopper
GOT - Grow Out Test
HR - Head Rice
HRA - Heat Recovery Attachment
HIPS – Highly-intensified Production System
HQS - High-quality Rice Seeds
HON - Hybrid Observational Nursery
HPYT - Hybrid Preliminary Yield Trial
ICT - Information and Communication Technology
IEC - Information Education Communication
IBNM - Inorganic-based Nutrient Management
ICM - Integrated Crop Management
IPM - Integrated Pest Management
JICA - Japan International Cooperation Agency
IRRI - International Rice Research Institute
IA - Irrigators' Association
KP - Knowledge Product
KSL - Knowledge Sharing and Learning
LCC - Leaf Color Chart
LFT - Local Farmer Technicians
LGU - Local Government Units
LPS - Low Pressure Steam-operated
SB - Stemborer
LE-CYPRO - Lowland ecotype Cyperus rotundus
MFE - Male Fertile Environment
MSE - Male Sterile Environment
MAS - Marker-assisted Selection
MRL - Maximum Root Length
MR - Milled Rice
MER - Minimum Enclosing Rectangle
MOET - Minus-one Element Technique
MC - Moisture Content

MAT - Multi-Adaptation Trials
MCRTP - Multi-crop Reduced Till Planter
MET - Multi-environment Trial
MYT - Multi-location Yield Trial
NAAP - National Azolla Action Program
NCT - National Cooperative Test
NFA - National Food Authority
NRAM - National Rice Awareness Month
NSIC - National Seed Industry Council
NSQCS - National Seed Quality Control Services
N - Nitrogen
NBSP - Nucleus and Breeder Seed Production Project
NFGP - Number of Filled Grains Panicle
ON - Observation Nursery
OSIS - One Stop Information Shop
OBNM - Organic-based Nutrient Management
PL - Panicle Length
PW - Panicle Weight
PVS - Participatory Varietal Selection
PWD - Person with Disabilities
PhilMech - Philippine Center for Postharvest Development and Mechanization
PRISM - Philippine Rice Information System
PhilRice - Philippine Rice Research Institute
PSA - Philippine Statistics Authority
PTC - PhilRice Text Center
P - Phosphorus
PVS - Plant Variety Selection
K - Potassium
QTL - Quantitative Trait Loci
RCBD - Randomized Complete Block Design
RSP - Registered Seed Production
RBB - Rice Black Bug
RCEF - Rice Competitiveness Enhancement Fund
RCEP - Rice Competitiveness Enhancement Program
RCM - Rice Crop Manager
RHGEPS - Rice Hull Gasifier Engine Pump System
RPH - Rice Planthopper
RSTC - Rice Specialists' Training Course
RTV - Rice Tungro Virus
RBFHS - Rice-based Farming Household Survey
KQ - Kernel Quality
SV - Seedling Vigor
ShB - Sheath Blight
ShR - Sheath Rot
SMS - Short Messaging Service
SNP - Single Nucleotide Polymorphism
SWRIP- Small Water Reservoir Irrigation Project
SRB - Stabilized Rice Bran
SUCs - State Universities and Colleges
SB - Stem Borer
TESDA - Technical Education and Skills Development Authority
TDF - Technology Demonstration Farm
TRV - Traditional Rice Varieties
TOT - Training of Trainers
TPR - Transplanted Rice
URBFS - Upland Rice-Based Farming
WS - Wet Season
WCV - Wide Compatibility Variety
YSB - Yellow Stemborer

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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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