# 2022 PhilRice R&D Highlights

## SMARTerRice

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PROGRAM

# SMARTerRice

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## EXECUTIVE SUMMARY

"SMARTerRice" or "SMT" was the lone Research Program that had resulted from the deliberations of the PhilRice Think Tank Team. They were tasked to streamline the organizational processes of the Institute in light of achieving the precepts of our corporate Strategic Plan 2017-2022. The overall goal of the Program is to achieve resilient and modern rice and rice-based farming systems for increased productivity, efficiency, and profitability. Specifically, we aimed to (1) determine the productivity, efficiency, and profitability of different packages of technologies for the irrigated and favorable rainfed rice environments; (2) evaluate and develop modern rice-based farming models and value-adding technologies for enhanced multiple streams of income and resiliency; and (3) enhance the application of digital technologies for advancement and modernization of rice and rice-based farming systems.

Its component projects include (1) Modernized rice production technologies for irrigated lowland ecosystem, (2) Modernized rice production technologies for rainfed lowland ecosystem, (3) Modernized rice-based farming systems and value-adding technologies; and (4) Rice farming 4.0.

By employing a multi disciplinary approach, packages of PhilRice technologies were configured for the irrigated and rainfed rice environments. This may include agricultural machinery technologies for land preparation, crop establishment, irrigation, crop care, and harvesting. The minus-one-element technique (MOET) stood as the centerpiece nutrient management technology to formulate correct fertilizer rates and application timing recommendations. For more efficacious technology evaluation, farmers' fields were targeted, while providing opportunities to showcase the complementary nature of technologies as a package.

Rainfed sites were selected in the following locations: Cuyapo, Talugtug, San Jose City of Nueva Ecija; Currimao and Batac City of Ilocos Norte; and Brgy. Guisguis, Sta. Cruz of Zambales. From the focus group discussions (FGD), the main farmer concerns were unavailability of water needed for rice cultivation, unpredictability of the weather, and weed infestations.

Field trials showed the efficacy of the varieties and better nutrient management techniques like MOET. Varying grain yield results were obtained mostly comparable to or better than the yields of farmer-practice benchmarks. Through observations and interviews, information on the prevailing insect-pests and weeds was also noted.

Within the umbrella of the *Palayamanan* Plus, the Sorjan cropping system consisting of assorted vegetables, NSIC Rc 160, taro, and addition of Nile Tilapia generated a net income of P74.26/m2 for 2022 (higher than in 2021), which also exceeded the target of P30/m2. The new climate-resilient vegetable production system (CRVPS) had self-irrigating vegetable production integrated in aquaculture. Another model was the intercropping of lettuce with lowland rice by placing it hallowed bamboo. The third model used sub-surface capillarigation system for leafy vegetable production.

To reduce drudgery in mushroom production, a bagging machine developed by PhilRice engineers produced 101 fruiting bags with an average weight of 915g per bag in one hour compared to the 46 fruiting bags with average weight of 843g per bag by manual bagging. A basic training on hydroponics was conducted to 103 PhilRice staffers from various divisions, including representatives from Agusan, Isabela, and Los Baños branch stations. A benefit-cost analysis of lettuce production estimated an annual income of P73,366, with payback period of 3.19 years, a 31% return on investment, and a 1.24 benefit-cost ratio. PhilRice partnered with Pilipinas Kaneko Seeds Corp. Scanned and consolidated were 200 existing and value-adding technologies (food) for rice (100) and other rice-based farming crops (100). These technologies were validated, verified, compiled, and prepared into a "Compendium of value-adding technologies for rice and other rice-based farming commodities."

The rice melange and pandesal enriched with stabilized rice bran (SRB) technologies were validated. The rice melange—NSIC Rc 160 (white), Calatrava (black rice), and Rc 19 (red rice)—was found to be more nutritious than plain white rice (Rc 160) as evidenced by the melange's higher contents of ash, fat, and fiber. It also had antioxidant activity due to the presence of anthocyanin and phenolic compounds. The 5% SRB-enriched pandesal had a sensory score and consumer acceptability rating comparable to the control. Value-adding technologies for fresh tomatoes through drying and taro corms (tubers) processed into flour were developed. A heat-recovery attachment (cylindrical-type oven) for the rice hull carbonizer to roast chicken and pork belly (liempo) was also evaluated. Finally, advisories through linear programming optimization using LINGO software for rice-vegetables mixes for rainfed farms with limited water supply, labor, and capital were developed. Initial validation of the CROP MIX APP for planting four crops showed that it can attain a net income of P168,164, which was significantly higher than the survey results of P116,879.

The Rice Farming 4.0 main components are: improvement of the AgriDoc app; Internet of Things for networked sensors and actuators in the field; agricultural drones; and agricultural robotics. The app improvement included features for agricultural supplies, service providers, and traders. Aside from farm inventory management and operation logging. Internet of things (IoT) devices for the irrigation gate control, AWD (alternate wetting and drying), greenhouse monitors, and furnace controller for the REMD 6-ton flatbed dryer were based on ESP32 microcontrollers. Using drones in partnership with AgriDOM Corporation, experiments were conducted during the dry and wet seasons (DS and WS) of 2021 and 2022, using their DJI Agras T16. Trials at the FutureRice Farm tested the possibility of reducing seeding rates for NSIC Rc 402 to 40kg/ha and 20kg/ha. Seeding rate trials of 18kg/ha and 10kg/ha were conducted for Rc 204H (Mestiso 20). A robotic seeder was developed using 1000W brushless motors, controlled by an ESP32 through a motor driver. A partnership with the UST College of Engineering, through its Research Center for Natural and Applied Science resulted in the RoboTractor project with Department of Science and Technology -Philippine Council for Agriculture, Aquatic, and Natural Resources Research and Development, which was tested within PhilRice.

## CORE-FUNDED PROJECT 1

# Modernized Rice Production Technologies For Irrigated Lowland Ecosystem

**Elmer G. Bautista and Kristine S. Pascual**

This project aims to integrate, validate, and test the adaptability of the best package of technologies for rice production that can help increase rice productivity, improve cost-efficiency, and enhance the market competitiveness of farmers in irrigated areas. Field trials were established during 2021-2022 DS and WS in PhilRice CES, Tarlac, Isabela, and Nueva Vizcaya. For every farmer-cooperator, a demo field (researcher-managed field or POTs) was established along with five additional areas following the farmer's practice in each location.

Results showed a 5.0% and 1.6% increase in grain yield in Tarlac and Isabela/Nueva Vizcaya sites, respectively by 2022 and a 22.3% and 8.5% reduction in cost of production relative to farmer's practice in Tarlac and Isabela/Nueva Vizcaya, respectively, by 2022.

In Tarlac, the unit cost of production of *palay* for both treatments increased compared to the previous season because of the spike in fuel prices. Despite that, the cost for POT was lower by 20.3% in DS (P12.6/kg) and 24.2% in WS (P11.6/kg) compared with farmers' practice (FP) (P15.8/kg in DS and P15.3/kg in WS). The lower cost was attributed to mechanical transplanting with a lower seeding rate, the use of inbred variety, and a lower amount of fertilizers based on the recommended MOET compared with FPs. In terms of yield, POTs were higher by 15.2% (5.3t/ha) during the DS but lower by 6.3% (4.5t/ha) in WS compared to FPs (4.6t/ha and4.8 t/ha).

For Nueva Vizcaya, the grain yields of the POTs were higher by 10.3% in DS (7.6 t/ha) but 7.5% lower in WS (5.3t/ha) compared with FPs (6.8t/ha and 5.7t/ha). FP had a higher DS cost by 9.3% (P8.6/kg) than the POTs (P7.8/kg); higher by 5.8% in FP (P9.8/kg) than POTs (P10.4/kg) in the WS. These were attributed to the cheaper mechanical transplanter and lesser chemical applications in the POTs field.

In PhilRice CES, mechanical transplanting yielded higher by 1t/ha than the Waray method. The Kubota-MOET (6.7t/ha) performed better during DS; the Shakti transplanter-LCC during WS (4.9t/ha). The lowest cost was P8.2/kg (WS) using Kubota with MOET; the highest was P11.7/kg using Waray in DS.

The learnings during the first year of the project helped the POTs to achieve higher than or equal yields with the FPs. This proves that site-specific technologies are very important in increasing farmers' yield and income. In all sites, the POTs incurred lower cost than FP due to the use of mechanical transplanter, MOET-based nutrient management, high-quality inbred varieties, and proper timing of chemical applications.

## CORE-FUNDED PROJECT 2

# Modernized Rice Production Technologies For Rainfed Lowland Ecosystem

**Dindo King M. Donayre and Ailon Oliver P. Capistrano**

This project aims to establish and evaluate the best package of modern rice production technologies for the favorable rainfed lowland environment. A total of 24 sites evaluated the best POT for Nueva Ecija and Ilocos Norte in CY 2021; 48 sites in CY 2022 including those in Zambales. Villages having large areas of rainfed rice were selected for the site validation, the conduct of focus group discussions (FGD), identification, and selection of farmers. FGDs determined the prevailing rainfed farmers' practices as to varieties, months of establishment, land preparation, pest/water/nutrient management, and harvesting. Results of FGD showed that unavailability of water needed for rice cultivation, unpredictability of the weather, and weed infestations were the common main concerns of the farmers. These concerns then were used as a basis for packaging technologies. Two months before land preparation or planting, a series of soil samplings were conducted on rainfed rice fields for the set-up of the minus-one-element technique (MOET). Results showed that fields in Cuyapo were deficient by 67% on Nitrogen (N) and Phosphorus (P); 17% on N, P, and (Potassium) K; and 17% for N and Zinc (Zn). Fields in Talugtug were deficient by 100% on N, P, and Sulfur (S); in Batac City, they were 100% deficient on N, P, K, and S. Fertilizer recommendation rates for each farmer field were then generated based on the MOET matrix. The POT was employed depending on the common crop establishment method in the area. It was then compared to the prevailing farmers' conventional practices (FP).

In 2022, the replicability of POT for transplanted rice (TPR) was also tested in six sites in Currimao, Ilocos Norte; 13 sites for transplanted, and wet and dry direct-seeded rice (DSR) areas of Sta. Cruz, Zambales. A series of FGD and soil samplings were also conducted to determine the farmers' practices and issues in rice farming.

## DRY SEASON 2022

Cuyapo, Nueva Ecija

The mean yields of wet DSR in sites with POT were 5.96, 6.10, and 6.01t/ha in 5, 8, and 10t/ha target yields; FP had 4.87t/ha. Three out of four sites with POT hit the 5t/ha target yield; none hit the 8 and 10t/ha. None of the sites hit the target 30% production cost reduction.

**Talugtug, Nueva Ecija**

The mean yields of TPR in sites with POT were 6.32, 6.61, and 6.68t/ha in 8, 9, and 10t/ha target yields; FP had 6.38t/ha. One site with POT hit the 8 t/ha target yield but no site hit the higher targets. No site hit the target 30% cost of production reduction.

## WET SEASON 2022

The mean yields of TPR across Talugtug WS sites with POT were 4.87, 5.14, and 5.08t/ha in 5, 6, and 7t/ha target yields; 5.16 t/ha in FP.

### San Jose City, Nueva Ecija

The mean yields of dry DSR across sites with POT were 4.44, 4.03, and 4.20 for 5, 6, and 7t/ha target yields; FP had 4.17t/ha. Only one site hit the 5t/ha target yield; the rest were below target. No site hit the target 30% cost of production reduction.

### Currimao, Ilocos Norte

Rainfed farmers drew water from shallow tube wells (STWs) to supplement crop requirements. Top inbred varieties planted are PSB Rc 18 and Rc 82 and NSIC Rc 160, Rc 216; while hybrids are Bioseed Rice 650, LP 2096, PHB 77, and NK 5017. Seeding rates were 40-60kg and 20-25kg/ha for inbred and hybrids. Other crops are planted after rice such as mungbean, tobacco, and corn. Increasing labor wages (P350/MD), lack of available labor (shift to construction jobs), and the sudden increase (2-3x higher) of farm inputs were the common problems in the locality that reduced planted rice areas due to capital problems.

The mean yields of TPR across sites with POT were 5.26, 5.71, and 6.08t/ha in 5, 6, and 7t/ha target yields, respectively. No site hit the 30% production cost reduction. Best technologies were complemented with technical know-how. Farmer-cooperators were equipped with skills in machinery operations (transplanter, mechanical seeder, etc.), seedbed preparation, establishment of MOET setups, and use of MOET App. The field setups were showcased to other stakeholders through a *Lakbay Palay*.

### Batac City, Ilocos Norte

Field validation setups were established in six sites following the modern POT with 6t/ha yield target. Crop productivity was pulled down by inclement weather conditions, disease infestation, and nutrient deficiency. Two sites were omitted due to severe sheath blight infestation. Based on potential yield, the POT attained and even exceeded the 6t/ha target in the three sites. Total production cost was P66,006/ha at P12.27/kg. The POT earned a gross income of P99,485 and a profit of P33,479/ha.

### Brgy. Guisguis, Sta Cruz, Zambales

Focus group discussion (FGD) was conducted to collect important information on the overall rice production practices of the village and determine issues and concerns surrounding their farming activities. A series of soil samplings determined nutrient deficiencies and generated MOET recommendations for each site. Results of FGD confirmed that the community is rainfed, but every farmer owns a water pump and a shallow tube well (STW). Most farmers manually transplanted NSIC Rc 160, Rc 222, and Rc 480. Most farmers were concerned with nickel contamination resulting in low yields. Half of their fields are deficient in N, P, K, S, and Zn.

The mean yields of wet DSR in three sites with POT were only 3.84, 4.06, and 4.20 t/ha for the target yields of 5, 6, and 7t/ha. No site hit the target 30% production cost reduction.

The mean yields of TPR in five sites with POT were only 4.51, 4.59, and 4.80t/ha for the target yields of 5, 6, and 7t/ha.

**Brgy. Bangcol, Sta. Cruz**

The FGD and soil sampling were done to collect important information on the overall rice practices of the village. The rainfed community could only plant rice once a year from May to June; manual broadcasting at a 100kg seeding rate; using NSIC Rc 222. The mining company nearby assists by lending farmers additional farm inputs. Unavailability of water and weed infestations are their top burdens. It was around 2016-2021 when they experienced nickel laterite and drought, for which they received assistance (seeds, training, and seminars) from the LGU. MOET analysis showed that 33% of the sites were deficient in N alone.

The mean yields of wet DSR across sites with POT were 5.26, 5.54, and 5.04t/ha in the 5, 6, and 7t/ha target yields; 3.99t/ha in FP. Two sites gained the target 0.5t/ha yield increase.

The mean yields of dry DSR across sites with POT were 5.25, 5.33, and 5.23 t/ha in the 5, 6, and 7t/ha target yields; 4.36 in FP. Ten sites gained the target 0.5t/ha yield increase. No site hit the target 30% production cost reduction.

## CORE-FUNDED PROJECT 3

# Modernized Rice-Based Farming Systems and Value-Adding Technologies

**Marissa V. Romero and Myrna D. Malabayabas**

The Sorjan cropping system consisting of alternate sinks and raised beds, pond refuge, trellis for vine vegetables and perimeter crops was improved by determining the best commodities that could contribute to higher net income per unit area. Assorted vegetables, NSIC Rc 160, taro and addition of Nile Tilapia were evaluated. Its components generated a higher-than-2021 net income of P74.26/m2, exceeding the target of P30/m2.

An exploratory study developed a new climate-resilient vegetable production system (CRVPS) to address climate-related challenges such as extreme drought, heavy or continuous rain, and rise in ambient air temperature, among others.  One system is the self-irrigating vegetable production integrated in aquaculture, which proved to work for string beans and eggplants tested inside the *Palayamanan* farm (Figure 1). Another model is the vegetable intercropped with lowland rice. Lettuce seedlings were placed in bamboo as containers positioned in between rows of newly transplanted rice. Capillary wicks were provided to allow entry of water inside the bamboo container. The third model involved the use of sub-surface capillarigation system for leafy vegetable production. This was combined with net tunnel as protective structure.

The mushroom bagging machine developed by PhilRice engineers was able to produce 101 fruiting bags (915g/bag) in 1h compared to the 46 fruiting bags (843g/bag) in manual bagging (Figure 2). The machine-produced fruiting bag needs to be pressed manually to become compact.

A basic training on hydroponics was conducted with 103 PhilRice personnel from various divisions including representatives from Agusan, Isabela, and Los Baños branch stations (Figure 3). A benefit-cost analysis of year-round lettuce production estimated an annual income of *P*73,366.70, with payback of 3.19 years, return on investment of 31%, and 1.24 benefit-cost ratio. PhilRice partnered with Pilipinas Kaneko Seeds Corp. to showcase lettuce varieties in hydroponics and aeroponics vertical gardens for two growing cycles. Results showed that plants at the top of the tower were significantly heavier by 31-63% compared to those in the middle and bottom segments.

A total of 200 existing and value-adding technologies (food) for rice (100) and other rice-based farming crops (100) were scanned and consolidated. These were validated, verified, compiled, and prepared into a "Compendium of value-adding technologies for rice and other rice-based farming commodities" (Figure 4).

Two previously developed technologies were validated: rice melange (Figure 5) and pandesal enriched with stabilized rice bran (SRB) (Figure 6). For rice melange, NSIC Rc 160 (white), Calatrava (black rice), and Rc 19 (red rice) were processed and mixed at an 8:1:1 proportion. Polishing both black and red rice for 15sec and soaking the melange for 15min prior to cooking produced better eating quality compared with the unpolished and unsoaked sample. Melange is more nutritious than plain white rice (Rc 160) as evidenced by its higher contents of ash, fat, and fiber. It also exhibited some antioxidant activity due to the presence of anthocyanin and phenolic compounds. For SRB-enriched pandesal, rice bran from Rc 160 was collected, sieved, steam-heated for 15min, oven-dried at 70°C for 1ha, and added into the pandesal dough at different levels (0, 3, 5, and 10%). Among the treatments, pandesal enriched with 5% SRB obtained sensory score and consumer acceptability rating comparable with the control. It also contained higher amounts of protein, ash, and fiber.

Value-adding technologies for fresh tomatoes and taro corms (tubers) harvested at *Palayamanan* were developed. Fresh tomatoes were processed into dried tomato flakes through oven-drying at 50 to 60°C for 12-16h (Figure 7). Percent recovery was 8% based on the fresh tomato weight. The product received good sensory acceptability and contained higher amount of ash, fiber, phenolic compounds, and antioxidants. Meanwhile, taro tubers were processed, oven-dried at 60°C for 24h, ground into flour, and sieved. Percent recovery was 17% based on the fresh taro weight. Processing of taro into flour resulted in generally higher proximate composition. It was used as base ingredient in the preparation of ice cream (Figure 8). The product received good acceptability among the panelists.

The suitability and effectiveness of the heat-recovery attachment (cylindrical-type oven) of the rice hull carbonizer to roast chicken (Figure 9) and pork belly (liempo) (Figure 10) were evaluated. Results of several trials showed that it can roast for 2h using 50kg of rice hull.

Advisories on the optimization of rice-vegetables mixes for rainfed farms with limited water supply, labor, and capital were developed. A linear programming (LP) model was formulated using LINGO software with income maximization as its objective function, and the usual production factors were used as constraints. The results and analysis derived from the LP model were executed in the technical coefficient application (TCG app), and CROP MIX APP developed that consequently followed the generated optimal cropping mixes. Initial validation of the CROP MIX APP showed that based on the forecasted income, planting four crops can attain a net income of P168,163.50, which is higher than the P116,879 computed net income in the average production cost and return survey.

## CORE-FUNDED PROJECT 4

# Rice Farming 4.0

**Jasper G. Tallada and Nehemiah L. Caballong**

The project is after integrating various information, electronics, and communications technologies (ICT) into rice farming for the realization of Agriculture 4.0 for rice production. The main components are: improvement of the AgriDoc app; Internet of Things for networked sensors and actuators in the field; agricultural drones; and agricultural robotics.

An improved version of the AgRiDOC App UX design was developed to include selling of farm products, buying input supplies, and availing of services. The main impetus of the improvement was to include agricultural supplies and service providers, and traders aside from the farm inventory and logging of operations. The mobile phone platform is to be developed using Android Studio as the development tool. UX design prototypes were created for the homepage wherein all functions can be accessed.

An improved version of the microclimate monitoring device design was also developed and installed. Internet of Things (IoT) is based on microcontrollers, which can be connected to the internet through which sensor data can be transmitted to a central server, and field actuators can be controlled following a pre-defined algorithm. The irrigation gate control at the FutureRice was based on the more versatile ESP32 microcontrollers. AWD monitors were connected to the system for automated control based on the water levels in the field. The same system was installed at the REMD model farm which was used by Engr. Paul Ramos for his dissertation. Several units of environmental (microclimate) monitors were developed that used waterproof SHT20 temperature and relative sensors. The units were briefly used at the greenhouses that showed critical levels of temperature exceeding 35°C. Similarly, units were also used for monitoring the BDD reversible flatbed dryers and for the seed warehouse monitoring. A furnace controller for a 6-ton flatbed dryer facility at REMD was also developed and installed based on the ESP32 microcontroller platform.

Agricultural drones are recent technologies that can be used for autonomous seeding, fertilizing, and chemical spraying. In partnership with AgriDOM Corporation, experiments were conducted in DS 2021 and WS 2022 using their DJI Agras T16. Experiment trials at FutureRice Farm tested the possibility of reducing the seeding rates for NSIC Rc 402 to 40kg/ha and 20kg/ha. In the same manner, seeding rate to 18 and 10kg/ha experiments were conducted for NSIC Rc 204H (Mestiso 20). In  all trials, comparable yields were obtained. For methods comparison, a side-by-side trial on using drone versus drum seeder for direct seeding of NSIC Rc222 was made yielding also similar productivity despite differences in seeding rates. Fertilizer and weed experiments were also conducted with promising results. Various technology demonstrations were held at different locations.

A robotic seeder was developed focusing on the propulsion platform onto which seeding meters or units can be fastened. The early approach was to use 24V DC 350W gear motors and an Arduino-based MEGA2560 microcontroller with BTS7960 high-voltage high-current motor driver. An improved design using 1000W 48V BLDC motors was used and driven by a 1000W motor driver and controlled using an ESP32 microcontroller

The UST College of Engineering through its Research Center for Natural and Applied Science particularly with the team of Dr. Anthony James C. Bautista had partnered with PhilRice for their RoboTractor project with DOST-PCAARRD. On top of the project, Dr. Bautista had allowed Dr. Jasper Tallada to undergo training on the development of drones as part of the DOST-PCIEERD Project on AquaDrone. Future collaborations are being planned with them.