Department of Agriculture

PHILRICE®

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DA-PHILRICE R&D HIGHLIGHTS

RICE ENGINEERING AND MECHANIZATION DIVISION

Content

DIVISION

Rice Engineering and Mechanization Division

Arnold S. Juliano

EXECUTIVE SUMMARY

Rice Engineering and Mechanization Division (REMD) developed technologies that mechanize and modernize farming operations to help reduce production cost and postharvest losses and optimize land, water, and other farm inputs, leading to enhanced productivity; market competitiveness, and climate change resiliency of rice/rice-based farmers.

The division managed four projects: (1) Division Operation and Services, (2) Express Lane Commercialization of Priority REM Matured Technologies, (3) Development of Engineering and Mechanization Technologies, and (4) Farm Service Center. The first project supports the research activities and delivery of services of the Institute through the following project components: (a) Provision of workshop services that cater to service requests of customers in custom fabrication and related metal working activities; and (b) Agricultural and Biosystems Engineering (ABE) related services, which cover the extension of technical assistance to clients and partners, engineering support to operation and branch stations, farm consolidation and mechanization services, and operation and maintenance of the institute weather stations at PhilRice CES and branch stations.

The second project aims to transfer matured rice engineering and mechanization (REM) technologies to agricultural machinery manufacturers for commercial production, formulate and implement marketing and promotion strategies for adopting and using REM technologies by rice farmers, and accelerate the pre-commercialization of promising REM technologies. The third project aims to develop engineering and mechanization technologies that would help make men and women farmers become globally competitive and climate change resilient. The fourth project intends to establish a systematized farm service center for research and seed production, which will be implemented in PhilRice CES and later in its branch and satellite stations while generating income for sustainability.

PROJECT 1

Division Operation and Services

Joel A. Ramos

It is the core function of the Rice Engineering and Mechanization Division (REMD) to deal with developing engineering interventions for improving productivity and increasing rice farmers' income. This is being implemented through developing farm machinery and equipment suited for local introduction and addressing the needs of Filipino rice farmers. Creating linkage and partnership with the local farm machinery manufacturers during concept development and the initial phase of technology commercialization helped bring technologies to the intended users. This reduces the gap between product developers and the users and creates mutual understanding among technology developers and farm machinery manufacturing industry key players.

REMD is also taking steps to ensure that developed technologies are promoted and reached by the customers, particularly during the transition phase of research to commercialization in coordination with concerned offices like the Business Development Division for commercialization and with the Training and Management Services Division for the technology identification and assessment.

Engineering solutions is a core competency of the division. Hence, this project was crafted and expanded to support research activities and delivery of services of the Institute through the following project components: (1) Provision of workshop services that cater to service requests of customers in custom fabrication and related metal working activities; and (2) Agricultural and Biosystems Engineering (ABE) related services, which cover the extension of technical assistance to clients and partners, engineering support to operation and branch stations, farm consolidation and mechanization services, and operation and maintenance of the institute weather stations at PhilRice-CES and branch stations.

In 2021, the project accommodated 42 service requests and 40 machine inquiries on custom fabrication and technical assistance to clients, apart from the engineering services and support to the divisions, projects, and branch stations. These services contributed to strengthening PhilRice institutional capability.

PROJECT 2

Express Lane Commercialization of Priority REM Matured Technologies

MJC Regalado

Since 1991 PhilRice, through its Rice Engineering and Mechanization Division (REMD), has developed and continues to generate engineering and mechanization technologies that cater to the needs of Filipino rice farmers. REMD has produced farm machinery and equipment prototypes such as the micro tiller, laboy tiller, riding-type leveler, drum seeder, rotary reaper, Maligaya flatbed dryer, reversible airflow dryer, seed cleaner, micro rice mill, multi-crop flour mill, and Maligaya rice hull stove. REMD collaborated with private manufacturers who developed these technologies into commercial products adopted by farmers, seed growers, and rice or food processors.

The division generated promising technologies: (1) riding-type boat tiller; (2) combine harvester; (3) riding-type transplanter; (4) gear-transmission power tiller with tillage implements and transplanter attachment; (5) multi-crop reduced-till planter; (6) combined conduction and far-infrared radiation dryer; (7) continuous-type rice hull gasifier-engine-pump system; (8) dual-fueled producer gas-diesel engine system; and (9) typhoon-resistant multi-purpose farm structure called "kwebo." These technologies are ready either for technology transfer and commercialization or pre-commercial development in partnership with local fabricators and manufacturers.

After passing an endurance test covering 20ha and accumulating 160 hours of field operation, the buoyant riding-type tiller was considered ready for technology transfer to a local manufacturer. The ACT Machineries and Metalcraft Corporation of Cauayan, Isabela, acquired a favorable fairness opinion report from DOST and was licensed by PhilRice to commercialize the tiller. ACT initially manufactured eight units for PhilRice, which were tested at CES before deployment. Four units were deployed to PhilRice REMD Farm Service Center and PhilRice Isabela, Agusan, and Midsayap branch stations. Technology demonstration and training on land preparation using the riding-type tiller were carried out at PhilRice CES and Isabela.

The combined harvester, riding-type transplanter, and far infrared dryer are in various pre-commercialization stages. Davao Beta Spring Inc. (DBSI) has fabricated its first and second combine harvester pre-commercial units, which featured improvements in the original

PROJECT 2

PhilRice prototype such as the hydrostatic power transmission to make harvesting operation more manageable and smoother. Both units were field-tested, and the second prototype is presently being improved to increase operational speed and field capacity and reduce overall weight.

Meanwhile, Rollmaster Machinery and Industrial Services Corporation (RMISC) of San Pedro, Laguna, has fabricated an improved model of the riding-type transplanter with a hydrostatic transmission replacing the previous gear transmission. Preliminary field trial results showed that the improved transplanter would be ready for field performance testing in 2022. RMISC has also improved one PhilRice combine harvester prototype by replacing its power transmission from gear to hydrostatic.

The project's dryer team also completed functionality tests of the main components of the combined conduction and far infrared radiation paddy dryer installed at the Sto. Nino Multipurpose Cooperative in Butuan City. With the rice husk gasifier, rotary drum dryer, oscillating grain cooler, far infrared radiation dryer, and bucket elevators modified or adjusted to function according to design specifications, the dryer, which Torralba Metalcraft Inc. of Butuan City fabricated, would be commissioned during the rice harvest season in March-April 2022. In addition, RS Welding Shop of San Jose, Occidental Mindoro, has started fabricating another pre-commercial unit of the dryer, which will be installed at the Kooperatiba ng Pamayanang Kristiyano ng Mapaya, a farmers' cooperative in San Jose, Occidental Mindoro. Overall, the fabrication of this dryer, which DOST-MIMAROPA funds, was about 80% complete.

Through a tripartite agreement, PhilRice partnered with the Isabela State University – Echague Campus in the field testing of the pre-commercial unit of the PhilRice multi-crop, reduced till planter that ACT Corporation fabricated. PhilRice and ISU conducted a half-hectare farmer's field trial in Mabuhay, Echague, in November, where rice, corn, and mungbean crops were established. AMTEC tested this pre-commercial unit at a farmer's field in Cauayan in December.

The gear-transmission power tiller with land preparation implements has passed 160 hours of intermittent endurance tests covering an aggregate of 20.5ha. Working drawings were prepared for P.I. Farm Products, Inc. of Valenzuela City, makers of the famous Lakas Kuliglig hand tractors and other farm machinery, which engaged in a research partnership with PhilRice to develop the improved power tiller further. P.I. Farms will also fabricate the PhilRice-developed walk-behind mechanical transplanter attachment to the gear-transmission tiller.

The continuous-type rice hull gasifier-engine pump system was installed at the 4-ha REMD farm. It was intermittently run for 60 hours from January to October. The average water discharge was 8L/s at 7.6kg/h rice hull consumption. The system logged a total operation time of 127 hours (July 2020 – October 2021). Continuous operation of the system could last up to 3 hours.

LG Lopez Industrial Sales and Services of Calamba, Laguna, has fabricated the PhilRice-designed continuous-flow gasifier for a dual-fueled (producer gas and diesel) single-cylinder diesel engine. The system was tested and modified to include a columnar gas filter using rice husk as absorbent. The producer gas from the gasifier could substitute up to 80% of the diesel fuel used for water pumping at a discharge rate of 15L/s. During training on biomass gasification conducted by PhilRice in collaboration with DA-BAFE for 35 DA-RFO agricultural and biosystems engineers demonstrated the prototype for electric power generation.

"Kwebo" with a 46 m^2 floor area as a poultry house for 100 free-range chickens was also constructed in Zaragoza, Nueva Ecija. During the establishment, four farmer-workers (two unskilled and two skilled) were trained on its construction, mainly made of materials such as bamboo, cement, sand, and mesh wire. The construction period was 106 days with a total cost of PhP138,735.

In addition, one of the project's objectives of formulating and implementing marketing and promotion strategies for the adoption and use of REM technologies by rice farmers was crystallized in a proposal titled "Technology Transfer, Commercialization, and Adoption of the Philippine Rice Combine Harvester in Bayanihan Agri-Clusters," which was prepared, presented to the PhilRice project review and evaluation committee and would be proposed for funding by the Department of Agriculture.

PROJECT 3

Development of Engineering and Mechanization Technologies

Ricardo F. Orge

This project developed engineering and mechanization technologies that can help men and women farmers become globally competitive and climate change resilient.

In particular, it deals with developing technologies for mechanizing rice production and postproduction operations that would enhance efficiency in the use of labor and other inputs, ensured timeliness of operation, reduced losses, and, ultimately, reduce the cost of operation.

Attain such; the project comprises studies categorized under three components. The first component deals with developing technologies for mechanizing rice production (land preparation to harvesting) and is complemented by the second component, which deals with developing rice postproduction technologies (drying to milling). In addition, the third component deals with conducting short-duration exploratory experiments that may lead to developing more advanced cost-reducing and resilient-enhancing technologies.

The six farm machines under component 1 were mainly undergoing a series of test runs and design modifications to improve performance under actual operating conditions. For example, the riding-type boat tiller underwent design modifications of specific parts to address mobility problems when working in deep-mud conditions. The same is true for the multi-purpose mini-tractor, which still needed further improvements, particularly its power transmission system. Seeding machines were also in the development process - one was designed to be attached to the gear transmission power tiller, which underwent field tests and design refinements prior to pilot testing in 2022. The other one is a self-propelled 8-row riding-type paddy seeder under fabrication. In addition, the engine-powered mechanical weeder completed its 50-hour endurance test, a unit deployed for pilot testing in a farmer's field in Sibunag, Guimaras, which initially received positive feedback from its user. Lastly, the fabrication of the stripper combine harvester was just completed and ready for testing by 2022.

Under component 2, the fabrication and preliminary test runs of the 2-ton reversible paddy dryer prototype have been completed.

PROJECT 3

They are now ready for testing and performance evaluation by the dry season of 2022. addition, the manually-operated brown rice machine completed and passed its 50-hour endurance tests with some refinements to further improve its performance. Unit of it was deployed to PhilRice-Bicol station for pilot testing.

Under component 3, two ideas were explored and initially evaluated for their cost-reducing and resilience-enhancing potential. One is using steam to create vacuum as a mechanism for pumping water and the other is recovering transpired water from trees for possible use as a supplemental source of irrigation water during extreme drought conditions. Up short-duration experiments still need to be done to get data to evaluate the technical feasibility of these ideas. Nevertheless, with all of these modest accomplishments in 2021, the project is fairly on its track towards helping attain the targeted outcome of increased productivity, cost-effectiveness, and profitability of rice farming sustainably through developing these technologies.

PROJECT 4

Farm Service Center

Arnold S. Juliano

FIELD OPERATIONS

From June to December 2021, 223 requests were received and acted. These requests involved 2021 W.S. land preparation, crop establishment, and harvesting operations and 2022 D.S. land preparation and crop establishment operations.

REPAIR AND MAINTENANCE

The repair and maintenance sector ensures that all farm machinery and equipment are well maintained and utilized. A preventive maintenance program was modified and implemented to ensure that all farm machinery and equipment were serviced regularly. The Farm Service Center has 106 farm machinery and equipment units, including the units collected from other divisions. According to the current status, 87.7% of farm machinery and equipment is serviceable, and obtains 109.6% of well-maintained and utilized farm machinery and equipment based on targets (80% based on DPCR).

GENERAL MAINTENANCE

The FSC General Maintenance of farm roads, irrigation, and drainage canals are our field laborers' most common daily routine. The daily activities of field laborers/technicians assigned to general maintenance. Regular inspection of farm roads, pump houses, irrigation, and drainage canals shall be conducted to prevent farm operation interruptions. Maintenance activities include: mowing and grass cutting, maintaining/cleaning farm canals, and filling up/re-gravel of the damaged part of the farm roads

SALES AND MARKETING

The Sales and Marketing sector had a total amount collected for the field operations, rental services, and irrigation fees amounting to PhP4,066,562.60. Every month, billings were prepared and distributed to other divisions for the acceptance of services rendered by FSC through the Field Operation Sector and for the certification of the Division Heads. Following that, FSC immediately processes the billings so that the funds collected are transferred to the account to be utilized for FSC's operational expenses. The Sales and Marketing Team also established a collection fund account for FSC, resulting in an overall savings of PhP1,710,324.97. This contributes to FSC's goal of achieving financial sustainability by generating PhP1M annually.

Extra-core Project 1

Water-Efficient and Risk Mitigation Technologies for Enhancing Rice Production in Irrigated and Rainfed Environments (WateRice)

Manuel Jose Regalado, Sudhir Yadav, Madonna Casimero, Elmer G. Bautista, Rizal G. Corales, Jovino L. De Dios, Edwin C. Martin, Kristine S. Pascual, Dindo King Donayre, Virender Kumar, Joel Janiya, Gio Evangelista, Oliver Silvela Jr, Mary Ann Burac, Joseph Sandro, Bjorn Manuel, and Johannes Mendoza

In line with the RDE agenda of the Philippine Rice Industry Roadmap 2030, WateRice aims to increase rice production efficiency, which will result in higher yields at lower production costs, higher income for farmers, increased productivity of using critical inputs, such as water, as well as reduced risks, through the development, dissemination, and adoption of appropriate crop management technologies in irrigated and rainfed environments.

The project has five thematic areas called work packages. **WP1** focuses on understanding critical knowledge gaps through gathering data and information on current management practices and perceptions of farmers in target areas.

A rapid rural appraisal through key informant interviews (KII) and a face-to-face survey of 150 farmers (26 female and 124 male) was conducted in the 2021 dry season (D.S.) to assess a prospective site in Nueva Ecija for introducing the DA farm clustering and consolidation strategy called Bayanihan Agri-Cluster (BAC) and evaluating its suitability for testing at landscape level the AutoMon^{PH}-based irrigation advisory service (IAS). Results of the KII conducted at five contiguous barangays, three in the Science City of Muñoz and two in Guimba, showed that almost all farmers at the site are unfamiliar with the BAC.

However, after the BAC was explained to them, almost all the respondents (94%) said that they would join the BAC because they thought it would effectively help the farmers, solve problems in sharing of irrigation water, and enable them to learn new technologies applicable to their farms. Predominantly, their irrigation water source is the turnouts from the NIA-UPRIIS Casecnan lateral. Most farmers follow the rotational irrigation schedule implemented by NIA and practice plot-by-plot, rather than plot-to-plot, irrigation of their paddy fields.

Most farmers plant inbred varieties NSIC Rc 222 and Rc 216 in July during the wet season and hybrids LP-937 and SL-8H in January during the dry season. Ninety-seven percent (97%) of the rice crops in the area are harvested using the combine harvester, and 92% of the farmers sell their produce immediately after harvest to raise money for loans payment. Based on these initial findings, the site might be suitable for introducing the BAC strategy using the Rice Business Innovation System (RiceBIS) approach of PhilRice, coupled with enhancing features, such as the AutoMon^{PH}-aided IAS, land re-formation or consolidation of small plots into larger plots with laser-guided land leveling, and mechanized transplanting for efficient water management and reduced production cost. It is further validated with the second round of KII to be done this 2021 W.S.

WP1 was also assessed through key informant interview (KII) of the extension approach and utilization of mechanical transplanters (MT) distributed by the DA in Region 3. Results showed that 38% or 32 irrigators' associations (I.A.) had utilized the M.T., more than half of the total number of transplanters distributed (54.5% or 46 units) were not used, and three I.A.s were not able to get their unit. Similar to the survey results conducted in Region 2 in 2020, the recipients who did not use the M.T. said that the tedious seedling preparation deterred them from adopting the technology.

WP2 aims to develop the AutoMon^{PH}-based irrigation advisory service (IAS) for automated monitoring of paddy field water levels and sharing relevant information on irrigation scheduling to farmers, irrigation association leaders, and system managers. While IRRI is tasked with AutoMon^{PH} hardware development, PhilRice develops a user-friendly online application for water level sensor evaluation and monitoring user interfaces. The WateRice Web App (https://www.waterice.philrice.gov.ph) can now accommodate two iterations of the AutoMon^{PH} IAS, using field-type and landscape-type sensors (with the gateway). The improved web app also features an IAS home dashboard, a sensor profile user interface that provides data/information gathered by a specific AutoMon^{PH} sensor and a graphical presentation of the collected data, which are also presented in tabular form, and an updated IAS data flow wherein NIA's operation and zone engineers, in addition to the senior water resources facility technician, will also be informed. An algorithm was also created to provide future IAS advisories to the farmers.

Extra-core Project 1

Moreover, 11 AutoMon^{PH} landscape-scale sensors were installed and tested at PhilRice CES to identify the sensors which will be used for the IAS trial at the Bantug-Bakal IA site in Bantug, Science City of Muñoz. Four sensors (36%) passed the evaluation, including various tests of range, antenna height and positioning, AWD tube height, battery consumption, sensing accuracy, and weather-proofing. After incorporating design and process improvements, 63% of seven sensors passed. However, the IAS landscape trial in Bantug in 2021 W.S. will require 16 sensors.

By introducing water management, mechanization, and nutrient and weed management solutions, **WP3** aims to improve production efficiency. Eighteen research trials (five in Region 2, nine in Region 3, and four in Region 6) on the integration of WateRice technologies and four on weed management in Region 3 were conducted in 2021 D.S. Moreover, two research-cum-demonstration trials on laser-guided land leveling (LLL) and one on mechanical transplanting (M.T.) were carried out in Region 3 (Nueva Ecija). Furthermore, nine M.T. and mat nursery seedling preparation demonstrations and four LLL trials were done in Regions 2 and 3. The results of the research trials showed that using AWD, weed management, M.T., and LLL technologies reduced the unit cost of rice production by 10%, from PHP 9.00/kg to PHP 8.10/kg. In addition, water productivity (kg of grain produced per cubic meter of water used) increased by 46% from 1.28 kg/m3 with the farmer's practice to 1.87 kg/m3 with the WateRice package.

Results of PhilRice on-station weed management trials showed that yields were similar in AWD and continuously flooded paddy field plots. Among weed management treatments, pre-mix Triafamone + tefuryltrione (Council active) as PRE (1-4 DAT) plus one hand-weeding at 30-35 DAT gave the highest yield and was similar to three hand-weeding treatments. In Region 6 (Iloilo), applying a granular seed spreader for crop establishment at 60 kg/ha, controlled irrigation using AWD, and integrated weed management recommendations increased rice production by 330 kg/ha compared to the existing farmer practice. In addition, it resulted in a higher average net income of PHP 21,527/ha with a return on investment of 72%, compared to farmer's practice which had an average net income of PHP 16,259/ha and 53% ROI.

WP4 develops and packages innovative and best management practices (BMP) for the rainfed lowland environment and validates them through on-farm technology demonstrations. In 2021 D.S., integrated BMP demonstration trials were established in Region 3 (Science City of Muñoz, Nueva Ecija) with eight farmer-cooperators and Region 12 (Mlang, Cotabato) with nine cooperating farmers. The BMPs tested in Muñoz included the use of certified seeds (NSIC Rc 480, NSIC Rc 222, Longping 2096, Longping 937), RCM nutrient management, and weed management using early post-emergence herbicide, while the farmers' practice (F.P.) consisted of certified seeds, farmer's usual fertilizer application rate, and timing, and weed management using pre-and post-emergence herbicides, followed by hand-weeding. As a result, BMP actual field plot yields ranged from 5.2–10.5 t/ha with a mean yield of 7.3 t/ha, which were significantly higher than F.P. actual yields, which ranged from 3.2–6.9 t/ha with a mean of 5.2 t/ha. As a result, the average unit production cost of PHP 7.00/kg with BMP was 30% lower than that with F.P. (PHP 9.95/kg). Meanwhile, in Region 12, specifically M'lang, Cotabato, in collaboration with the New Janiuay Farmers Association, the BMPs featured, among others, the use of the plastic drum seeder for row seeding (DSR-PDS). The bundle of BMPs tested at six farmers' field plots included registered seed of inbred rice variety (NSIC Rc 216) with a DSR-PDS seeding rate of 60kg/ha, use of RCM for nutrient management (107-27-37 kg NPK/ha), and a combination of Pretilachlor (0.4L/ha applied at 0-3 DAS) and Fenoxaprop-ethyl+ethoxysulfuron (1 L/ha applied at 15-25 DAS) for weed management. The F.P. used good seeds of NSIC Rc 238 and Rc 358 at 120-160 broadcast seeding rates/ha, 60-25-19 kg NPK/ha fertilizer rates.

For weed management, a combination of Bentazon at 1 L/ha was applied at 14 DAS, and Fenoxaprop-ethyl+ethoxysulfuron at 0.4L/ha was applied at 25 DAS. In the three other farmers' field plots, a similar bundle of BMPs was used, except that crop establishment was by manual direct/broadcast seeding (MDSR) at the same rate (60 kg/ha). F.P. in these three plots consisted of certified NSIC RC 238 and good seeds of NSIC Rc 218 at 120-160 broadcast seeding rates/ha, 60-25-19 kg NPK/ha fertilizer rate.

For weed management, a combination of Butachlor+Propanil at 2 L/ha was applied at 6 DAS, and Dichlorophenoxyacetic acid at 0.6L/ha was applied at 15 DAS. Results showed that with BMP+DSR-PDS, the actual yield was 4.4 t/ha, 19% higher than the mean yield obtained with F.P. (3.7 t/ha). The unit production cost (based on cash cost) with BMP+DSR-PDS was PHP 9.85/kg, which was 7.7% lower than that of F.P. (PHP 10.67/kg). With BMP+MDSR, the average actual yield was 4.0 t/ha, 11% higher than that of F.P., which was 3.6 t/ha. Unit cost production with BMP+MDSR was also 12% lower at PHP 10.40/kg than with F.P. (PHP 11.80/kg). These results imply that the introduced bundle of BMPs in the favorable rainfed environments of Regions 3 and 12 was an effective technology package for increasing yield and lowering production costs.

Extra-core Project 1

WP5 is finding ways to develop and recommend an enabling environment for adopting WateRice-developed crop management technologies. Three field demonstrations of the mechanical transplanter and another three demonstrations of the laser-guided land leveler were carried out, with 105 participants (23 female and 82 male). To engage the private sector in scaling out of WateRice technologies, the project facilitated the signing of the MOU with PTC Holdings Corp., which is part of the Yuchengco group of companies, and DA-RFO 3 on the promotion of LLL and M.T. in Region 3, specifically Tarlac. Agreements with three farm machinery manufacturers on the fabrication and improvement of the LLL drag bucket were also being formalized through MOU. Three PhilRice branch stations (Batac, Ilocos Norte; San Mateo, Isabela; and Murcia, Negros Occidental) also adopted the LLL technology. One training was already conducted at PhilRice Isabela branch station in collaboration with the station's Agricultural and Biosystems Engineering unit.

Moreover, IEC materials, such as the AutoMon^{PH} Operation Manual (Tagalog Version) and the Rice Technology Bulletin on Mechanical Transplanting of Rice, were drafted. Other knowledge products in the pipeline are (1) Common Weeds in Irrigated Lowland Rice in the Philippines; (2) Weedy Rice Leaflet; and (3) Best Management Practices for Rainfed Lowland Rice Production: A Technoguide. In addition, the field trial of the AutoMonPH-based Irrigation Advisory Service at the landscape level covering about 30 hectares was planned for implementation in 2021 W.S. in collaboration with NIA-UPRIIS and the Bantug-Bakal Irrigators' Association in the Science City of Muñoz.

Extra-core Project 2

Development of Sustainable Rice Straw Management Practices and Technologies for Food in the Philippines (RiceStrawPH) – PhilRice Component

Caesar Joventino M. Tado, Rizal G. Corales, Elmer G. Bautista, Virginia D. Ompad, Mary Joy S. Lictawa, Anileen O. Pajarillo, and Leo Q. Diaz

Rice straw is abundant and perceived to have low value in the Philippines because of its difficulty collecting and lack of opportunity to use it for profitable uses such as composting, mushroom production, and ruminant fodders. Moreover, rice straw alone is a poor compost and quality feed due to its low digestibility and protein content. However, it can be an alternatively valuable feedstock if it is pre-treated using mechanical and biochemical methods.

It is also illustrated that rice production with the removal practice of rice straw for other profitable uses will generate higher energy efficiency and economic benefits than burning and incorporating rice straw into the field. However, there are still limited and poor technologies of rice straw processing for commercialization, leading to low straw prices, particularly in the Philippines. In addition, there is still limited exploitation of markets, value chain, and partnerships between farmers and other stakeholders, hampering sustainable management of rice straw.

Given those limitations and opportunities, this project aimed to develop sustainable technologies and management practices of rice straw in the Philippines, focusing on bioenergy, mushroom, and ruminant fodder production. The project will be conducted with the collaboration of the International Rice Research Institute (IRRI), Philippine Rice Research Institute (PhilRice), Philippine Carabao Center (PCC), Philippine Center for Postharvest Development and Mechanization (PhilMech), and the Bureau of Animal Industry (BAI). Adopting these sustainable technologies and practices later will add significant value for rice farmers and reduce their environmental footprint.

Extra-core Project 2

A Localized Mushroom Substrate Bagger using an electric power source was designed and fabricated to improve the bagging efficiency during rice straw-based mushroom production. It was fabricated by cooperating local manufacturer using locally available materials for easier repair when needed. The initial test showed that the bagging *capacity of the equipment was 2-3 fruiting bags per minute with at least two person power needed to operate the machine. The output rice straw-based fruiting bag is similar to the manually made at the 6-inch diameter and 12-inch length.*

A localized PhilRice Cabinet-type Mushroom Solar Dryer was designed and fabricated by a local manufacturer to preserve the remaining unsold mushrooms because of its delicate characteristics. The unsold mushrooms must be needed to dry to lengthen their shelf life for future use without losing their vital nutrients and delicacy. The *solar collector has 6000 cm long and 100 cm in diameter. The cabinet is made of food-grade stainless sheets with sizes of 1448 cm in length, 690 cm in width, and 1860 cm in height. The drying chamber consists of 8 drying trays of food-grade perforated sheets.*

Although an imported rice straw baler is available in the market, a localized Rice Straw Baler was fabricated by trying to locally fabricate it using manufacturers' capability, shop equipment, and materials. The overall dimension of the rice straw baler is 115 cm long and130 cm wide, and the total weight is 330 kg. A locally purchased tire is used with Tire size: 16 x 6.50 x 8 x 4 ply rating. The baling machine has a capacity of 80 to 120 bales per hour under optimum field conditions with a bale size: of 50 cm diameter, 70 cm long, and 14-16 kg weight. It is pulled by a 4W Tractor (25-50 H.P.) with a match PTO speed of 540-600 RPM.

These rice straw machines need further intensive test in actual field conditions which was affected by the height of covid occurrence when it was completely fabricated.

Extra-core Project 3

Improving Brown Rice Quality, Shelf-Life, and Engineering Technologies

Arnold S. Juliano, Ricardo F. Orge, Joel A. Ramos, John Eric O. Abon, Phoebe R. Castillo, Joey P. Miano, Tyrone C. Juganas, and Silvestre C. Andales

This project aimed to improve brown rice quality and shelf-life and pilot test brown rice engineering technologies. It will ensure the availability and accessibility of affordable brown rice in the market, providing rice consumers with a healthy, nutritious, and shelf-stable product.

The final prototype for household application (manually operated and motor-driven) was fabricated at the REMD workshop. The village-type brown rice machines were made in partnership with the accredited manufacturer. Problems encountered during a series of tests were evaluated and necessary modifications were incorporated into the prototype. A list of damaged parts was quickly prepared, and replacement parts were made available. The final prototypes were subjected to AMTEC testing and applied with appropriate I.P. protection before bringing to the pilot sites.

A storage setup comprising 12 units of SACLOB and three units of ordinary storage using plastic sacks was established in PhilRice CES for the material durability assessment (Figure 1). The result showed that SACLOB is more effective as a secondary container when storing brown rice as it provides a double layer of protection against pests, molds, and moisture compared to ordinary storage using plastic sacks. Furthermore, with thicker material for SACLOB (new: 0.60mm; old: 0.45mm), no holes caused by insects were observed during the 2021 validation, and a low oxygen level inside the storage was maintained.

Figure 1. Establishment of 12 SACLOB units for validation in BDD Warehouse.

Extra-core Project 3

Monitoring of brown rice machines' pilot units (BRM) deployed to the cooperating users was continued in 2021. Actual field data on machine performance were gathered, and the users' experiences in the machines' actual operation were assessed. The project team also addressed problems encountered by the user. As a result, minor corrections or adjustments of the pilot-test units have been addressed, after which operators were again briefed on the proper operation and maintenance procedure and provided some troubleshooting guide. They were also reminded to refer to the operation manual in case of problems and constantly reflect on any observations and remedies done to the record book.

Technical assistance was provided to the cooperating users of portable BRM in Region 2 (San Mateo, Isabela), Region 3 (Gerona, Tarlac), Region 6 (Victorias City, Negros Occidental), and Region 13 (Butuan City, Agusan del Norte), (Figure 2). The cooperating users encountered the same problems during the actual milling operation, such as the presence of unhulled grains and low brown rice recovery, which can be attributed to high feeding rate of paddy, incorrect clearance and adjustment of rubber roll hullers, worn-out belt, and misalignment of pulley (Appendix 1). The actual performance of portable BRM deployed to cooperating users achieved a brown rice recovery ranging from 59-74% and an actual output capacity of 2-8kg/h. The unit in Victorias City in Negros Occidental had the highest utilization of around 50 hours with almost 600kgs of paddy processed, while the unit in Gerona, Tarlac, had limited utilization (Appendix 2).

Figure 2. Monitoring of portable BRM in Tarlac (left) and Negros Occidental (right).

Some noticeable problems encountered by cooperating users of village-type BRM in San Mateo, Isabela and, Zaragoza, Nueva Ecija are the low recovery and the presence of stones in the samples. As attested by the cooperating user, these problems partly discourage potential customers and limit the machine's operation and utilization.

Extra-core Project 3

As a solution, the project team considered fabricating destoner as this is not initially integrated into the pilot units of village-type BRM. However, the unit deployed in Bago City, Negros Occidental, was not utilized until the later part of 2021 due to the following reasons: excessive vibration and oscillation of tray separator; voltage drop at source; the detached mounting base of tray adjuster; a large amount of paddy observed in the huller output chute; and slow downward flow of paddy/grains mix (Appendix 1). These problems were not immediately addressed due to pandemic travel restrictions. However, they were eventually corrected in the later part of December 2021 (Figure 3). With the data collected from the users, the performance of the village type BRM obtained a brown rice recovery ranging from 67-77% and an actual output capacity of 61-135kg/h (Appendix 3).

Figure 3. Monitoring of Village-type BRM in Isabela (left) and Negros Occidental (right).

The cooperating users of retrofitted BRM deployed in Santiago City, Isabela, and Nueva Ecija had no technical issues in the operation of the machines, as both units are working well during monitoring (Figure 4). The varieties that they usually process are NSIC Rc160, Black Rice, and Red Rice. Based on the data recorded by the cooperating users, the retrofitted BRM yielded a brown rice recovery of 69-72% and an output capacity of 110-118 kg/h (Appendix 4). It already processed around 6.5T and 3T of paddy for the units deployed in Nueva Ecija and Isabela, respectively.

Figure 4. Monitoring of Retrofitted-type BRM in Isabela (left) and Nueva Ecija (right).

Extra-core Project 3

Pilot testing of SACLOB

Using plastic sacks, a storage setup comprising 12 units of SACLOB units and 12 units of ordinary storage containers was pilot tested in Isabela, Negros Occidental, and Agusan Del Norte. Among the samples from each pilot test site, Agusan Del Norte recorded the lowest oxygen reading of 13.5%, while Isabela plateaued at 17.0%. Moreover, both treatment samples obtained from pilot test sites showed no significant difference in the general acceptability of brown rice. The general acceptability of brown rice from SACLOB units ranges from 8.2-8.7. In contrast, brown rice from plastic sacks averages 8.1, falling into the “like moderately” category.

Extra-core Project 4

Development of Package of Technologies for Drip-Irrigated Aerobic Rice

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The project aimed to develop the use of a drip irrigation system in aerobic rice cultivation complemented by an appropriate package of technologies to enhance the yield potential and increase water productivity in a water-scarce environment.

In 2021 D.S., the 80-cm lateral spacing of the drip irrigation significantly ($P<0.05$) lowered the grain yield of rice by 24-25% relative to 40 and 60-cm spacing and 29% relative to flash flooding. In 2021 W.S., there were no significant differences in the grain yield among treatments because of sufficient rainfall. However, with no rainfall, drip irrigation reduced supplementary irrigation by up to 100% relative to flash flooding.

Water savings using drip irrigation was higher by 38-47% in D.S. and 36-100% (without rainfall) in W.S. relative to flash flooding.

The water productivity in D.S. increased by 29-76% relative to flash flooding. In contrast, the total water productivity in the wet season was minimal due to high rainfall and relatively low yield (≤ 4000 kg/ha).

In general, the 60-cm lateral spacing produced the higher yield, water productivity, and savings among the drip irrigation treatments.

Based on the 2-year field experiments, we developed a techno guide for drip-irrigated aerobic rice as a reference for agricultural extension workers, service providers, and farmers in the farming community.

This project also fabricated, tested, and improved a prototype of a water pumping and delivery system for irrigating crops in hilly uplands. The system is composed of the following major components: (a) the cable pump assembly (to be installed near the creek that is usually located at the foot of a mountain), which does the actual water pumping function, and (b) the control lever assembly (to be installed at the slopes of the mountain where the crops are grown) where force is applied, either manually or mechanically (use of an electric motor or internal combustion engine), and (c) the cables which transmit the force applied in the lever to the cable pump. have also conceptualized two options for establishing a drip irrigation system in hilly uplands.

In 2021 D.S., grain yield in plots planted with bush sitao was relatively lower than in plots with no vegetables. Black rice intercropped with pechay had the highest yield and income. *In 2021WS, rice intercropped with vegetables was not feasible due to frequent heavy rain.* were two weeds *(Echinocloa colona and Fimbrystylis miliacea)* specie dominated in D.S. while three weeds *(Echinocloa colona, Eleusine indica, and Fimbrystylis miliacea)* species in W.S.

The highest yields were obtained at N100% and N75%, producing statistically similar yields of 4872.02 kg/ha and 4771.33 kg/ha. We also tested traditional rice varieties (Azucena, Balibod, Cuevas, and Dinorado) on drip fertigation setup with 100% of the recommended dose of N-Fertilizer. The yield performance of the four high-value rice varieties suggests that drip irrigation is a potential game-changer in water-scarce areas, thus opening promising studies for further utilization.

Extra-core Project 5

Improving Crop Productivity in Drought-Prone Rainfed Lowlands in the Philippines with Mechanized Dry Seeding Technology (MP Seeder Project)

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The mechanized dry direct seeding method addresses problems of high labor cost, water scarcity, and crop failure during delayed monsoons. This project supports the RDE Agenda's vision of ensuring food security for the Philippines by increasing crop productivity, promoting crop diversification, introducing mechanization, and increasing resiliency to climate change. It aims to increase yield, reduce crop establishment costs and increase the net income of farmers in rice-based areas by developing the mechanized dry direct seeding technology package.

The benefits of using M.P. Seeder are not confined to rice production in rice-based areas. It can also use to seed other crops, thereby promoting crop diversification. Smallholder farmers in rice-based areas still manually seed high-value crops, such as corn, because there is no option for appropriate mechanized seeding. Like that in rice, manually seeding high-value crops is time-consuming, and uniformity of crop stand during emergence is not assured. M.P. Seeder, which is applicable to rice and other crops, can enable farmers to plant high-value crops in a timely manner in combination with best management practices, thereby improving their annual crop production.

Focusing not only on rice but also on high-value crops would be a good strategy for promoting the use of M.P. Seeder. Often farmers are reluctant to take risks in the cultivation of staple food crops, and they hardly accept any drastic change in their management practices. However, the financial gains achieved from efficiently establishing high-value crops and the convenience of mechanical seeding may be enough for farmers in the project areas to mechanize seeding using the M.P. Seeder.

The development of a mechanized option for direct dry seeding of rice to suit local conditions is now adapted to other crops, corn, and mungbean, but fine tuning to cater to the required seed rate of corn based on variety and site is still needed. In addition, the metering plates for fertilizer applicators will be validated in on-farm verification trials in 2021. A fertilizer hopper for corn was developed and improved to have an engineering plastic to prevent corrosion due to fertilizer. The MP Seeder- fertilizer hopper should deliver different rates of basal fertilizer according to site/location.

Developing management options to improve crop establishment and appropriate nutrient management will boost seedling vigor and enhance biomass accumulation that will support high yield. Reducing the seed rate from 120 kg/ha to 60 kg/ha resulted in a higher yield in some sites. In contrast, similar grain yield in other sites was observed from on-farm generation trials. The reduction in seed rate has enormous consequences on reducing crop establishment costs. Reducing to 40 kg/ha seed rate was tested under technology verification trials during 2020WS.

Site-specific best management practices to go with the seeder for rice, corn, and mungbean need to be verified in all ecosystems under rice-based rainfed areas and water-scarce environments (drought-prone, favorable, and tail-end). In addition, crop diversification by establishing corn and mungbean after rice would increase annual productivity and income in the target areas. Hence, developed MP Seeder+BMP packages for rice, corn, and mungbean needs to be validated. More so, M.P. Seeder technology packages and commercialization strategies must be laid out and tested to achieve full impact and sustainability in rice-based environments.