2020
PhilRice R&D Highlights

Rice Engineering and Mechanization Division

Contents

DIVISION

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Division head: Arnold S. Juliano

EXECUTIVE SUMMARY

The Rice Engineering and Mechanization Division (REMD) helps improve the national level of farm mechanization and modernize rice production and postharvest operations. To do this, REMD develops resource-efficient and environment-friendly agricultural and biosystems engineering technologies suited for local introduction. It has three projects: 1) Development of a modern rice farm model; 2) Provision of custom engineering services; and 3) Workshop maintenance and operation. Its outputs address the Institute's Strategic Plan outcomes on increased productivity, cost-effectiveness, and profitability in a sustainable manner; improved rice trade through efficient postproduction, better quality, safety, health, nutrition, and income; advanced rice science and technology as continuing sources of growth; and enhanced partnerships and knowledge management for rice research and development.

Begun in 2018, the 4-ha modern rice farm model is what will become the face of Agriculture 4.0 (Project I). The model consisted of components such as land consolidation, use of appropriate machines or automatic devices, and establishment of improved irrigation and drainage facilities, access roads, and field ramps to allow for machine access. The project tested and identified specifications and combinations that would be most advantageous to farmers who are considering adopting the model. To complement this effort, a guidebook was developed based on the 2019 drafted guidelines on how to develop a fully mechanized farm for irrigated lowland rice production. The guidebook features the benefits, procedures, and cost of the various components of a mechanized farm.

REMD also provided other services and carried out system-wide initiatives that helped the Institute carry out its various research activities (Project II). Custom fabrication and related metal works generated a net income of ₱243,643.79 in 2020 with overall positive feedback from clients (41% Excellent, 59% Very Satisfactory). An Agricultural and Biosystem Engineering (ABE) unit was established in each branch station to leverage its untapped human resource pool to promote engineering technologies within their regional jurisdiction and manage the station's farm operation and equipment effectively. An ABE training module is ongoing, as well. Instrumentation services were provided to assist researchers, wherein a custom-designed hydrometer for maintaining the existing EC and pH monitoring system

for saline-prone areas was developed and tested. Agrometeorological (Agromet) stations were operated and maintained at the CES and branch stations to collect daily weather data, which were then provided to other researchers.

Vital to the division's pursuit of quality R&D outputs is maintaining its workshop facility properly (Project III). Aside from the usual procurement of necessary supplies, a database derived from the workshop's operation was created to improve documentation of all its services and fabrication activities.

REMD primarily deals with engineering interventions that help address the needs of Filipino rice farmers. Bringing these technologies to the intended users is another issue. This is where local farm machinery manufacturers play an important role in the RDE continuum. REMD networks with private players to fill the gap between product developers and the users. This strategy fast tracks localization, promotion, and commercialization of our machines bringing our R&D products closer to our stakeholders.

PROJECT 1

Development of REMD Farm Model for Modernization and Mechanization Goal

Project Leader: Manuel Jose C. Regalado

Agriculture 4.0 points out the need to consolidate small- and medium-sized farms to bring about economies of scale, particularly for crops that require mechanization and massive use of technology. Congruently, this project aimed to develop a 4-ha modern rice farm model through land consolidation and other appropriate engineering interventions.

Results of an experiment conducted to determine the field efficiencies of the major farm machines operated on four different plot sizes showed that the highest efficiencies were obtained from the 5000-m^2 plots, with comparable performance with that of the 2300-m^2 plots. However, wetland leveling of the 5000-m^2 plots proved difficult to execute properly, resulting in challenges in irrigation and drainage. Hence, about one-fourth of a hectare would be the recommended area of plots in a consolidated farm.

Evaluation of the 232m concrete irrigation ditch constructed at the center of the farm showed an average conveyance efficiency (EC) of 85%-93%. The majority (60%) of the survey respondents attested that the concrete canal conveyed water faster and was easy to clean and maintain. The majority (60%) gave the drainage canal very satisfactory and satisfactory ratings, while the rest said that draining water was slow due to debris and the canal was poorly constructed. These findings implied that these structures should be further improved in terms of efficiency and effectiveness.

The farm was also provided with a single-lane gravel road (544-m long x 4-m wide) along its north, east, and south borders and eight 8-meter-wide concrete ramps to facilitate access of machines, as well as field operations. Results of accessibility tests showed that with the access road and ramps, fuel consumption in different operations and damage on dikes could be reduced by 25-50% and 80-100%, respectively.

Results of field experiments conducted in 2020DS and WS to assess rice yields with and without laser-guided leveling showed that laser-leveled fields had higher yield and lower unit production cost compared to non-laser-leveled ones. The harvesting losses and farm operation efficiency were also gathered and analyzed. Results revealed average harvesting losses of 6.93%, which was higher than PAES maximum harvesting loss of 3.50%, and the farm operation efficiencies obtained were higher by 5.14-11.04% compared with PAES efficiency requirement.

This year, the guideline on developing a fully mechanized farm for irrigated lowland rice production was being improved into a guidebook. This book featured benefits of mechanized farming, procedure, costs of land consolidation and establishment of modern infrastructure, and lessons gleaned from the project.

Land Consolidation with Optimum Plot Sizing for Efficiency and Leveling Effects

Elmer G. Bautista, Katherince C. Villota, and Myrwilliene C. Mariano

This study aimed to determine and establish the plot size that would provide optimum efficiency to machines. Four machines – power tiller, transplanter, combine harvester, and four-wheeled tractor – were tested; efficiency data were gathered on 500m^2, 1000m^2, 2300m^2, and 5000m^2 plot sizes. The highest efficiencies were obtained from 5000m^2 plot but were comparable with the efficiencies obtained from the 2300m^2 plot. Difficulties during the operation of machines and poor management of the established rice crop were encountered on the 5000m^2 plot. Poorly accomplished wet leveling of this plot eventually resulted in difficulty in irrigation and drainage activities in some portions of the plot. Hence, the recommended plot size for a consolidated farm is about one-fourth of a hectare.

Establishment of Efficient and Suitable Irrigation and Drainage Facilities at the REMD Model Farm for Mechanization

Kristine S. Pascual, Alaissa T. Remocal, Arnold S. Juliano, and Manuel Jose C. Regalado

An improved irrigation and drainage system was established in 2019 at the 4-ha REMD model farm. A 232-m concrete irrigation ditch at the center and a 464-m concrete drainage canal at the farm's borders were constructed. Both canals were equipped with 16 steel gates to facilitate irrigation and drainage within the 16 plots. The conveyance efficiency (E_c) of the irrigation ditch was evaluated. Ten respondents (three females and seven males) who were researchers and field workers at the model farm provided feedback on irrigation water delivery. Results showed that the average E_c of the irrigation canal varied from 85% to 93% from downstream to upstream portion. In addition, survey results showed that six out of ten (60%) respondents said that irrigation water delivery was faster and convenient with the lined canals, which were also easy to clean and maintain.

However, all the respondents said that several closed gates were leaking when one or two gates were opened during irrigation. For the drainage canal, six out of ten (60%) respondents who rated it as very satisfactory and satisfactory said that draining water was faster. In contrast, the rest said that draining water was also slow due to debris and the poor construction of the canal. Overall, respondents rated the irrigation and drainage system of the model farm as 7 out of 10.

Provision of Appropriate Machines and Access Roads for Mechanization

Katherince C. Villota, Arnold S. Juliano, Myrwilliene C. Mariano, Julius R.Waliwar

The study aimed to strategically establish roads and ramps at the REMD farm and evaluate the effectiveness of these structures on the operation of machines and operators. A total of 544 meters of gravel road and 48 meters of concrete ramp were established in the area. Results showed 25% to 50% fuel savings and 80% to 100% reduction on damaged bunds could be obtained with these access structures in the farm.

Evaluation of Fully Mechanized Four-hectare REMD Model Rice Farm

Arnold S. Juliano, Katherince C. Villota, Myrwilliene C. Mariano, Isagani P. Pineda

The study conducted an experiment at REMD farm during 2020DS and WS. Laser Land Leveling (LLL) and Non-laser Land Leveling (NLL) were compared to determine the advantages of the fully mechanized and modernized farm in yield and production costs. 2020 DS results showed average yields of 4.63t/ha and 5.09t/ha under NLL and LLL, respectively. 2020 WS results, on the other hand, showed an average yield of 5.15t/ha produced at P9.28/kg under NLL and 5.89t/ha at P8.37/kg under LLL. The LLL had a higher yield and lower unit production cost compared with NLL. The harvesting losses and farm operation efficiency were also gathered and analyzed. Harvesting losses obtained were at an average of 6.93%, which was higher than the PAES maximum harvesting loss of 3.50%. Farm operation efficiencies obtained were higher by 5% to 11% compared with PAES efficiency requirement. In addition, the guidelines for developing a fully mechanized and modernized farm were further improved.

PROJECT 2

Division Operations and Services

Project Leader: Joel A. Ramos

The provision of required engineering solutions falls within the core competency of the division. Hence, this project supported the implementation of research activities and delivery of services within the Institute through the following project components: 1) Provision of custom fabrication and related metalworking activities to internal and external clients; 2) Establishment of Agricultural and Biosystem Engineering (ABE) unit in the branch stations, which aimed to strengthen the capability of the stations to promote engineering technologies as well as managing the farm operation and equipment in the station; 3) Instrumentation services, which aimed to assist researchers with the instrumentation needs of their respective studies; and 4) Operationalization of agrometeorological stations, which aimed to enhance the management of agrometeorological stations at PhilRice-CES and the branch stations.

Forty-two (42) workshop-related requests were catered to on a first-come-first-served basis, generating a net income of ₱243,643.79 and receiving 41% Excellent and 59% Very Satisfactory ratings. About 40 farm machinery inquiries were attended to thru emails, phone calls, SMS, and walk-ins. ABE Unit was created in each branch station to raise awareness of the importance of monitoring, assessment, and maintenance for all farm machinery, equipment, and postharvest facilities. The training module for the ABE Unit was drafted. A custom-designed PLA plastic hydrometer to maintain the existing EC and pH monitoring system for saline-prone areas was developed and tested. Daily weather data were collected. Periodic maintenance of the Agrometeorological stations was done.

Supporting RDE through Shop Custom Service Provision

Joel A. Ramos, Phoebe R. Castillo, Rodolfo S. de Gracia Jr., Arnold S. Juliano

Now a regular part of the division's operation, the study dealt with the steadily increasing demand for workshop services from researchers, offices, and private clients. In 2020, the team catered to 42 various service requests on a first-come-first-served basis, generating a total revenue of P462,834.25 and a net income of P243,643.79. These services included the fabrication and supply of rice hull carbonizer, custom fabrication of laboratory tools, and other related workshop services (rolling, bending, cutting). Feedback of customers showed high satisfaction with the services provided. Delivery of service was rated 89% on time and 11% earlier than expected. Quality of produce was given 76% Excellent and 24% Very

Satisfactory ratings. Moreover, 37 farm machinery inquiries were attended thru emails, calls, text messages, and in-person.

Establishment of Agricultural and Biosystems Engineering (ABE) Unit in PhilRice Branch Stations

John Eric O. Abon, Arnold S. Juliano, Rachelle Marie S. Martin, Phoebe R. Castillo, and Eugene S. Espique

REMD stands as the lead centralized provider of Agricultural Engineering (AE) services for research, development, training, and extension nationwide. As it is based in Region 3 with limited staffing, the simultaneous regional demands for AE services are attended by the branch stations. However, these requests are sometimes unfavorably responded to. To leverage on the expertise and potential of PhilRice branch stations as mechanization and modernization allies, especially in their areas of responsibility, REMD initiated the creation of ABE Unit in all PhilRice branch stations. Composed of agricultural engineer/s, technicians, and operator/s, the ABE Unit aims to raise awareness on the importance of monitoring, assessment, and maintenance for all farm machinery, equipment, and postharvest facilities. Personnel of the ABE unit in all branch stations were capacitated through training, retooling, monitoring, and evaluation. The issuance of an administrative order in December 2020 further solidified the Institute's commitment to seeing this through.

Instrumentation Services

Jasper G. Tallada and Danielle B. Fenangad

Instrumentation plays a vital role in achieving the measurement requirements of research. Many of the instruments are too costly or do not fulfill the specific requirements of researches. The advent of open-source electronics technology such as Arduino and Raspberry Pi had paved the way for the easy development of instruments, especially now that sensors and control units or modules are constantly being brought to the marketplace to extend the capabilities of these microcontroller gadgets. This study aimed to provide instrumentation services by developing basic instrument modules and a custom monitoring system. Developing an instrumentation module involved (1) drafting the hardware design, (2) assembling and programming the hardware/prototype, (3) installing the prototype, and (4) field testing the module. A 3D-printed hydrometer was designed and fabricated. The hydrometer, made of PLA plastic, was lightweight and did not easily break compared with a hydrometer made of glass. The hydrometer was subjected to different salinity levels resulting in consistent measurements.

PROJECT 2

Operationalization of Agrometeorological Stations at CES And Branch Stations

Danielle B. Fenangad and Jasper G. Tallada

Agrometeorological (Agromet) stations are set up in different parts of the country to help monitor and gather weather data for agricultural researches. To ensure accurate and reliable weather data, maintenance, calibration, and efficient data management should be given importance to improve data collection and handling. This study aimed to enhance the operation and maintenance of existing PhilRice Agrometeorological Stations at CES and the branch stations. Among the activities done were updating the stations' metadata, periodic collection of weather data and regular calibration, and repair and maintenance of weather instruments. Daily weather data were collected from the manual instruments and the automatic weather station (AWS) from January to October 2020. Purchase of new AWS units was initiated this year and is expected to be completed early next year. As of November 2020, 20 weather data requests were served.

PROJECT 3

REMD Workshop Maintenance and Operation

Project Leader: Joel A. Ramos, Phoebe R. Castillo, Rodolfo S. de Gracia Jr., and Arnold S. Juliano

This project aimed to keep the workshop facility ideal for the conduct of workshop-related activities to produce better quality R&D outputs. Specifically, it aimed to ensure that all equipment was maintained in good working condition, provide necessary consumable supplies for sustained operation of the equipment and facility, and create a database of workshop operations. In 2020, regular maintenance and servicing of shop equipment were performed following the preventive maintenance plan. Consumables and maintenance supplies amounting to P351,018.24 were procured to ensure continued operation of the shop and its existing equipment. The project catered to 42 custom service requests and served fabrication activities for three core and three extracore funded projects.

Rice in Change: Patterns, Pathways, Perspectives (RICH-3P)

CAngulo, MBecker, SRo, KKWin, MJCRegalado, and RRDClavero

Rice-based systems in Asia are currently undergoing rapid and highly dynamic changes. The intensity and frequency of external pressure factors (climate change, market dynamics, and policies) differ by country and region and solicit adequate responsiveness of the socioecological systems to minimize risks for rice farmers. Such responsiveness, however, is strongly modulated by system-inherent determinants such as economic and socio-cultural attributes. With two interdisciplinary workshops and data collection combined with capacity-building measures, the project aimed to analyze emerging patterns and pathways of change in major rice production systems in Cambodia, Myanmar, and the Philippines. It also aimed to assess likely future perspectives on rice systems and their implications for household well-being and food security at the regional scale.

In Cambodia and Myanmar, major changes in the rice production system over the past 15 years included the following: 1) change from draft animal-powered to engine-powered mechanized land preparation; 2) change from the use of traditional to modern rice varieties; 3) change from subsistence farming to commercial rice farming; 4) increase from single to double rice cropping per year; 5) change from manual transplanting to direct-seeding owing to a shortage in labor supply, especially in rainfed areas; 6) increase in the use of mineral fertilizers and chemical pesticides; 7) from manual weeding to use of herbicides; and 8) change from manual reaping to combine harvesting.

In the Philippines, the changes in rice production systems include: 1) mechanized land preparation now uses 4-wheel tractors for primary tillage; 2) new higher-yielding inbred and hybrid rice varieties; 3) shift from transplanting to direct seeding (dry seeding) due to labor cost and water scarcity; 4) increased use of mineral fertilizers and chemical pesticides; 5) manual reaping to combine harvesting; and 6) increased production costs.

At the second workshop held in April 2019 in Phnom Penh, Cambodia, the project implementers agreed to have two additional sites for the Philippines to gain more information on how things have changed for Philippine rice production systems at peri-urban and remote rural sites, which were in Bulacan and Aurora, respectively.

The Philippine project team gathered data on past and present rice farm practices by interviewing 402 farmers at the selected sites: 201 from San Ildefonso, Bulacan, and 201 from Dilasag, Aurora. To ensure the accuracy of data and analysis, soil sampling and farm area measurements were also done. The data have been encoded and sent to the University of Bonn for analysis. After his visit in January 2020, the project leader brought all soil samples to Germany for analysis. Currently, data analysis is about 80% complete, and a joint paper for journal publication is being written.

Pilot-testing of Combined Conduction and Far-Infrared Radiation Paddy Dryer

MJCRegalado, ATBelonio, JJABatanes, and JAdelaCruz

Under the DOST-PCAARRD Rice Mechanization Program, a previous project implemented at PhilRice-REMD developed a rapid paddy drying technology employing combined conduction heating and Far-Infrared Radiation (FIR) drying principles and using a rice husk gasifier as the heat source. To develop an improved prototype that is ready for commercialization and acceptable to farmers and other end-users, this project aimed to fabricate, install, and pilot-test the combined conduction and FIR paddy dryer.

The project engaged Torralba Metalcraft, Inc., a private manufacturer based in Butuan, Agusan del Norte, which fabricated and installed a pilot unit of the FIR dryer at the Sto. Nino Multi-Purpose Cooperative in Butuan City. The cooperative provided counterpart funds for the completed construction of the dryer shed. The dryer would be ready for commissioning and endurance testing during the 2021 DS harvest period. Another manufacturer, the Davao Beta Spring, Inc. (DBSI) of Davao City, entered into an R&D agreement with PhilRice to fabricate, install, test, and improve at their cost an FIR dryer unit within the Davao region. Moreover, the DOST MIMAROPA regional office, through its Occidental Mindoro Provincial Science and Technology Center, executed a memorandum of agreement with PhilRice, the Kooperatiba ng Pamayanang Kristiyano ng Mapaya (KPKM), San Jose, Occidental Mindoro, and the Occidental Mindoro State College to fund a project on the fabrication, installation, and testing of the FIR dryer at the KPKM. The project recently conducted an inception meeting and forum on the FIR drying technology.

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

MJCRegalado, SYadav, MCasimero, EGBautista, RGCorales, JLDeDios, ECMartin, KSPascual, DKMDonayre, VKumar, JJaniya, GEvangelista Jr, MABurac, JSandro, BManuel, and JMendoza

In line with the RDE plan 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, and 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 (WP). **WP1** focuses on **understanding key knowledge gaps** by gathering data and information on current management practices and farmers' perceptions in target areas. Results of the 2020 surveys with 160 farmers (114 male, 46 female) affiliated with five small water irrigation system associations in Regions 2 (Cagayan) and 3 (Bataan) showed that farmers irrigate once/twice a week during the DS and once a week during WS. Moreover, they generally perceived that the project's ICT-based automated field water level monitoring system (***AutoMon^{PH}***) is a helpful, time-saving device providing accurate water level readings. However, interviews of 15 *AutoMon^{PH}* users in techno demo trials in Regions 2, 3, and 6 revealed risks in usage, such as short sensor battery life, affordability, and farmers' full cooperation when *AutoMon^{PH}*-aided irrigation advisory service (IAS) is implemented. Eleven farmers from the Bantug-Bakal IA in Bantug, Muñoz agreed in 2019 to be cooperators of *AutoMon^{PH}* field trials, laser-guided land leveling (LLL), and mechanical transplanting. After three seasons, they said that they obtained higher yields owing to the laser-leveled fields, they spent less on transplanting because of mechanization, and that they appreciated the easy and practical use of *AutoMon^{PH}*.

WP2 aims to **develop the *AutoMon^{PH}*-aided irrigation advisory service** for the automated monitoring of paddy field water level 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 be used to accommodate two iterations of the *AutoMon^{PH}* IAS, using field-type and landscape-type sensors (with the gateway). Seventeen (17) *AutoMon^{PH}* sensors provided by IRRI were installed and evaluated at LSIS (7) and

SSIS (10) sites in Regions 2, 3, and 6. Of the 17 sensors tested, 14 (82%) passed the functionality test, 13 (76%) passed the data reliability and communication link test, while three (18%) failed all test criteria owing to battery deterioration and erratic telco signal. Moreover, six sensors passed the environment durability test, while six are for review. Overall, only 10 (62%) passed the initial evaluation in 2020DS.

In the WS, four landscape-scale sensors and one gateway were installed at PhilRice (FutureRice farm) to test the new iteration of the *AutoMon^{PH}* IAS. These sensors could transmit water level and other data even if there were solid interferences blocking the gateway provided that the sensor and gateway elevations are the same. In addition, seven new field-scale sensors from IRRI were installed at the fields of six farmer-cooperators in Bantug and the REMD model farm. Of the ten (10)sensors evaluated, nine sensors passed the sensing function and mechanical durability tests; four sensors passed the communication link and environment durability tests; and no sensor passed the battery life test.

By introducing water management, mechanization, and nutrient and weed management solutions, **WP3** aims to **improve production efficiency**. Fifteen (15) mechanized transplanting field demonstrations and trials were carried out in Regions 2 (Isabela) and 3 (Nueva Ecija), while five trials were done in Region 6 (Iloilo) using the blower-type mechanical seed spreader. Results of cost analysis showed that within the 12 sites of Nueva Ecija, mechanized transplanting service would be at a 50% profit margin, which is equivalent to about P9,000.00, inclusive of seedling preparation but excluding seed cost. This is 11% to 18% cheaper than the total manual transplanting and seedling preparation cost of P10,000 to P11,000 per hectare. Results of demonstration trials of the laser-guided land leveler (LLL) in four fields at four turnouts in Bantug, Muñoz showed that field capacity varied from 0.1 to 0.4h with field efficiencies ranging from 36% to 72% and elevation differences within the standard ±1 to ±2 cm precision level. In the integrated weed management (IWM) trials in Nueva Ecija and IWM plus Rice Crop Manager (RCM) nutrient management trials in Iloilo, results showed no significant yield differences between IWM and farmers' practice (FP) and IWM plus RCM and FP. Likewise, there were no significant differences between yields of WateRice package of technologies (POT) and FP in Nueva Ecija based on the 22 field trials in the three regions of the combined water management (alternate wetting and drying), mechanization (mechanized transplanting or seeding and/or laser leveling), and improved weed and nutrient management technologies. However, water productivities obtained with WateRice POT during DS in Bantug, ranging from 2.79 to 3.14kg of paddy per cubic meter of water, were 44% to 62% higher. In Iloilo, the WateRice POT farmers' field plots had an average yield of 4.7t/ha within four sites and resulted in a lower unit production cost of P7.30/kg. This is higher than the FPs' 4.1t/ha yield and P7.85/kg average cost.

WP4 develops and packages innovative **and best management practices (BMPs) for the rainfed lowland environment** and validates them through on-farm technology demonstrations. In 2020DS, four technology demonstration trials were established in Rosario, La Union. The BMPs tested included the use of certified seeds (NSIC Rc 416 variety), RCM nutrient management, and weed management using early post-emergence herbicide. In contrast, the FP consisted of the use of good seeds, farmer's usual fertilizer application rate and timing, and weed management using pre-emergence herbicide followed by hand-weeding. The yields of the BMP plots ranged from 3t/ha to 4t/ha with a mean yield of 3.8t/ha. These were higher than FPs' yields of 2.3t/ha to 4mt/ha with a mean of 3t/ha, although the differences were not statistically significant. Moreover, the average unit production cost of BMP (P10.60/kg) was almost 10% lower than that of FP (P11.70/kg). Therefore, the average net income of BMP plots was P8,237/ha or 46.6% higher than with FP. Wet season trials were relocated to Muñoz using seven farmers' fields. BMP field plots yielded 4.4t/ha to 8.3t/ha with a mean yield of 7.5t/ha, while FP plots resulted in 5.0t/ha to 7.8t/ha with a mean of 7.2t/ha. Although the yield differences between BMP and FP were not significant, BMP had Php7,366/ha or 17% additional income, which was attributed to the lower cost of fertilizers used. In M'lang, North Cotabato, the BMPs featured the use of RCM and the plastic drum seeder for row seeding in six farmer's field plots (0.25ha each) in the DS. In contrast, they used broadcast seeding with a lower rate (60kg/ha) in three farmer's field plots in the WS. Dry season yields of BMP plots ranged from 4.6t/ha to 6.8t/ha with a mean of 5.7t/ha, while FP yields varied from 4.3t/ha to 5.4t/ha with a mean of 4.9t/ha. The yield advantage of BMP over FP was 0.8t/ha or 16%. The average unit production cost with BMP was P7.80/kg, which was 9% lower than FP with P8.60/kg. The reduction in production cost with BMP could be attributed to the rate and timing of fertilizer application, weed management, and the variety used. Overall, BMP had a 40% (P2,486.50) higher net income over FP.

In the WS, BMP yields ranged from 4.2t/ha to 8.4t/ha with a mean of 6.2t/ha, while FP yields varied from 3.6t/ha to 7.1t/ha with an average of 5.8t/ha. The yield advantage of BMP over FP was 7% (0.39 t/ha). Moreover, the BMP unit production cost at P7.10/kg was 0.84% lower than FP at P7.16/kg, while BMP net income was higher by 9% (P8.05). In addition, results of grow-out tests of weedy rice variants (19 in the DS and 12 in the WS) showed that these were quite competitive compared with common varieties, such as NSIC Rc 222.

WP5 is finding ways to **develop and recommend an enabling environment** for the adoption of WateRice-developed crop management technologies. With travel limitations owing to quarantine protocols and restrictions, this project focused on the production of learning materials, such as the training manual "Water Management for Rice-Based Systems," *AutoMon^{PH}*, and mechanical transplanting operation manuals. Nevertheless, two field orientations and demonstrations of the laser-guided land leveler involving 50 participants (36 male, 14 female) were conducted. Moreover, two mechanical transplanter demonstrations and mat seedling nursery training activities were held involving 114 participants (98 male, 16 female). After an online consultation meeting with agricultural machinery manufacturers, five local manufacturers agreed to partner with the WateRice project in the commercial production of the LLL bucket.

Development of Technology Package for Drip-irrigated Aerobic Rice

KSPascual, RFOrge, DKMDonayre, RMLampayan, ATRemocal, MFGalapon, JFumera, OHAbdulkadil, and NDipatua

With the drought becoming more intense and the looming water scarcity, aerobic rice and drip irrigation system as adaptation strategies must be explored. This project aims to improve further the yield potential and water productivity of aerobic rice with efficient irrigation technology like the drip irrigation system, complemented with other efficient production technologies. The project is composed of four components and focuses on the development of water, weed, and nutrient management for drip-irrigated-aerobic rice, including a system of pumping and distributing water for upland irrigation.

This year, study 1 conducted a field experiment to determine the effects of different spacing of laterals in optimizing water delivery systems, reducing cost, and improving the water productivity of drip-irrigated-aerobic rice. Initial results showed that producing a kilogram of rice using a gravity-fed drip-irrigation system under aerobic soil conditions required 1,549L to 1,777L of water. These values were lower by 21% to 31% when compared with flash flooding. Changing the spacing of the sub-lateral drip line (40cm, 60cm, and 80cm spacing) had no significant effect on the grain yields of the drip treatments (4,395kg/ha to 6,037kg/ha) and even when compared with the control (5,836kg/ha.). However, the drip treatments improved the water productivity of aerobic rice by 23% to 55% relative to the control, with 0.46kg rice per cubic meter of water.

Study 2 completed the fabrication of two water pumps with varied designs, which were tested by pumping water from a river to the rice production of an IP community in Brgy. Renibon, Pigcawayan, North Cotabato. A mini-dam was constructed to facilitate water collection from the river and served as the water's take-off point for the ram pump. In addition, a water pond was constructed for storing excess water from the ram pump.

Study 3 focused on the development of weed management for drip-irrigated aerobic rice. In a field experiment during the dry season, the most dominant weed species were *Echinochloa colona, Cyperus difformis, Cyperus iria, Ipomoea triloba*, and *Macroptelium lathyroides*. Plots treated with herbicides aided with hand weeding had fewer weed densities compared with non-weeded plots. Post-emergence herbicide with two times of hand-weeding showed comparable grain yield and had the least weed control costs of P7,157.92/ha relative to weed-free treatment.

Lastly, study 4 focused on the development of a nutrient management system for drip-irrigated aerobic rice culture. Initial results indicated that under the same level or amount of fertilizer (i.e., 160 nitrogen kilogram per hectare), aerobic rice yields were higher in drip fertigation treatments (with 4,394kg/ha) where fertilizers were applied through the drip systems. This was compared when fertilizer was manually applied with surface irrigation (3,300 kg/ha). Under drip fertigation treatments, yields did not vary significantly between fields applied with 80, 120, and 160 kg of Nitrogen per hectare.

Overall, the technologies and information generated in this project contribute to increased productivity, cost-effectiveness, and profitability of rice farming in a sustainable manner.

Mechanized Seeding Technology: Improving Crop Productivity and Increasing Income in Rice-based Rainfed and Water-Scarce Environments in the Philippines

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Mechanized dry direct seeding method addresses problems of high labor cost, water scarcity, and crop failure during delayed monsoon. This project supports the vision of the RDE Agenda of ensuring food security in 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 cost, and increase the net income of farmers in rice-based areas by developing the mechanized dry direct seeding technology package (MP). The MP seeder project had designed 15 MP seeder prototypes for rice, corn, and mungbean, which are now adapted to seven target regions. The MP seeder was finetuned to address the required seed rate of rice, corn, and mungbean based on variety and site. In addition, the metering plates for fertilizer applicator were initially tested in on-farm verification trials to meet the required basal fertilizer for corn. The development of management options that will improve crop establishment and nutrient management to boost seedling vigor and enhance biomass accumulation to promote higher yield is now in its second season data. Reducing the seeding rate from 120kg/ha to 60kg/ha resulted in higher if not similar grain yield based on one season data. Reducing further to 40 kg/ha seeding rate was tested this 2020 WS. Comparison between shallow seed depth (~2cm) and deeper seeding depth (~5cm) resulted in similar grain yield. For nutrient management, application of complete fertilizer as basal and two splits of urea during mid-tillering and panicle initiation resulted in yield increase compared to other fertilizer treatments. These results need to be verified in other ecosystems such as favorable and irrigated-tail-end.