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Culture of innovation

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Agriculture is one of the most promising areas for unmanned aerial vehicles (UAV) or drones. Equipped with the right sensors, drones can spray the precise amount of liquids for uniform coverage. The UAV sprayer (*in photo*) at the International Rice Research Institute (IRRI) increases efficiency—up to five times faster than with traditional sprayers—while reducing the amount of chemical runoff that may pollute water sources. UAV technology has been proven so successful that drones will be deployed globally as part of the RICE–Global Rice Array, a network that brings together an international community of rice scientists to conduct a joint effort in enhancing the power of phenomics. See *Plant phenomics: unlocking the potential of rice diversity* on pages 5 to 7 of *Rice Today* Vol. 16, No. 3. (Photo by Isagani Serrano, IRRI)

CONTENTS

rice TODAY Vol. 17, No. 2

Cover design by Maria Angela **Peñafiel**

Photo by Isagani **Serrano**

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Lightbulb moments

by Alaric Francis **Santiaguel**

Innovations, no matter how simple they may appear, have been propelling civilization forward and, throughout its long history, inventive ideas have shaped the agricultural sector.

Take the wooden digging stick. Our ancestors relied on this implement, a design of great simplicity, to dig out holes in the ground to plant seeds and unearth roots and tubers for food. The digging stick also made it easier to convert land into new farms. Thousands of years and countless "lightbulb moments" later, farmers now have a wide array of modern agricultural machinery to produce, harvest, and store crops.

The early plant breeders are believed to have domesticated the first crops some 10,000 years ago by storing and carrying edible seeds of wild plants for future consumption. Some experts say that crop diversification could have started from the mere act of storing seeds of plants that possess certain qualities that they liked. Yet, this modest change led to agricultural productivity that enabled empires and nations to rise. Building on past innovations in crop breeding, scientists have created tools that allow them to delve into the plants' DNA to create new varieties with improved characteristics.

But what is an innovation? How do you spot it? Most importantly, how do you create it?

Idea to Value,[1] an online community that helps people improve their ability to come up with new ideas and convert creative concepts into concrete products, interviewed several innovation "instigators and insurgents" to define the word.

Drew Boyd, co-author of *Inside the box: A proven system of creativity for breakthrough,* said that an innovation is anything that is "new, useful, and surprising."

"Work that delivers new goodness to new customers in new markets, and does it in a way that radically improves the profitability equation," said Mike Shipulski, an innovation thought leader.

Corporate innovation consultant Jeffrey Baumgartner describes it as the "implementation of creative ideas in order to generate value, usually through increased revenues, reduced costs, or both."

From the many different responses he received, Nick Skillicorn, chief editor and founder of *Idea to Value,* came up with his "ultimate" definition: "Executing an idea which addresses a specific challenge and achieves value for both the company and customer."

The International Rice Research Institute (IRRI) is synonymous with some of the biggest innovations in rice science: from better rice varieties that feed billions of people every day to complex experiments to re-wire the rice plant and turn it into a lean, mean grain-producing machine. But, in this issue of *Rice Today,* we feature a host of ingenious contraptions and methods outside the realm of rice breeding.

Some of these, like the digging stick, may be of the most basic design and yet are useful, address a specific challenge, and generate value. "Great innovations are the simple ones that make you slap your forehead and say, 'Gee, why didn't I think of that?'" Mr. Boyd said.

Other innovations are speeding up the transfer of technology generated by scientists from the laboratory into the hands of farmers constantly battling destructive rodents and weeds, low productivity, and unfavorable environments.

Big or small, modest or grand, these innovations are helping IRRI and its partners move forward their mission to end hunger and poverty. ■

[1] www.ideatovalue.com

Sowing the seeds of innovation

by Ando Mariot **Radanielson** and Robert **Coe**

Innovation lies at the heart of the new strategic plan of the International Rice Research Institute (IRRI). It is a building block for attracting long-term investment and strengthening the organization's role within the rice science sector. Initiatives that generate new ideas and support original ways of working serve as a foundation for the organization's future.

In 2017, the IRRI Seed Grant Scheme awarded USD 15,000 each to six research teams led by young scientists. (See *Winning science: Meet the awardees of the first IRRI Seed Grant Scheme* on pages 24-27 of *Rice Today,* Vol. 16, No. 3.) The aim was to foster innovative and collaborative research and provide young scientists with experience in securing and managing independent research funding. We report on the outcomes, challenges, and lessons learned from the first year of the scheme.

Accessing local knowledge to help farmers

The winning proposals included the team led by Harold Valera, a social scientist in IRRI's Sustainable Impact Platform. The team wanted to gain a better understanding of farmers' behavior toward the adoption of new technology such as *Rice Crop Manager* (RCM), a decision-support tool designed to help Philippine farmers increase their yield and income.

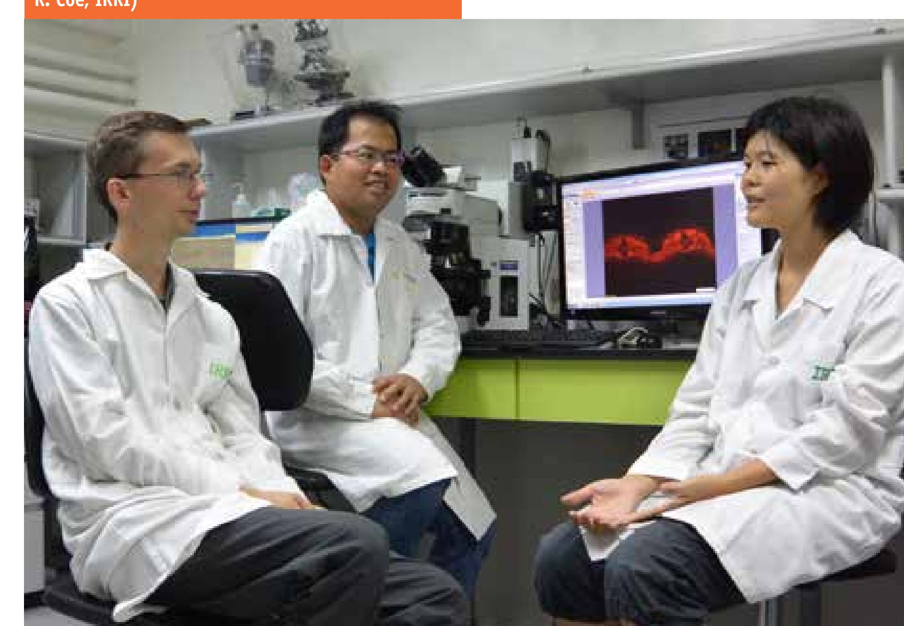
From the field surveys conducted in the province of Camarines Sur, Dr. Valera's team discovered that smallholder farmers at the study sites benefit more from RCM adoption in terms of yield increase.

"Our results show that a majority of the sample farmers who attended the RCM interview have received printed recommendations and most of them have fully adopted RCM," Dr. Valera said. "Farmers' participation in training enabled them to have positive perceptions about RCM knowledge, extension workers, and dissemination."

Dr. Valera added that the success of their research has, in part, been due to a highly effective collaboration with researchers at Central Bicol State University of Agriculture. "Without access to this local knowledge, the conduct of this survey would not have been as effective," he said. (See *Rice Crop Manager in the Philippines: Understanding adoption, attitudes, and perceptions* on page 7.)

A rice farmer from Camarines Sur holds up her survey form evaluating *Rice Crop Manager.* (Photo by H. Valera, IRRI)

Dr. Hsiang Chun Lin (*right*) discusses the results of her research with fellow grant awardees Dr. Dmitri Chebotarov (*left*) and Dr. Harold Valera. (Photo by R. Coe, IRRI)



Dr. Nguyen Van Hung demonstrates *EasyHarvest* during the 2018 IRRI Science Week. (Photo by Isagani Serrano, IRRI)

IRRI is effectively translating its upstream research into real-world benefits and providing a means for measuring its success and opportunities for future development.

Securing our research future

Nguyen Van Hung, also in the Sustainable Impact Platform, is part of a team that develops new technologies in mechanization and postharvest processes at IRRI. His team used the research grant to develop *EasyHarvest*, an application that optimizes the scheduling of combine harvester services.

"We anticipate that this app could help reduce postharvest losses by 3% and farmers' costs by as much as 10%," said Dr. Nguyen.

The app's pilot system was demonstrated at the 2018 IRRI Science Week, during which he discussed how the Seed Grant Scheme enabled his team to generate proof-of-concept data that can be used to attract additional funding.

"This has proven to be a very effective use of limited financial resources as it offers the potential to build future research capacity," he said. (See *EasyHarvest–ICT-enabled geolocation and optimized scheduling for combine harvesters* on page 8).

Managing effective collaborations

Working directly with plant breeders, scientist Nitika Sandhu in the Rice Breeding Platform set out to identify rice varieties suitable for direct seeding rice and develop appropriate nutrient management practices.

"This technology aims to improve the productivity of rice crops in marginal environments, ultimately contributing to food security in the future," Dr. Sandhu said.

Her research plan was perceived as highly ambitious and the peer-review panels were concerned that she would be unable to deliver all of the objectives. However, Dr. Sandhu accomplished all of them by forming strategic partnerships and sharing resources to conduct large experiments with shared hypotheses. The project represents incredible value for the money and is an excellent example of how effective management can maximize the results obtained from research.

Finding simple innovative solutions

Nikolaos Tsakirpaloglou, a molecular biologist in the Strategic Innovation Platform, sought to evaluate the performance of biofortified rice lines under future climatic conditions. This would ensure that the lines were grown in the appropriate geographic zone to maximize their impact on offsetting the effects of malnutrition.

Dr. Tsakirpaloglou originally thought he needed to use specialized growth chambers in which he could manipulate the carbon dioxide concentration in the air. After a discussion with researchers from the C_4 Rice Center, he realized that these would not adequately simulate field conditions, thus limiting the impact of the research.

"However, there was an alternative solution to this problem," Dr. Tsakirpaloglou said. "We could achieve a similar effect by growing the rice plants under shading conditions (covered by mesh) to alter the irradiances and subsequently photosynthesis and growth levels."

This cheap and practical solution enabled the team to collect data from plants grown under field conditions. Their research highlights the benefits of collaboration to share ideas and knowledge.

Pioneering research

Hsiang Chun Lin, an expert in applied photosynthesis and systems modeling in the Strategic Innovation Platform, led a team to screen for differences in the organelle genome sequences of 3,000 rice varieties. In the first analysis of its kind, the team identified useful alleles for photosynthetic and agronomically important traits in chloroplast and mitochondrial genomes.

"These two structures play an important role in photosynthesis and have their own distinct inheritance and protein function," Dr. Lin said. "The aim of our research was to both improve our understanding of the evolution and domestication of rice and find variation that can potentially be used for improving rice photosynthesis. If differences in the genome sequence can be related to traits that affect growth, biomass production, and yield, this will help inform the breeding process by identifying suitable breeding lines."

Dr. Lin said that their analysis yielded some interesting results. Now, they face the challenge of converting their scientific finding into knowledge that other researchers can freely use.

Translating basic research

Dmitri Chebotarov, a computational geneticist in the Strategic Innovation

Rice Crop Manager in the Philippines: Understanding adoption, attitudes, and perceptions

IRRI International Rice Research Institute

Seed Grants 2017

Background

As information and communication technologies become more ubiquitous, a decision-support tool called *Rice Crop Manager* (RCM) was developed to help Filipino farmers increase farm yields and profitability by providing tailored crop nutrient management advice. It is estimated that RCM adoption could add 300 kg of unmilled rice to each hectare grown per season. For the farmer, this would mean an increase in income of PHP 4,000 per hectare.

Extension workers use RCM to provide farmers with field-specific fertilizer recommendations. More than 1.3 million recommendations have been generated since 2013. However, there is little data on how many farmers received RCM recommendations. A major challenge to RCM uptake is the dissemination of the recommendations.

Questions on the adoption of RCM recommendations and whether they lead to increased yields have also been raised. Aside from yield benefit, the RCM tool can provide better information to farmers to avoid fertilizer misuse, which is environmentally costly. For example, the production of fertilizer (especially nitrogen) is very energy-intensive. Wasteful consumption might cause much higher global or regional energy use. However, if farmers do not use the recommendations, then there is space for improvement.

With this in mind, the Seed Grant aimed to examine the adoption of RCM and its impact on yield. It also examined whether low-yielding farmers benefit from the adoption of RCM. Finally, it attempted to understand farmers' perceptions of RCM related to training and extension workers.

What was done

To accomplish the Seed Grant objectives, Dr. Valera incorporated concepts based on the adoption decision process in the household survey instrument, including RCM awareness, knowledge, and compliance. Farmers' perceptions of RCM related to training, extension workers, and dissemination were also captured. He also examined existing data on how farmers used fertilizer and identified the type of extension workers. Finally, he conducted a household survey involving 300 randomly selected farmers in the municipalities of Buhi, Bula, and Nabua in Camarines Sur Province in the Philippines.

This project brought together scientists and researchers working on the RCM, Agri-food Policy platform, and gender research teams across IRRI.

Dr. Valera and Andrew Arellano (left), a field assistant from Central Bicol State University of Agriculture, visit one of the women farmers in the survey sample in Nabua, Camarines Sur.

Results and Lessons Learned

The study found that 66% of the sample farmers who attended the RCM interview have received printed recommendations, of which 60% fully adopted the RCM advice. The positive yield impact of RCM tends to be more strongly felt by farmers at the lower end of the yield distribution, suggesting that lower-yielding farmers benefit more from RCM adoption in terms of yield increases. The results also found that some farmers did not adopt the RCM advice because they felt the need to adjust the recommendation because of weather conditions and water availability. The nonadoption of the RCM recommendation can also be attributed to cash constraints, delays in the delivery of the recommendation, damage caused by either pests or typhoons, and following their own practices or habits. Moreover, some farmers were hesitant to follow the RCM recommendation because they were not fully convinced of its benefits. The study also found that farmers' participation in training enabled them to have positive perceptions about RCM knowledge, extension workers, and dissemination.

Next Steps

For more robust M&E evidence, the IRRI RCM team has started incorporating questions, farmers' perceptions of RCM, and reasons for the adoption and nonadoption of RCM into their monthly RCM Farm Monitor tool. The results of the project were presented during the Philippine Department of Agriculture's RCM National Planning and Updating on 8 March 2018. There is also a consideration to use the relevant statistical analysis employed in the project in the future plans of the RCM team in training staff of the Department of Agriculture in their monitoring, evaluation, and learning activities.

For more information, contact Harold Valera (h.valera@irri.org).

EasyHarvest – ICT-enabled geolocation and optimized scheduling for combine harvesters

IRRI International Rice Research Institute

Seed Grants 2017

Background

Procuring timely, appropriate, adequate and efficient farming equipment for the needs of rice farmers is difficult. Scheduling for combine harvesters, in particular, is a challenge; in the status quo, a farmer calls for combine service that comes on a first come, first serve basis. Poor communication, poor matching of field conditions with machines and poor scheduling lead to high costs, low productivity, high environmental footprint, low operational efficiency and high crop losses. For instance, it is estimated that an optimized scheduling target can potentially reduce postharvest loss by 3% and harvesting costs by 10%, resulting in a savings of approximately USD 1 million per year for a 40,000 users targeted. The Seed Grant sought to develop a system to address these existing constraints to provide better access and availability to machinery services.

What was done

EasyHarvest is a web-based tool in the pilot stage of development. It provides a smart link between farmers and combine harvester service providers. It is designed to optimize the scheduling of combine harvester services by matching the actual needs of farmers and the availability of the contractors' machines. *EasyHarvest* uses algorithms for predicting farm conditions, anticipated harvesting times, and available infrastructure based on available data in a cloud-based platform, and it becomes "smarter" as more data are used in its algorithms.

It has the following key components:

- User interface and database structure for farmers and contract service providers
- Model algorithm for optimizing the schedule of operations
- Integration with current IRRI ICT platforms (e.g., *Rice Crop Manager*) via two-way sharing of data

EasyHarvest combines its users' most common tasks with the scheduling of harvest machinery, with each stakeholder, such as farmers, service providers, and farm managers, having access to different user interfaces.

1. Farmers: ability to share information about their field and estimated harvesting date, receiving information on available machines, and booking the services that match their needs.
2. Service providers: the ability to share information about their combine harvesters and harvesting schedules on a real-time geo-located map, which also helps them keep track of their assets in the field.
3. Farm managers: the ability to see a proposed optimal schedule for each field available and optimize management accordingly.

Partners

For the Seed Grant, we worked closely with the Seed Grant Program, Ziegler Experiment Station, *Rice Crop Manager* Team and the Postharvest and Mechanization Team.

Results and Lessons Learned

Using the Seed Grant fund, we were able to create a cloud-based platform and optimized scheduling system that is currently functional and running.

Next Steps

Following the Seed Grant funding period, we have developed a concept for the next generation or *EasyHarvest*^{Pro}. This platform will broaden the tool's application to include the following:

- Optimized scheduling and operations of the combine harvester, laser-leveling machines, transplanters, straw balers, and more
- Smart (image processing-based) fertilizer and pesticide application
- Smart (drying and storage, modeling and remote sensing based) postharvest management

We hope to create a more robust decision support tool to promote best practices into the rice farming value chain for sustainable rice production.

For more information, contact Martin Gummert (m.gummert@irri.org) or Hung Van Nguyen (hung.nguyen@irri.org).

Platform, led a team in developing a Marker Placement Prioritization Algorithm (MAPPA). This software will help breeders maximize the value of genomic information and speed up its use in breeding. This research was born out of a conversation with Juan Arbeláez Vélez, a scientist in the Rice Breeding Platform.

"At the time, I was thinking about how I could help breeders," said Dr. Chebotarov. "Dr. Vélez pointed out that what is currently missing is a good tool to design low-cost genotyping chips, so we set out to create such a tool."

The beta version of MAPPA has been validated in simulated breeding trials and will now be tested in field experiments. Once complete, the tool will be released as open-source software.

"Our team is very keen to receive suggestions about this tool from the scientific community to ensure that we deliver a usable product," Dr. Chebotarov said.

Challenges and lessons beyond science

The principal investigators identified budgeting and time management as the two greatest challenges in conducting their research.

Accurately estimating the cost of their experiments was difficult without a precedent to guide them. They viewed the grant fund of USD 15,000 as an amount that must be spent rather than a maximum allocation. It was also hard for them to put a value on in-kind contributions from their existing research networks. Even with sound budgets in place, forecasting the final cost of goods and services proved to be an arduous task.

This led to modest underspending by almost all of the teams. They also encountered a constant struggle in juggling the time for planning, managing, and undertaking experimental work. They had neither the time nor the money to do everything they wanted and faced hard choices about setting their priorities.

They offered the following advice to future Seed Grant Scheme awardees:

Communicate frequently, clearly, and confidently. Be clear about what you are doing and why from the beginning. Do not assume that other people understand or share your vision. Continue discussions because projects could evolve quickly in very unexpected ways.

Experience is key. Seize every opportunity to learn but also seek the guidance of more experienced researchers. The guidance and knowledge of their supervisors have been essential in the success of the principal investigators.

Value of collaboration. Innovation can be found in unexpected and unusual collaborations. By bringing scientists from across the organization together, the awardees were able to share their passion, spread their enthusiasm, realize they have a great deal in common, and gain a better understanding of how their research fits into the bigger picture.

The way forward

Research goes on even after the Seed Grant Scheme has ended. The awardees continue to analyze their data and prepare their manuscripts for publication. The tools and applications they developed will be refined, tested, and then released. When possible, the results will be used to support applications for further external funding.

The feedback and suggestions received this year will be used to shape the second year of the scheme, which will be managed by Technology for Development lead Carolyn Florey, plant breeder Dr. Shalabh Dixit, and postdoctoral fellow Helena Wehmeyer.

More information about the scheme and the research it has generated is available at http://irri.org/seed-grant. ■

Dr. Radanielson is a cropping system scientist and Dr. Coe is a scientist in plant phenomics at IRRI.

The IRRI Seed Grant Scheme aims to sow the seed for the next generation of rice scientists. (Photo by I. Serrano, IRRI)

Effects of photosynthetic variations on the grain content of iron (Fe) and zinc (Zn)

IRRI International Rice Research Institute

Seed Grants 2017

Background

Dietary deficiencies in Fe and Zn affect rural and urban communities with limited access to a diverse diet. Biofortification of rice comprises a potentially sustainable approach for alleviating these deficiencies as part of existing interventions (diverse diet, supplementation, and food fortification). Recently, we reported on a biofortified rice line grown under field conditions that satisfies the prerequisites to meet approximately 30% of the estimated average requirements.[1]

To assess the effect of a possible reduction in photosynthesis due to climate change on grain micronutrient content, agronomic characteristics, and gene expression profiling of selected candidate gene events, our Seed Grant proposed to study three high-Fe/-Zn lines grown under different irradiances in a biosafety screenhouse setting. Overall, the study tested the effect of climate on the nutrient content of grain, specifically the resilience of new transgenic lines that have high Fe and Zn content in the polished grain.

What was done

Previously published work[2] and preliminary results from our studies in high-CO_2 chambers of non-GM lines indicated a reduction in Fe and Zn content in polished grains.

To test the effect of climate on grain nutrient content, we grew selected high-Fe/-Zn lines along with their azygous and wild-type controls under different irradiances (0%, 50%, and 75% shading) in screenhouse conditions during the 2017 wet season in the Philippines. For each of the respective irradiances, 20 homozygous T3 plants per event were included (see images for the experimental setup). Measurements, including determination of biomass and leaf or canopy nitrogen distribution, leaf gas exchange measurements, instantaneous measurements of leaf photosynthesis, determination of chlorophyll content, and determination of leaf chlorophyll and Rubisco content, etc., were conducted. Leaves at the vegetative stage from selected events were collected for subsequent gene expression (RNA seq) analysis. The agronomic performance (including plant height, number of panicles to be harvested, number/weight of field seeds per plant, etc.) of the transgenic events grown under the different irradiance conditions was assessed. Last but not least, the Fe and Zn content of harvested polished grains was determined through inductively coupled plasma mass spectrometry.

Partners

The study was primarily performed in collaboration with Dr. Hsiang-Chun Lin, postdoctoral fellow in the C_4 Rice Center, who designed and oversaw the photosynthesis-related experiments. Dr. William Paul Quick, head of the C_4 Rice Center, and Dr. Inez Slamet-Loedin, head of the Genetic Transformation Laboratory, participated in the planning of the study and surpervised its overall progress. In addition, several individuals from the two laboratories contributed at various stages of this study and assisted with the performance and data collection as in-kind contributions of the respective heads of the laboratories.

Results and Lessons Learned

Preliminary analysis of the results from the study indicates differences in the agronomic characteristics as well as the Fe and Zn content of the harvested polished grains between the different biofortified high-Fe/-Zn lines grown under different irradiances. However, a more thorough investigation of the results is underway to determine the extent of these differences and to suggest potential reasons why this is occurring. Moreover, an overlay of these data with the photosynthesis- and gene expression-related results will enable a more holistic and detailed overview of the reasons underpinning these changes.

Next Steps

It has been shown that the Fe, Zn, and protein contents of polished rice grains are negatively affected under elevated CO_2 conditions.[2] By modulating the irradiance levels under which the biofortified high-Fe/-Zn lines were exposed, the team aims to investigate how climatic factors affect the nutrient content of grain, especially in the new biofortified varieties being developed at IRRI with high Fe/Zn content. Such information will have a major impact in deciding the geographic locations for maximum impact and mitigating the effects of future climate change. In this respect, the study enabled the collection of novel data on the effect of climate on grain nutrient content and related data on the gene networks affected that underpins these changes. Hence, this study has provided and will continue to give novel data on a fundamental question that addresses the link between grain quality and environment that is poorly understood. In combination with earlier preliminary data, it will also provide data for a significant publication.

[1]Trijatmiko, K. R., Dueñas, C., Tsakirpaloglou, N., Torrizo, L., Arines, F. M., Adeva, C., et al. (2016). Biofortified indica rice attains iron and zinc nutrition dietary targets in the field. Sci. Rep. 6, 19792. doi:10.1038/srep19792.
[2]Myers, S. S., Zanobetti, A., Kloog, I., Huybers, P., Leakey, A. D. B., Bloom, A. J., et al. (2014). Increasing CO_2 threatens human nutrition. Nature. doi:10.1038/nature13179.

For more information, contact Nikolaos Tsakirpaloglou (n.tsakirpaloglou@irri.org).

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GRAIN OF TRUTH

Connecting the Dots: the role of social science research in agricultural R&D systems

by Prakashan Chellattan **Veettil** and Debjani **Samantaray**

India is the world's second-largest producer and biggest exporter (more than a fourth of the world's exports) of rice, yet, paradoxically, its people suffer from hunger and malnutrition. To solve real-world problems such as these, we need to build a bridge between social science and agricultural research to form a better understanding—and find more accurate solutions—using interdisciplinary analyses of problems.

The "human face" of science

The overarching purpose of agricultural research is to benefit society. But, without contributions from social science to serve as its "eyes and ears," researchers' capacity to prioritize research, catalyze adoption, and bring transformative impact can be diluted. With its ability to influence millions of lives, social science plays a critical role in reinforcing agricultural research systems by providing science with a human face and improving the priority-setting process for investment in agricultural research.

"To ensure that all stakeholders in the rice value chain benefit, we need to focus on inputs of farmers and understand better how consumer demand works," said Nafees Meah, IRRI's representative for South Asia. "Social science, in consonance with biological sciences and technological advances, has the ability to enhance the relevance of research by customizing it to the needs of farmers and society."

IRRI has facilitated the release of more than a thousand IRRI-bred and improved rice varieties in 78 countries since its establishment in 1960. The success of these high-yielding varieties are outcomes of R&D. IR8 was not only widely accepted by farmer communities but also ushered in the original Green Revolution in many Asian countries. Another milestone variety, IR64, became one of the most widely grown rice in Asia. And the flood-tolerant Swarna-Sub1 marked the start of the Second Green Revolution.

On the other end of the spectrum, some well-studied agricultural R&D outputs such as urea-treated straw, residual cropping in fallow, and crop insurance have encountered low acceptance by farmer communities. Social science can help understand how demand-driven varieties of rice can be produced along with effective agricultural extension systems and robust crop insurance mechanisms and the best technology that can help convey information to farmers.

"As a technical leader, IRRI needs to promote the contribution of social sciences, to ensure farmer perceptions are contributing to prioritizing R&D efforts," said Keijiro Otsuka, professor of development economics at the National Graduate Institute for Policy Studies in Tokyo, Japan and a former chair of the IRRI Board of Trustees (2004-07). "India and the rest of Asia need to focus on working better with farmers to promote land aggregation, and encourage the adoption of technological advances and mechanization."

Professor Otsuka emphasized the catalyzing role of agricultural research systems in bringing about economies of scale through land reconsolidation and eventual mechanization such as the "small farmers, large field" scheme piloted by IRRI in Odisha, India.

"The Food and Agriculture Organization cites rice as a strategic commodity in maintaining stability in South Asia," Dr. Meah said. "Therein lies the need to enhance our understanding of behavioral issues of stakeholders in the rice value chain. Social science can play a pivotal role to make sure biological R&D responds to the needs of farmers and consumers and provides robust and informed policy frameworks."

"For true transformation in agriculture, we must prioritize research and work in partnership with our populations to encourage active adoption by farmers and end consumers," said Dr. Tin Htut, permanent secretary of Myanmar's Ministry of Agriculture, Livestock, and Irrigation, who stressed the importance of cooperation in achieving better interdisciplinary efforts.

Innovate, catalyze, transform

"IRRI is adopting a modular approach, wherein stand-alone modules can be chosen by stakeholders in the rice value chain for implementing as per specific priorities and local conditions," said Dr. Meah.

Having successfully implemented several breeding and crop management programs, multidisciplinary teams at IRRI are working together to develop optimal product and investment portfolios to benefit stakeholders in the rice value chain, using modern genetic approaches such as DNA fingerprinting, remote sensing for real-time rice monitoring and yield estimation, and others.

"With better collaboration between stakeholders from interdisciplinary fields, we can ensure the optimal use of scarce resources while ensuring food security," said Dr. Praveen Rao, vice chancellor of PJTSAU.

These efforts at connecting the dots to integrate social science and biological research wield power to bring about transformative change in agriculture and society at large. ■

Dr. Veettil is an agricultural economist in IRRI's Agri-Food Policy Platform. Ms. Samantaray is a senior specialist in IRRI South Asia's Core Communications Unit.

In Memoriam

Bienvenido Juliano

(1936-2018)

by Gene **Hettel**

Bienvenido "Ben" Juliano, 81, world-renowned cereal chemist and Philippine National Scientist, passed away on 21 February 2018 in Los Baños, Laguna. Dr. Juliano was among the first group of elite scientists who set the direction of the International Rice Research Institute (IRRI) during its early years. Arriving as an associate chemist in 1961, he went on to spend more than 32 years at IRRI, most of them as head of the Cereal Chemistry Department.

Dr. Juliano's rice taste-panel research showed that the amylose and amylopectin contents of the starch largely determined rice's cooking and eating quality. He found that a higher proportion of amylose provided a greater tendency for rice to cook dry and fluffy. So, based on this research, it became clear that the rice eaters of the Philippines and Indonesia preferred medium-amylose rice grains. The first IRRI variety to meet this requirement was named IR24 in 1971.

"Without question, the broad scope of Dr. Juliano's work in cereal chemistry advanced decidedly the world's knowledge of the cooking, eating, and nutritional qualities of the rice grain," wrote IRRI's first director general, Robert Chandler, Jr., who hired him. "He was a pioneer in analyzing IRRI's world collection of rice varieties for protein content."

In 1993, he produced two books that brought together many elements of his scientific body of work, *Grain Quality Evaluation of World Rices*, published by IRRI, and *Rice in Human Nutrition*, published by the Food and Agriculture Organization (FAO). Dr. Juliano put together the FAO book to serve a wide range of readers in government, universities, and industry as a general source on most aspects of rice production, processing, trade, and consumption. His IRRI book (written with C.P. Villareal) was aimed at rice breeders and chemists involved in grain quality breeding programs and food scientists and nutritionists interested in rice grain quality, composition, processing, and use. It was translated into Japanese in 1999.

"It is primarily due to Dr. Juliano's dedicated work in this important research area that IRRI and other scientists can routinely measure grain quality in pre-breeding efforts that are serving the national agricultural research systems," wrote former IRRI Director General Klaus Lampe.

Dr. Juliano also released a 10-chapter book in 2003, revised in 2007, *Rice Chemistry and Quality*, which was launched by the Philippine Rice Research Institute (PhilRice). After he left IRRI, Dr. Juliano helped build the grain-quality research capability of PhilRice, where he continued to pursue his rice research as a senior consultant/expert, bringing his time devoted to cereal research to a half century.

After his retirement, Dr. Juliano was invited to visit cereal laboratories in Vietnam, Myanmar, China, Bangladesh, Cuba, and Taiwan to give recommendations to their rice quality breeding programs.

Dr. Juliano received numerous honors and awards throughout his stellar career, including being the only non-Japanese Asian to be presented with the Medal of Merit by the Japanese Society of Starch Science in 1982, the only Asian and rice scientist to receive the Thomas Burr Osborne Medal from the American Association of Cereal Chemists in 1988, and the first Filipino to be honored by the Association of Southeast Asian Nations (ASEAN) as an Outstanding Scientist and Technologist during the ASEAN Science and Technology Week (1988). In 2000, he was bestowed the honor of National Scientist by Philippine President Joseph Estrada.

In 2004, he received a plaque of recognition for lifetime research on rice quality awarded by IRRI on the occasion of the dedication of the new Grain Quality and Nutrition Center.

"A key legacy of Dr. Juliano at IRRI is the establishment of the Grain Quality and Nutrition Center," said Dr. Bruce Tolentino, IRRI's deputy director general for Communication and Partnerships. "He laid the foundations of the methods and approaches to grain quality testing at IRRI." ■

Mr. Hettel is a senior consulting editor and content specialist at IRRI.

After his training, Mr. Ali has become the official cameraman of the group. "We are able to help farmers in Sumber Hidup produce videos about their daily farming life," he said. (Photo by R. Quilloy, IRRI)

Film-making farmers and the changing landscape of rice extension in Indonesia

by Reianne **Quilloy**, Buyung **Hadi**, and Trina **Mendoza**

It is time for farmers to take the lead in telling their stories and conceptualizing ways to connect their fellow farmers with effective technologies.

Rice is commonly produced in the tidal swamp areas of South Sumatra predominantly as a single annual crop because the dry-season cropping suffers from rat and weed damage and labor shortage. In recent years, best management practices and technologies were introduced through the Assessment Institute of Agricultural Technology (AIAT) to encourage farmers to plant rice more than once a year.

"By rolling out these effective technologies, we can achieve sustainable intensification of rice production in these outer islands," said Budi Raharjo, AIAT program manager. "We believe more farmers will benefit from the technologies if they hear how they work in a language that is familiar to them. Even more so if these are promoted by farmers who have actually used the technologies."

Rice intensification in the outer islands of Indonesia, a project of the International Rice Research Institute (IRRI) funded by Give2Asia, invested in building the capacity of farmers and extension workers so that they can lead the continuing process of intensifying rice production by using videos to disseminate new technologies.

Empowering visuals

Building on this idea, communication experts from IRRI and the College of Development Communication at the University of the Philippines Los Baños (UPLB) developed a training program in participatory video production for farmers and extension workers. Twenty farmers and 13 research and extension staff of AIAT-South Sumatra participated in the program and produced their own videos. The farmers were from the tidal swamp areas where best management practices are being promoted by the project, *Closing rice yield gaps with reduced environmental footprint.*

The training consisted of (1) teaching basic skills on video production, including operating a video camera, filming videos, and conducting interviews; (2) developing a storyboard to organize their ideas; and (3) basic video editing. Each village also received a laptop, video camera, audio recorder, and a tripod so that they could produce videos on their own after the training. A year after the training, the trainees collectively assessed the videos they produced and the significant outcomes.

Trainees from the four villages produced eight videos on a range of topics: promoting best management practices and using a drum seeder in sowing, rodent management using a trap barrier system and targeted community actions, and using machinery to overcome the labor shortage.

"We conceptualize the stories together and assign specific roles," said Saidina Ali, one of the participants, in describing how they organized the village production team. "I was assigned the role of a cameraman. At first, I didn't even know how to handle a camera. Now, I am the official cameraman of Mekar Sari. I would say that, from having zero confidence, I can now rate myself as an 8 (out of 10) in operating a video camera."

He shared how they used the skills they gained to produce videos for farmers living in the nearby village of Sumber Hidup. "We were able to help them produce a video about their daily farming life," said Mr. Ali. "The video was shown at a farmers' congress in Java. I feel happy that I can now do other things like making videos."

Raharjo, an extension worker in Air Saleh, found creating videos to be a good tool to help convey more information by demonstrating important farming practices. "We recently produced a video about a tractor-pulled drum seeder we developed," he said. "We want to show farmers our latest innovation and how it works so that other farmers could also use it."

"This initiative is impressive in allowing and motivating the farmers to share best management practices and not merely to comply with project deliverables," Mr. Budi said. "These farmers choose the topic they want their target audience to see and understand. Videos are one of the most effective tools for sharing best management practices based on their experience so others could learn from them."

The group also found it useful for them to document farming activities.

"We think we are able to communicate better through videos," said Mr. Wasikin, one of the participants and a 2016 Outstanding Farmer awardee. "I would like to document my daily farming life so I could inspire others so that they, too, could earn more from farming."

With support from Give2Asia, some of the videos produced by these farmers were broadcast by TVRI South Sumatra, the local station of the national television network. Technologies such as the trap barrier system to manage rodent infestation and the mechanized drum seeder for crop establishment were showcased during these broadcasts.

Reflecting on the experience, the participants looked back on the video-making program and the outcome of the training. "We want to continue producing more videos, not just for the sake of telling stories," said the participants. "We also want to show our fellow farmers that we can do more than farming. We can also make videos." ■

Ms. Quilloy is a communication and outreach specialist at IRRI. Dr. Hadi is the IRRI country representative for Cambodia and the coordinator of IRRI-Give2Asia. Ms. Mendoza is an assistant professor in the College of Development Communication, UPLB.

Impact from behind the scene

"Videos can be a transformative and empowering tool," said Buyung Hadi, IRRI scientist and the coordinator of Give2Asia. "At IRRI, we have mastered producing videos wherein we explain the how-tos and interview farmers on how they use them. The next step in the evolution of this method is to teach the farmers themselves to produce the videos. I expect that the end product will reflect farmers' realities better than videos produced by scientists. This should, in the end, increase the videos' appeal for other farmers.

"It is vital for us at IRRI to realize the multiple ways by which technologies can be disseminated," Dr. Hadi added. "When we empower farmers and other intermediaries to express and communicate their insights to their peers, we embed a technology in a social network that will, we hope, carry on perfecting and disseminating it."

Mr. Wasikin continues to produce videos with fellow farmers in his group in Telang Rejo, and his daughter and granddaughter. (Photo by R. Quilloy, IRRI)

Transforming information into a commodity

by Lisa Mariam **Varkey**, **Sandeep**, Vikram **Patil**, Preeti **Bharti**, Sheetal **Sharma**, and Prakashan Chellattan **Veettil**

Can agricultural advisory services provide business opportunities for agro-input dealers?

In Odisha, India, the agricultural sector has a domineering influence on the life and livelihood of 61% of the populace and, thus, holds the key to the socioeconomic development of the state. Because rice is the state's principal crop, its low productivity, which is below the national average, has been affecting the sector significantly for some time.

One of the major reasons widely cited for the low yield and income of the farmers in the state is poor nutrient management in terms of quantity and the timing of application. One significant way of overcoming this problem is through customized agricultural advisory services on nutrient management.

Routing fertilizer information

Under this objective, the government of Odisha has been promoting *Rice Crop Manager* (RCM), a web-based software developed by the International Rice Research Institute (IRRI), as part of the emerging role of information and communication technology (ICT) in the agribusiness sector. To disseminate the recommendations, IRRI uses its staff, community resource persons, and public dissemination channels such as village agricultural workers.

RCM centers (or *kendras*) are also an important path for delivering the recommendations. The RCM kendras are equipped with ICT devices used by trained agricultural extension staff. The centers were established under a project implemented by IRRI and the government of Odisha to increase the productivity of rice-based cropping systems and farmers' income in the state.

Some nongovernment RCM kendras also complement the government-run centers.

Efforts are being made to popularize RCM kendras among farming communities and to encourage farmers to visit them before the start of each cropping season to receive personalized recommendations for their rice crop.

In addition to the kendras, RCM opens up potential avenues to improve the scalability and accessibility of agricultural advisory services through private extension agents. In India, input dealers are rated as the most significant source of information for farmers, making them a significant category of private extension agents.

Our study was an exploratory attempt to determine the possibilities of making input dealers a major dissemination channel for RCM interventions as well as to ascertain farmers' willingness to pay for private extension services.

Understanding the players

We conducted our study in Puri District because, in addition to being agriculturally rich, the district serves as the hub of IRRI and RCM activities.

A total of 50 farmers were randomly chosen from the farmer population provided with RCM recommendations during the 2016-17 rabi season. Our sample group consisted primarily of small and marginal farmers with an average landholding size of 1.3 hectares. Half of the farmers were monitored by IRRI staff, village agricultural workers, or nongovernment organizations throughout the season to ensure that they followed the RCM recommendations provided. The other half was not monitored. The management practices for both plots were similar in all aspects except nutrient application.

Interviewing an input dealer as a potential conduit for the dissemination of RCM recommendations. (Photo by Manas Ranjan Sahoo)

Among the factors we explored were the differences in the cost of cultivation and yield between RCM practices and farmers' own practices, and the farmers' satisfaction with the RCM recommendations. We also examined their willingness to receive RCM recommendations for the coming seasons and to pay for the service from fertilizer input dealers as well as their diversity in terms of willingness to pay.

Thirty-four dealers were randomly chosen and surveyed to identify the variation in their socioeconomic characteristics, business operations, and, more importantly, their responses toward advocating RCM interventions as a potential business model. The dealers in our sample had a fair amount of experience as input dealers, with an average of 16 years. Most of the dealers had small firms, with a few wholesalers included. They indicated that the major share of their income came from fertilizer business.

Revealing numbers and behaviors

We asked the farmers to mark their preferences for the existing dissemination channels as well as the proposed private (paid) input dealer channels. A big revelation in the study was that, in the absence of "doorstep delivery" of RCM recommendations, farmers were inclined to obtain the services from nearby input dealers at a minimal cost—with a few even ready to shell out an average amount of USD 0.77—rather than availing of the free services from RCM kendras located about 15 kilometers (on average) from their homes. We also found that the more educated and the younger farmers were more receptive to RCM technology as they were ready to purchase the recommendations from dealers even at higher costs.

In a season, farmers visit the RCM kendras located in block or district offices less frequently than agricultural supply dealers. The study revealed that 72% of the sample farmers reported at least quarterly visits to dealer shops in a year but only 12% visited the kendras at least once. Also, 84% of the sample farmers had been purchasing from the same input dealer for more than 10 years.

The preference of the farmers to pay for agricultural advisory services from private extension dealers over the free services offered by RCM kendras reveals that (a) farmers, because of more frequent contact and better accessibility, have developed a better rapport with input dealers than with public extension systems located far away, and (b) even small and marginal farmers see considerable promise in RCM technology for gaining agricultural prosperity.

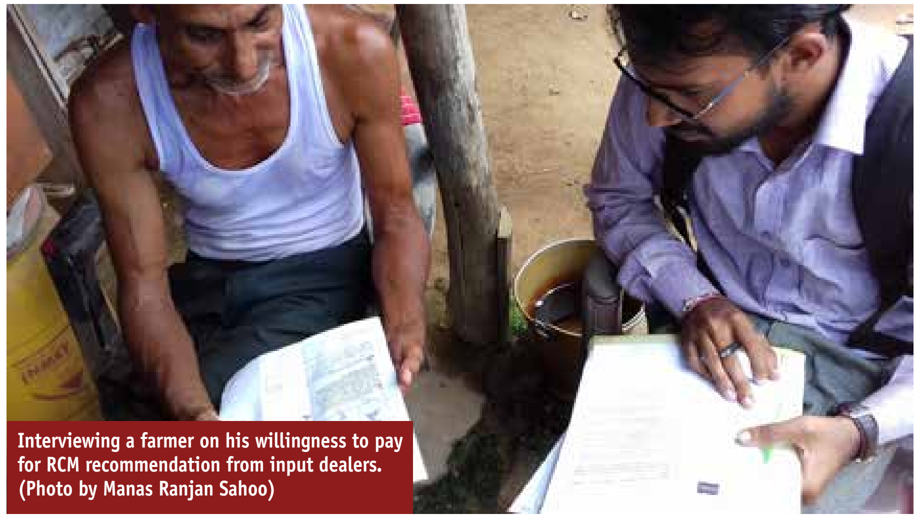
Our study also revealed that the farmers' way of using fertilizer followed a highly skewed consumption pattern in which their average application of muriate of potash and diammonium phosphate was above the average level recommended by RCM. At the same time, the amount of urea they used was below that of the average RCM recommendation.

The role of balanced fertilizer application in bringing in considerable change need not be overemphasized. The farmers in the RCM plots reported an average yield gain of 2 tons/hectare vis-à-vis the plots under the farmers' own practice. In these smallholder plots, the yield gain through balanced nutrient management can bring in additional returns of more than USD 77 per hectare and can lead to potential agricultural progress.

In addition, 96% of our sample farmers perceived production and productivity gains while 92% realized a potential cultivation cost reduction from the adoption of RCM technology.

Information dealers

An equally important step, apart from obtaining farmers' perceptions, toward establishing ICT-based agricultural advisory services on a business scale would be obtaining the perceptions and responses of input dealers toward the sale of RCM recommendations from their shops. All the dealers in our sample responded positively to adopting RCM interventions on a business scale at minimal service costs.



Interviewing a farmer on his willingness to pay for RCM recommendation from input dealers. (Photo by Manas Ranjan Sahoo)

Among the dealers, 85% told us that they had given suggestions to farmers on fertilizer doses and, hence, the amount of fertilizer they needed to purchase. A good 76% of the dealers reported that farmers actually paid attention to their suggestions. This is particularly important considering that an average of 800 farmers visit each dealer's establishment annually. Out of these, approximately 300 farmers were their long-time customers who visit them 18 times a year on an average. The distribution of RCM recommendations through input dealers would give their suggestions a scientific basis. This would also give RCM technology wider coverage and help ensure higher compliance of farmers with the recommendations.

Setting up an ICT establishment and proficiency in operating an ICT device are the two essential requirements needed for instituting the dissemination of RCM interventions in a commercial mode. We also looked at the ICT-readiness of the dealers in terms of personnel and facilities. Every shop had an average of two employees, with at least one being proficient in using ICT tools.

Although only 15% of the dealer respondents presently have the required ICT facilities at their stores to generate and sell RCM recommendations, all of them were willing to make the sale of RCM recommendations a supportive side business and put up the required infrastructure.

When asked about the potential benefits they perceived from the sale of RCM recommendations as a side business, the majority opined that this would serve as a new source of income and a form of service to the farming community.

A new information delivery ecosystem

This study should be seen as a pilot attempt to examine the possibility of setting up a proposed ICT intervention business model.

The readiness shown by farmers and dealers toward this potential business proposal has given us confidence about opening up new avenues for better and wider dissemination of RCM technology. The efforts required in training input dealers or their staff in operating the RCM app would also be minimal since they are already acquainted with ICT devices and are knowledgeable about agricultural practices.

Although the results are positive, our study further warrants a detailed and elaborate business diagnostic study to represent the entire state and pilot-test the model. ■

Drs. Varkey, Patil, and Veettil are an assistant scientist, associate scientist, and scientist, respectively, in the Agri-Food Policy Platform at IRRI India. Ms. Bharti and Dr. Sharma are specialist and scientist, respectively, in the Sustainable Impact Platform at IRRI India. Sandeep is a student at Assam Agricultural University and an intern at IRRI India.

Drying with water

by James **Quilty**

Mr. Guevarra and Mr. Ricardo Hernández, associate manager at IRRI's Post Harvest and Goods Control, are two of the seven-member team that developed the geothermal rice dryer. (Photo by Isagani Serrano, IRRI)

The International Rice Research Institute (IRRI) is globally recognized as a center of excellence in research that delivers sustainable solutions to rice-based agri-food systems. To make significant progress, IRRI relies on its capacity to stay at the forefront of innovation in research and in the operations that support these research activities.

In Asia, in the 1960s, when IRRI started its mission to eliminate hunger and poverty, improve the lives and livelihoods of rice farmers and consumers, and protect rice agri-food system environments, the water buffalo and sickles were often the most advanced "machines" used in rice farming. Since IRRI began working on mechanization in the 1970s, it has developed numerous machines and implements that are now commonly used in rice farming across the continent. These include hand tractors, axial-flow threshers, and grain dryers. In addition, IRRI has developed mechanized solutions to improve research operational efficiency and reduce the cost of research.

From fossil fuel to "recycled" air

In 2013, an innovative idea was proposed by Rolando Torres, a research technician at the Experiment Station (now the Zeigler Experiment Station or ZES). Mr. Torres suggested setting up a shipping container connected to the hot-air exhaust of the large air-conditioning system servicing the research laboratories at IRRI headquarters in Los Baños in the Philippines. The proposed system would use the warm, dry air from the exhaust as the heat source for drying rice paddy and rice straw inside the container.

Prior to this, IRRI relied on kerosene-powered grain dryers to reduce the moisture content in grains to a level that is safe for storage. Aside from being expensive, kerosene, a fossil fuel, is a nonrenewable energy source that emits the greenhouse gasses nitrogen dioxide, sulfur dioxide, and carbon monoxide. All three can cause health problems when inhaled. Kerosene dryers also required constant monitoring throughout their operation because of the risks associated with having a flame as a heat source when drying biomass.

"I took up the idea of using the heat from the air-conditioning system as it presented an opportunity to reduce IRRI's carbon footprint, eliminate the risks associated with kerosene dryers, and lower the cost of drying," said Leigh Vial, head of the Experiment Station at the time.

Dr. Vial gave Rolando Guevarra, a mechanic and fabricator working at the Experiment Station, and the Experiment Station team the task of designing and assembling the air-heated drying unit.

"The container was fitted to a ducting system with a canopy above the exhaust outlet of the

Dr. Vial led a number of projects to improve the infrastructure and the processes at the ZES. (Photo by I. Serrano)

air-conditioner," Dr. Vial said. "The canopy channeled hot air into the container with the rice grains and straw placed on shelves inside."

A blind spot

The system had a significant shortcoming, though. For bulk-harvested material at IRRI, the flatbed dryers heated by kerosene were intended to achieve equilibrium drying (between 14% and 17% moisture content) while maintaining high grain quality and seed viability. The research of Martin Gummert, who leads the Postharvest and Mechanization Research Cluster at IRRI, showed that relative humidity must be maintained at or below 70% to effectively achieve equilibrium drying.

"Unfortunately, this challenge with the drying system heated with air-conditioner exhaust proved too difficult to overcome because the large air-conditioning units were switched off every night," Dr. Vial said. "At night, the humidity in the container would rise above 70%, causing a rewetting of the rice grains and straw."

This rewetting deteriorates both grain quality and seed viability. With the kerosene dryers, the problem could be avoided if the systems were kept running and carefully monitored by staff throughout the night.

An idea in hot water

An alternative heat source was therefore needed and it just so happens that the irrigation water IRRI draws from an aquifer is warm. Dr. Vial realized that this was a potential source of heat that could be used in place of the air-conditioning system's exhaust. In 2014, the construction of the first geothermal dryer was undertaken, again through the efforts of Mr. Guevarra.

The same container design was used in this system, but with two variants: one with a mobile roll-in-roll-out shelving system; the other with the flatbed dryer design. The water temperature from one of the wells that supply irrigation water within the Upland Farm area of IRRI is 45–48 °C. When passed through a heat exchange system, the water sufficiently increases the air temperature to achieve efficient equilibrium drying. After passing through the heat exchange system, the water is then channeled into a reservoir and used to irrigate the research fields.

"As a result of the development and installation of these water-heated dryers, the cost of drying operations has decreased by more than 80%," Dr. Vial said. "The risks associated with having a flame in the proximity of drying biomass have been eliminated and the gas emissions from drying activities at IRRI have declined drastically."

By 2017, the ZES had fabricated eight geothermal dryers located in the Upland Farm complex. These dryers are based on a 20-foot (6.1-meter) shipping container and have been converted to the flatbed dryer-type system, which increases the speed and efficiency of loading and unloading of paddy and rice straw. On average, it takes 2 to 3 days to dry the moisture content from the harvested biomass from around 23% to 14–17%. Unlike kerosene dryers, the system can run 24 hours a day, 7 days a week.

From innovation to the new norm

The geothermal dryers now fulfill a critical role in postharvest processing for breeding and agronomy research activities at IRRI headquarters. Each season, these dryers are responsible for drying almost 100,000 samples. Because of the critical nature of these dryers, a backup hot-water supply that can provide a continuous flow to the system, if the pump servicing the irrigation well is interrupted, is being developed.

The aim of the backup system is to use solar power to produce hot water during the day and then switch to the main IRRI power supply when the solar panels are not generating power. Once fully operational, the system will provide an opportunity to develop dryers with a low operating cost and low carbon footprint at other points on the farm where the water from the aquifer is not hot enough for drying operations.

The new drying systems used for grain and biomass are among many examples of how practical innovative solutions improve IRRI's operational efficiency thanks to the creativity and inventiveness of its dedicated staff. ■

Dr. Quilty is the Integrative Research Support Platform leader at IRRI.

Geothermal dryers have replaced kerosene flatbed dryers in postharvest processing for breeding and agronomy research activities at IRRI headquarters. (Photo by I. Serrano, IRRI)

HIDDEN INNOVATIONS

by Alaric Francis **Santiaguel**
photos by Isagani **Serrano**

Outside the spotlight that shines on scientific breakthroughs are a number of creative and ingenious devices that help improve day-to-day operations at the International Rice Research Institute (IRRI).

At IRRI, innovation, like rice, is life. Working with other research centers and partners around the globe, IRRI scientists strive tirelessly to discover, translate, and integrate scientific advancements that enable the adoption of technologies, practices, and policies to solve the complex global problems of its beneficiaries in rice-growing countries.

But, innovations at the institute are not limited to the confines of its laboratories. Albert Einstein once said, “Innovation is everyone’s responsibility, not just R&D’s.” Paul Cornelio Maturan and Rolando Guevarra are just two of the innovators at the institute who apply their problem-solving creativity and resourcefulness to improve IRRI’s day-to-day operations.

Mr. Maturan is a scientist and part of a project that seeks to make the Philippine rice breeding program more efficient. In between, he constantly works with other staff members to provide solutions to problems ranging from moving heavy objects to reducing noise and dust pollution and making a process cheaper and easier.

“Whenever Paul sees people struggling with their chores, he thinks of ways to make the job easier,” said Mr. Guevarra, a mechanic and fabricator at the Zeigler Experiment Station (ZES). “He discusses his ideas with me and I come up with the prototypes.”

Ultimately, the seemingly small impact of these innovations helps researchers get the big jobs done—faster and better.

The seed-treatment machine

Innovator: Mr. Maturan

IRRI’s Seed Health Unit, established in 1982, conducts major rice seed health testing for phytosanitary certification and post-entry clearance. It is the single gateway for all rice seeds, rice grains, nonseed biological materials, soil samples, and materials other than rice coming into and going out of IRRI. For exported materials, especially seeds, the unit ensures compliance with the plant quarantine regulations and seed health standards of the importing country.

Problem: Conducting treatment of seeds (between 500 and 2,000 grams) was laborious. The process consisted of putting the seeds inside a plastic container and shaking it until all the seeds were uniformly coated with fungicide.

Solution: The seed-treatment machine can treat from 20 to 10,000 grams of seeds simultaneously. The machine not only reduces the treatment time but also is safer and more efficient than the manual method. Since the early 1980s, hundreds of thousands of seed samples bound for different countries have passed through the machine.

The two-levee pathway

Innovators: Mr. Maturan and Teodoro Cuevas

Some of the world’s most productive and important rice varieties are developed and first tested at IRRI’s ZES. These include IR8, IR36, and IR42, which dramatically increased rice’s yield potential, ushering in an exciting new era in Asian food security and rural development.

Problem: Wide rice bunds are necessary when tractor-mounted pesticide sprayer booms are used in field experiments. Constructing wide rice bunds is prohibitively expensive, costing about USD 13,500 per hectare. It also requires heavy equipment such as a backhoe, dump truck, and grader. The alternative is to use manual pesticide application, a health hazard for workers even with proper safety equipment.

Solution: Building two levees parallel to each other can serve as a pathway for a tractor sprayer. The construction of the levees costs only a fraction of the wide rice bunds at USD 192 per hectare. In addition to the tremendous savings, the two-levee pathways result in more effective spraying since the sprayer boom is closer to the plant canopy, resulting in less chemical drift.

A sound-proof vacuum room

Innovators: Mr. Maturan (in photo) and Mr. Cuevas

Emasculation is the process of removing the anthers from the florets of the rice plant. The simplest and most efficient emasculation technique is to clip the spikelets and remove the remnant anthers with tweezers. IRRI’s emasculation facility uses a vacuum for faster and more efficient removal of the anthers.

Problem: Vacuums generate deafening noise levels. The noise level of a standard household vacuum cleaner is 78–80 decibels, with some models capable of producing sound above 80 decibels. The noise produced by the vacuum machine during emasculation is significantly higher than that. In addition, the small confined space of the vacuum chambers amplifies the sound further and renders the earplugs worn by workers almost useless. Chronic exposure to loud noises has been linked to hearing impairment, hypertension, ischemic heart disease, annoyance, and sleep disturbance.

Solution: Acoustic foam panels were attached to the walls of the vacuum chamber, thus dramatically reducing the noise level. The foam panels acted as sound absorbers and prevented the noise from continuing to bounce and echo throughout the chamber.

A pressurized irrigation outlet

Innovators: Mr. Maturan and Efren Bautista (in photo)

Rice and water are practically inseparable. At the ZES, the availability of irrigation water is essential to many of the experiments conducted there, particularly during the dry season.
Problem: Using diesel-powered water pumps and gravity irrigation is slow.
Solution: Install a pressurized irrigation outlet coming from a pivot irrigation system. It takes half the time to irrigate the field. The water pressure is also strong enough to enable the switch from gravity irrigation to sprinkler irrigation.

Metal seedling trays

Innovators: Messrs. Maturan and Cuevas

Although IRRI is exploring direct-seeded rice (DSR) systems as an alternative to manual transplanting, the traditional method of growing rice is still widespread. Therefore, many rice field studies at IRRI continue to employ manual transplanting.
Problem: IRRI's field staff use wooden seedling trays that are quite heavy when dry and even heavier once the wood absorbs water. The box shape of the wooden seedling tray makes it difficult to pull or push across the muddy field surface and it must be carried from one spot to the next. The trays also tend to become stuck in the mud.
Solution: A fabricated metal seedling tray is lightweight and its sled-like shape allows it to slide across the paddy; so, it can be easily pulled. Holes at the bottom of the tray allow water to keep the roots of the rice seedlings wet.

The label roller

Innovators: Mr. Maturan, Ruth Carpio, and Mr. Guevarra

In any experiment, proper labeling is an effective tool for increasing efficiency, improving accuracy, and reducing errors. Labels also play an important role in the management of an experiment.
Problem: Although label printers have eliminated the need for handwritten labels, they do create another problem. A single field experiment at the ZES may require thousands of tags that a printer rolls out as a single narrow strip—up to several meters long—that ends up tangled on the floor. Rolling up a strip of labels manually could take up to half an hour and leave ink stains on the hands.
Solution: The label roller makes it easier to handle the tags. By feeding the end of the strip into the roller, even a strip consisting of thousands of tags can be rolled up in minutes, minus the ink stains.

The label holder

Innovators: Mr. Maturan, Carmela Malabanan, and Messrs. Cuevas and Bautista

Problem: Unlike in laboratories, installing labels in a field experiment is more challenging. Each tag must be carefully removed from the rolled-up strip of labels and attached to a bamboo stick. Installing thousands of labels requires a lot of time and people.
Solution: The label holder enables a researcher or assistant to place several tags on the side of the body, thus facilitating the attachment of the label.

Megabins and racks on wheels

Innovators: Messrs. Maturan, Cuevas (back in photo below), and Guevarra (front)

Problem: At the institute, it is not uncommon for workers to move heavy loads of paddy, fertilizer, and soil samples, among other things. But, the megabins and racks, which can hold loads of up to 300 kilograms, are not designed for mobility. Lacking wheels, they may require several able-bodied men to drag a fully loaded container across a smooth concrete surface. On rough surfaces, these containers are virtually unmovable and their contents must be carried manually to their destination.
Solution: Wheels, which are not part of the manufacturer's design, were added to the megabins and racks. A single worker can now easily move a fully loaded container even on rough surfaces.

Sturdy shelters

Innovators: Mr. Maturan, Juanito Rosario, and Mr. Guevarra

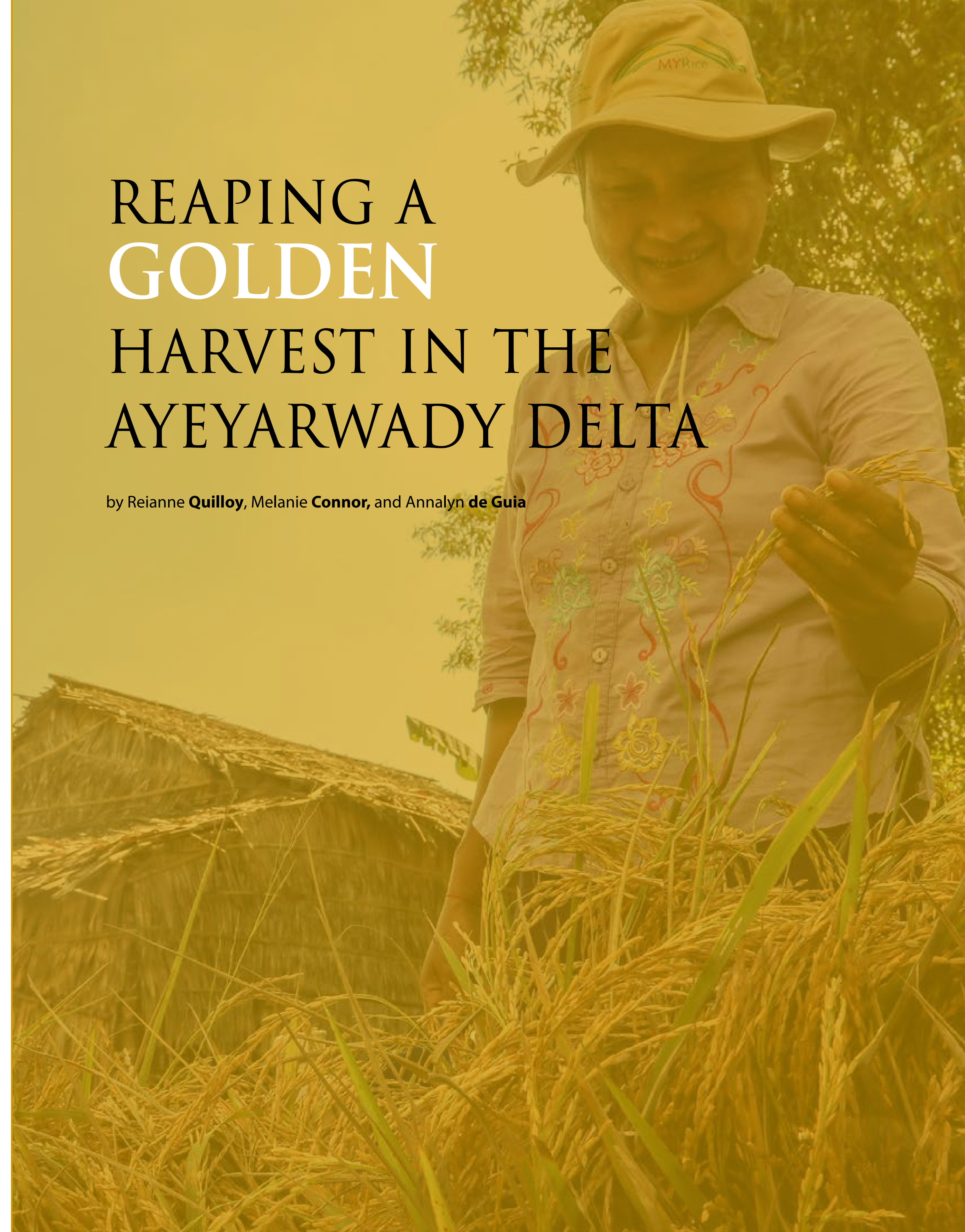
Problem: Commercial umbrella-type tents provide scientists and field staff performing scientific measurements or recording observations in the middle of fields with much-needed shelter. This is particularly essential during the long dry season in the Philippines, when the temperature ranges from 21 to 32 °C. The tents, however, easily topple in strong winds.
Solution: Durable scrap materials were fashioned into field shelters. The fabricated shelters are not only reliable and sturdy; they can be transported from one spot to another if needed.

Rope-equipped pickup trucks

Innovator: Mr. Maturan

Problem: It is not unusual to lose paddy or other biomass samples when transporting these from the field experiment sites, where they were collected, to laboratories or other locations for analysis or postharvest processing.

Solution: Each pickup truck was provided with ropes that were attached to the back. In this way, the ropes are never removed, misplaced, or forgotten. Because the ropes are always available, each truck can carry more load, thus reducing the number of collection trips.



REAPING A GOLDEN HARVEST IN THE AYEYARWADY DELTA

by Reianne **Quilloy**, Melanie **Connor,** and Annalyn **de Guia**

Rice is life in Myanmar, where 70% of its rural population engages in rice farming for their livelihood. Building on this strength, the government is set to regain its past position as a major global rice exporter. To achieve this goal, scientists at the International Rice Research Institute (IRRI) and farmers in the Ayeyarwady Delta have been working together since 2013 to improve the country's rice production by introducing an array of IRRI-recommended best management practices.

Working closely with the Department of Agriculture, IRRI introduced better crop establishment techniques; improved management of fertilizer, water, and pests; new postharvest technologies; and modern rice varieties. Learning Alliances were also started to foster linkages among the private sector, government, and farmers' groups to develop viable business models based on upgraded pre- and postharvest production practices.

Understanding how change happens

Best management practices were introduced to Myanmar through the projects *Closing rice yield gaps with reduced environmental footprint* (CORIGAP) and *Diversification and Intensification of Rice-based Cropping Systems in Lower Myanmar* (MyRice). These two projects, funded by the Swiss Agency for Development and Cooperation and the Australian Centre for International Agricultural Research, respectively, target the sustainability and optimal productivity of the country's "rice granaries" in the Ayeyarwady.

"We want to identify the key outcomes and understand the changes that happened in the villages where the best management practices were introduced," said Grant Singleton, a scientist at IRRI and coordinator of the two projects. "It is important for us at IRRI to understand how we can work together with our national partners to enable smallholder rice farmers and their families to observe, test, and embrace science-based solutions that lead to improved livelihoods from increased yields and improved production efficiency."

To better comprehend the gains from adopting the best management practices, the project team evaluated income-related changes by conducting interviews with farmers who have had a significant change in income (more than USD 100 per year). The data were collected using a brief questionnaire using a mobile data collection platform. The survey questionnaire was conducted with 129 farmers, and of the farmers who experienced a significant increase in income.

In a separate activity, 13 women were interviewed in Letpadan Township to investigate how the adoption of best management practices affected their traditional roles and the impact of these changes on smallholder families and their communities.

Technologies for better lives

The farmers identified the best management practices that helped improve their production and led to higher profits and extra household income in the last five years. The practices included balanced nutrient management, ecologically based rodent management, improved varieties, good weed management, and improved postharvest technologies.

Results of the survey revealed that, by using best management practices, farmers earned, on average, an extra income of USD 101.75 per hectare every year. The farmers reported allocating the additional money for food (26%), healthcare (18%), education (14%), socio-cultural activities (32%), and other household items (10%).

Mr. Thein Win reported that his income from his combined monsoon and summer crops in 2017 increased by USD 415 using the best management practices he chose

"I used improved varieties, including Yaenelo 7, and the drum seeder," said the father of three who has been farming rice for more than 30 years. "I applied pesticides and fertilizer judiciously. Upon using these techniques, I noticed significant changes such as fewer insect attacks and better seed spacing and aeration. I also used a lower seed rate. Because of these, I could say we now have extra money to invest in our children's education. Our standard of living has improved from five years ago."

Moreover, his family was able to buy more household items and agricultural equipment.

The women's perspective

Aside from reaping the benefits of more profitable farming and a better education for their children, the wives look at the increased income through a different but equally important lens.

"We can buy clothes for the whole family and dolls for my daughter," said Thin Thin Lai, mother of three young children.

Some also reported improvements in household nutrition as they are now able to eat three meals per day whereas previously they ate only two meals per day.

"In the past, we could not eat sufficiently," Mrs. Lai added. "Now, we can even buy snacks such as fruits."

"We can buy more food, such as meat and fish," Mrs. Ohnmar said. "Unlike before, we can have up to four different types of curries now."

The families have seen many changes since the best management practices were rolled out. These changes took place on both a personal and community level. The respondents mentioned that the increase in their income enabled them to donate more to build pagodas, an important Buddhist practice. They also put some of the money into the community fund to build more infrastructures, such as roads, which benefits the community.

A full, healthy plate for the world

The rice industry stakeholders in Myanmar continue to develop solutions for sustaining agricultural development, and the continuous support of IRRI and its experts will play a vital role in the development of the country's rice sector.

"We, as scientists, together with the farmers and other rice industry stakeholders, all want the same thing—improved lives and a full, healthy plate for the world's households," Dr. Singleton said. "That is why, for the remaining three years of CORIGAP, we and our national research partners in China, Myanmar, Thailand, Vietnam, Indonesia, and Sri Lanka will ramp up our efforts in working together with farmers and their families to maximize their potential in producing more rice. More importantly , promotion of best management practices will help farmers to be more resilient and climate-smart under various changing climatic conditions.

"We want to ensure that the technologies that work well for them can be used efficiently, effectively, and economically, and that there would be positive environmental outcomes for rural communities and biodiversity," he added. "Our focus is to provide a new pattern of behavior so that farmers will continue to use these best management practices beyond the life of the project." ■

Ms. Quilloy is a communication and outreach specialist at IRRI and the Learning Alliance facilitator of the CORIGAP and MyRice projects. Dr. Connor is CORIGAP's postdoctoral fellow investigating the adoption of best management practices and the impact on farmers' lives, and Ms. de Guia is an assistant scientist for the CORIGAP project.

Using the recommended best management practices on managing pest, Mr. Thein Win observed lesser insect attacks in his field.▲

The MyRice project staff, farmers, and Myanmar's Department of Agriculture work together to ensure optimal use of the best management practices that are suitable in each locality.▶
(Photos by R. Quilloy, IRRI)

National partners are a linchpin to agricultural development. CORIGAP-PRO works closely with national partners like Myanmar's Department of Agriculture to help the country boost its rice industry. (Photo by R. Quilloy, IRRI)

Climate change impacts on rice in Africa

by Sander **Zwart** and Pepijn **van Oort**

Climate change is affecting vulnerable cropping systems in Africa. Extreme events, such as droughts, heat waves, and floods, lead to crop losses and food insecurity among rural and urban populations. Gradually increasing temperature and atmospheric CO_2 content impact the diverse rice cropping systems throughout Africa. Although rice production in certain areas is negatively affected, cooler high-altitude areas may become more suitable. In this study, we quantified the impact of climate change on rice productivity for the main season and dry season of irrigated rice systems and for lowland and upland dryland systems. We used geospatial analysis in combination with crop modeling across a large number of representative sites in Africa to calculate changes in rice yields for different Intergovernmental Panel on Climate Change (IPCC) climate change scenarios. These results were compared with baseline conditions in the years around 2000.

The largest decreases of 40% to 80% are mapped for irrigated rice cultivation in the Sahel zone in West Africa in the hot dry season, which we attributed to reduced plant photosynthesis at extremely high temperatures. In the same area in the wet season (slightly cooler), irrigated rice yields were predicted to decrease by around 40%. These scenarios call for more research on photosynthesis at extremely high temperatures. Current regional policies promote dry-season rice cultivation. The scenarios presented here question whether this is a sustainable option for the future.

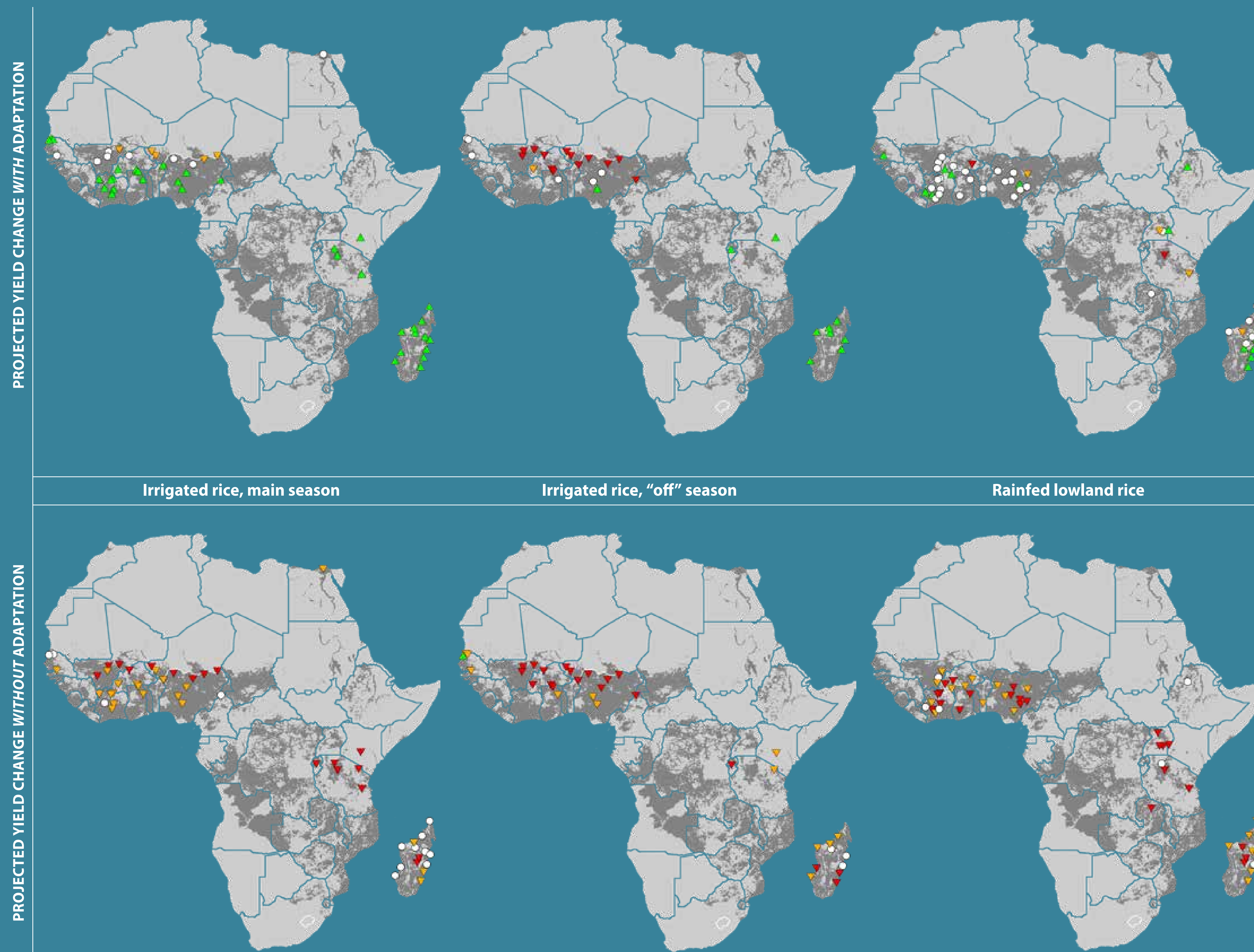
Irrigated rice production in East Africa is projected to increase slightly due to CO_2 fertilization and less cold stress. There, new opportunities arise for rice development in highlands. Also, new opportunities may arise for shifting from single to double rice cropping and, in some locations, even triple rice cropping may become possible.

We defined improved varieties as a means of adaptation for African rice farmers and we evaluated potential impact. These varieties have a so-called higher "temperature sum," which makes them suitable for environments in which agricultural seasons become shorter. We increased the varieties' temperature sums such that simulated duration from sowing to maturity in a future hotter climate would be the same as in the current climate. It was found that adoption of such varieties leads to less reduction in rice yields in all rice-growing environments. However, the Sahel is still vulnerable, whereas lowland rainfed production can be stabilized.

Mapped changes are for Representative Concentration Pathways 8.5 (RCP8.5), the worst-case scenario set by the IPCC characterized by increasing greenhouse gas emissions over time. ■

Dr. Zwart is a former senior researcher at the Africa Rice Center (AfricaRice) and is now affiliated with ITC at the University of Twente in The Netherlands. Dr. van Oort is a former senior researcher at AfricaRice and is now affiliated with Agrosystems Research at the Wageningen University & Research in the Netherlands.

The full study was published open access in Global Change Biology:
PAJ van Oort & SJ Zwart. 2018. *Impacts of climate change on rice production in Africa and causes of simulated yield changes.* Global Change Biology 24(3):1029–1045. DOI: 10.1111/gcb.13967.



Bangladesh hits two rice production problems with collective action

by Bernadette **Joven**

Good science, commitment, and noble intentions are needed to solve two of the country's rice production problems: water scarcity and methane gas emissions.

Drought is a common problem in Bangladesh. The northwestern region of the country is more prone to it than elsewhere. Although groundwater is available for supplemental irrigation, its overexploitation is causing concerns such as the diminishing supply of drinking water and suspected links to arsenic-contaminated water.

Bangladesh is also very vulnerable to natural disasters caused by climate change. Methane, a greenhouse gas, is produced by anaerobic bacteria in the soil when rice fields are flooded. Like carbon dioxide, methane in the atmosphere absorbs the sun's heat and contributes to global warming. The Food and Agriculture Organization of the United Nations (FAO) points to paddy rice cultivation as a major source of methane in Bangladesh with an estimated emission of 1175 Gg (2014) or about 33% of the total agricultural emissions.

Reducing water, mitigating methane

The Northwest Focal Area Network (FAN) is a multi-sectoral network of stakeholders working to improve rice-based systems in Bangladesh and alleviate the problems that beset rice production, particularly water scarcity and methane emissions.

The network was formed through the five-year *Poverty Elimination Through Rice Research Assistance* (PETRRA) project implemented by the International Rice Research Institute (IRRI) and Bangladesh Rice Research Institute (BRRI). Funded by the U.K. Department for International Development, PETRRA ended in 2004 but the Northwest FAN continued to operate. (Noel Magor talks more about PETRRA in his *Pioneer Interview*, on page 49.) At least 11 institutions and agencies currently comprise the network (refer to box on page 34).

The Northwest FAN has been testing and adopting alternate wetting and drying (AWD) technology with hundreds of farmers in 8 districts and 17 locations in Rangpur Division in northwest Bangladesh. AWD is a promising technology that has been proven to work in Vietnam, Indonesia, China, and the Philippines. It can cut water use by up to 30% in rice production. In doing so, it also reduces emissions of methane by as much as 50%. If the target of farmer-adopters is reached, the aggregate benefit in terms of water conservation and lower methane emissions could be significant.

However, explaining and demonstrating to the farmers how AWD works and its benefits are only a part of the equation. The other and more immense task is taking this technology to scale to achieve a bigger impact.

"The Bangladesh government has been promoting the use of AWD technology to lower methane production in flooded rice systems," explained Bjoern Ole Sander, a climate change expert at IRRI. "In the country's *Intended Nationally Determined Contributions*, the government moves to scale up rice cultivation using AWD with a target adoption of 20% in rice cultivation by 2030."

▲ A map prepared by a farmers' group in Kurigram indicates the different land levels within the catchment.

◀ Community meetings serve as a venue where farmers can share and learn about the benefits of AWD.

Farmers participate in group planning to help manage their water resource more efficiently and equitably. (Photos by Ahmad Salahuddin, IRRI-Bangladesh) ▶

AWD in Rangpur

The northwest part of Rangpur Division is one of the most vulnerable areas in Bangladesh mainly because of the increasing scarcity of groundwater and the occurrence of droughts. Farmers deal with the problem by using pump-operated irrigation systems although they still confront several production challenges.

Most of the farmers experience difficulty in producing Boro rice (dry-season irrigated rice), which accounts for more than half of the country's rice production, because the amount of water during the boro season is not enough. Also, the rising cost of fuel to run the water pumps for additional irrigation is an additional burden on resource-poor farmers.

These scenarios spur the move to consider AWD as a viable option among Rangpur farmers to help manage their water resource more efficiently and equitably while maintaining or even increasing their yield and income through savings on irrigation cost.

AWD technology is not new in Bangladesh. It has been promoted to small groups of farmers for testing, evaluation, and adoption since 2004. Now, technology adoption needs to be taken a few notches higher—through outscaling and upscaling.

In 2014, IRRI and BRRI implemented the Paddy Rice project to provide technical and policy guidance to national governments to implement greenhouse gas emission mitigation options. The project, which is under the Agriculture Initiative of the Climate and Clean Air Coalition (CCAC), focuses on AWD as a mitigation measure for methane emissions in rice systems.

The Northwest FAN modus operandi

"We tapped the Northwest FAN for its past success in disseminating rice-based technologies such as winter rice varieties BRRI dhan28 and BRRI dhan29, short-duration variety BRRI dhan33, and the Leaf Color Chart, among other interventions," said Dr. Sander, who leads the Paddy Rice project.

The Northwest FAN operates around the following three main approaches:

Coordination. The network illustrates the importance of synergy among stakeholders. Network partners comprising government and nongovernment agencies and actors are working together, carrying out different roles and sharing expertise and resources. They all have their eyes set on helping the farmers of the region increase their income and pull themselves out of poverty.

"Usually, projects are managed in a way in which the donors and the project implementers focus on project-driven functions rather than producing sustainable outcomes for the benefit of the community," said Akram Hossain Choudhury, Barind Multipurpose Development Authority chairman and Northeast FAN member.

But, Dr. Choudhury sees the genuineness of the project partners and indicated his keen interest in spreading AWD technology to deep-tube-well operators, which number by the thousands.

The agenda is to encourage farmers and private shallow-tube-well owners to form groups that will adopt and disseminate AWD technology across the region. Each group will consist of 10–25 farmers, which covers roughly 6–8 hectares of paddy fields. The network's inclusive approach sets the impetus for active involvement and concerted effort among all actors and brings out a sense of ownership.

Knowledge enrichment. Each tube-well group is continuously provided with the required knowledge and skills—from the basics and use of AWD technology to data collection and record-keeping. Information and communication materials such as videos, fact sheets, brochures, flyers, and training supplements are being produced to enhance learning.

Capacity building. IRRI and BRRI have been providing technical inputs on AWD and other production concerns. Training of trainers and consultations with farmers and tube-well owners were conducted. Sharing and learning about the benefits of AWD, importance of technology outscaling, and influencing policy (upscaling) are being held at the community, regional, and national levels.

Network members and their roles:

- Bangladesh Rice Research Institute (BRRI), Rangpur – provides the technical know-how through training of agricultural extensionists. It also provides local materials for the AWD tube.
- Bangladesh Agricultural Research Institute (BARI), Rangpur - provides the technical know-how
- Department of Agricultural Extension (DAE), Rangpur and Dinajpur Region – trained agriculture extensionists train the farmers
- Agriculture Information Services (AIS) – shows IRRI video on AWD; currently producing an AWD video through a farmers' lens (in Bangla)
- Barind Multipurpose Development Authority (BMDA), Mithapuur, Rangpur – disseminates information
- Northbengal Institute of Development Studies (NIDS) – conducted the baseline survey and in-charge of data management
- Hajee Mohammad Danesh Science and Technology University (HSTU) - conducted the baseline survey and in-charge of data management
- Rangpur Dinajpur Rural Service (RDRS) Bangladesh – network secretariat and coordinator for farmer mobilization
- SKS Foundation, Gaibandha
- Solidarity, Kurigram
- Udayankur Seba Sangstha (USS), Nilphamari

ALL are involved in concept development, capacity development, implementation, monitoring, reporting, sharing, and dissemination of technology.

The next steps

Off to a good start, the Northwest FAN will continue to spread the "AWD word and work" through subdistrict meetings in all 17 locations.

"Sharing of AWD application and actual experiences aims to motivate other potential actors and duplicate the same initiative," said Ahmad Salahuddin, an IRRI consultant in the Impact Acceleration Unit and the institute's representative to the Northwest FAN.

Preparations are underway for the conduct of a region-wide general network meeting.

"Farmer representatives, tube-well owners, high-level decision makers of government and nongovernment agencies, and other stakeholders will be gathered to further talk and work together," added Dr. Salahuddin.

Thus far, the Northwest FAN has already made headway in disseminating the technology despite the scant budget. This proves that a dearth in the budget is not a deterrent for valuable technologies, like the AWD, to reach the farmers. The challenge lies on how to drive an effective extension and communication campaign at the least cost.

Another lesson here is that in addressing important issues like water management and climate change mitigation, it is important to have a good science (technology), committed people and institutions, and noble intentions. ■

Ms. Joven is a senior communication specialist at IRRI.

Two farmers holding AWD panipipes. (Photo: SKS Foundation)

An app to help African rice farmers beat weeds

by Savitri **Mohapatra**

Weeds are serious constraints to rice production in sub-Saharan Africa across all rice environments and are the biggest drain on farm resources. Annual weed-inflicted yield losses in rice in Africa are conservatively estimated at 842,000 tons (paddy) under irrigated conditions, 756,000 tons under rainfed lowland conditions, and 648,000 tons under rainfed upland conditions, amounting to at least USD 1.5 billion per year.

Surveys by the Africa Rice Center (AfricaRice) indicate that farmers perceive weed infestation as the largest single cause of yield loss in rice in sub-Saharan Africa. As most of them cannot afford herbicides and few have access to mechanical weeders, farmers are left with no other option to protect their crop against weeds but manual weeding. Manual weeding consumes more labor than any other single farm activity and most farmers rely heavily on family labor for this task.

It is estimated that improved weed control, when combined with good soil fertility management, could raise rice yields by 1 ton per hectare. Improved weed management is therefore vital to prevent losses in rice yield and production costs. For this, rice farmers in sub-Saharan Africa need timely and reliable advice to make better decisions on the most appropriate weed control options.

But, at present, they have limited access to such information.

AfricaRice recently launched a powerful decision-support tool, called *RiceAdvice-WeedManager*, to help African rice farmers find the most effective and cost-efficient weed management strategies that match their specific farming conditions and available resources.

Potentially, all rice farmers in sub-Saharan Africa could benefit from this interactive tool as it could be used across rice-growing environments from rainfed uplands to fully irrigated lowlands, thus leading to significant improvements in efficiency, productivity, and income.

The *WeedManager* app has been developed in close association with Co-Capacity, a knowledge management organization based in The Netherlands, with support from the CGIAR Research Program on Rice Agri-food Systems. It is strongly based on research findings of AfricaRice and its partners, which have long been involved in developing efficient, affordable, and feasible weed management strategies for resource-poor rice farmers in sub-Saharan Africa.

The app is now being field-tested with farmers in Nigeria and Tanzania with the help of the Competitive African Rice Initiative, commissioned by the German Federal Ministry for Economic Cooperation and Development.

"We are planning to organize a series of training programs on the use of the *WeedManager* app, which is an exciting tool for weed management," said Dr. Kazuki Saito, an agronomist at AfricaRice.

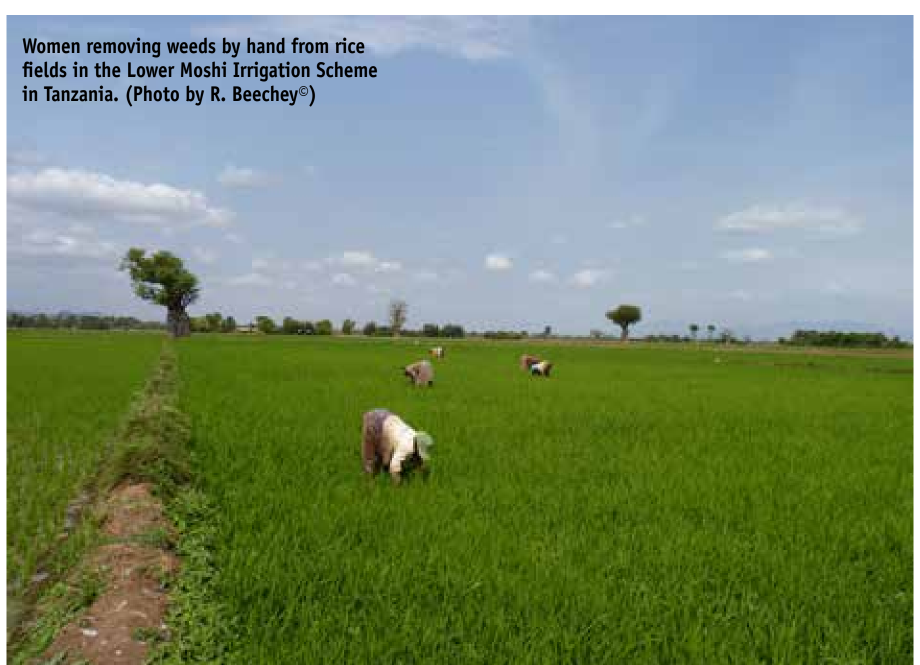
The app provides a range of adapted recommendations for weed management—before, during, and after the main rice-cropping season—based on information

Preparing a tank mixture of herbicides prior to application in Kinondoni Irrigation Scheme Tanzania. (Photo by J. Rodenburg, NRI, University of Greenwich)

entered for each participating farmer relating to his/her field conditions, available resources (financial, human, equipment, and natural), and prevailing weed problems. Each farmer decides on the recommendations to adopt and can then be further advised and monitored by service providers.

"The *WeedManager* app stimulates the adoption of targeted and integrated weed management practices by smallholder rice farmers in sub-Saharan Africa, helping reduce their reliance on manual weeding," explains Jonne Rodenburg, the former AfricaRice agronomist who spearheaded the development of the app. "This contributes to sustainable productivity enhancement leading to food security and income generation."

The app can be used by farmers, extension workers, private rice agri-business companies, development agencies, and other stakeholders interested in obtaining expert advice on weed management for rice production. It can also open opportunities for young professionals to serve as service providers by delivering personalized recommendations generated by the app to smallholder rice farmers and assisting farmers during the implementation of the recommendations.



Women removing weeds by hand from rice fields in the Lower Moshi Irrigation Scheme in Tanzania. (Photo by R. Beechey©)

The *WeedManager* app is complementary to the farmer-to-farmer instruction videos produced by AfricaRice and its partners on weed management, *Striga* management, safe and efficient herbicide application, and the use of mechanical weeders in rice. (Watch the videos at https://bit.ly/2GQ45VC.)

The *WeedManager* app is free and can be downloaded to any Android smartphone or tablet from Google Play. It is currently available in English and French but other languages are planned. The *WeedManager* app uses the same login data as the *RiceAdvice* app earlier launched by AfricaRice. (See *RiceAdvice: An app tailor-made for African farmers* on pages 5-7 of *Rice Today*, Vol. 16, No. 2.). ■

Ms. Mohapatra is the head of Marketing & Communications at AfricaRice.

SARD-SC beneficiaries discussing the project. (Photo by R. Raman, AfricaRice)

Creating value together in Africa's rice sector

by Savitri **Mohapatra**

"If you want to go fast, go alone. If you want to go far, go together," says an African proverb.

The rice component of the CGIAR-led *Support to agricultural research for development of strategic crops in Africa* (SARD-SC) project seems to have taken to heart this time-tested wisdom to achieve greater collective impact.

Funded by the African Development Bank (AfDB), the SARD-SC project was implemented from 2012 to 2017 to raise the productivity and profitability of cassava, maize, rice, and wheat, which are among the six strategic crops selected by African heads of states. AfricaRice executed the rice component with its national partners in 11 African countries.

As the conventional technology transfer approach does not address the complex issues of agricultural development, the rice component adopted the multi-stakeholder innovation platform approach, in which value chain actors are part of the information-sharing and decision-making process and benefit financially.

"Technologies can be scaled out comparatively easily if we create the right environment by bringing together technological, biophysical, and institutional factors; soft skills; technical expertise; products; and services," stated Sidi Sanyang, program leader for rice sector development at AficaRice and coordinator of the SARD-SC rice component.

Catalyst for change

Seventeen innovation platforms, which served as the main tool for system-wide change and impact, were established in the rice sector development hubs—key rice-growing environments—in the beneficiary countries. "Thanks to the innovation platforms, the value chain actors shared experiences, learned from each other, built trust, and mobilized themselves into associations to solve common problems," explained Dr. Sanyang.

Based on demand, the platforms focused on specific technologies and innovations generated by AfricaRice and its partners such as improved seed, the *RiceAdvice* app, good agricultural practices, mechanical weeders, the ASI thresher, the Grain quality enhancer, Energy-efficient and durable Material (GEM) parboiling technology, and the packaging/branding of local rice to make it more competitive with imported brands.

The innovation platforms emphasized active interaction with small and medium enterprises involved in farm mechanization, rice processing, and seed supply, which helped promote rice agribusiness. For instance, the project collaborated with Hanigha Nigeria Ltd. to manufacture more than 500 ASI (known as ATA in Nigeria) threshers that were sold in the beneficiary countries.

Maïmouna Coulibaly, CEO of Mali-based Faso Kaba, one of the enterprises that the SARD-SC rice component collaborated with, won the 2017 Africa Food Prize for producing and marketing quality seed for farmers. "We thank AfricaRice and its partners for collaborating with us, which contributed to our getting this prestigious recognition," Mrs. Coulibaly said.

Transformative effect

Project results show that the SARD-SC rice component has benefited more than 20,300 households (4.5% above the project's target).

"Today, we are seeing how substantially the lives of the value chain actors have changed," said Dr. Sanyang.

In 2016, Charles Loki, a young Benin farmer who set up a rice processing enterprise thanks to the project, milled about 300 tons of paddy. He made a net profit of about USD 2,880 by selling the milled rice, which competes well with imported rice.

"What helped us was the training that we received through the innovation platform in seed production, good agricultural practices, and contractual

The *RiceAdvice* app, mechanical weeders, and GEM rice parboiling system were among the technologies promoted by the SARD-SC project through the innovation platforms in the rice hubs. (Photos: K Ahouanton, AfricaRice; J Rodenburg, Natural Resources Institute; R Raman, AfricaRice)

arrangements," Mr. Loki said. "This has improved our household's living conditions and our children's education."

He plans to expand his rice mill's capacity to 500 tons this year.

The knowledge and skills enhanced by the innovation platforms are shaping business opportunities, especially for women and youth, which are contributing to the sustainable productivity of the rice sector and bringing about a policy shift to support local rice value chain development.

Women's participation in the innovation platform ranged from 24% to 80% across various interventions, including training of value chain actors. About 460 young people were actively involved in the innovation platform process. The capacity of 2,025 national partners was strengthened and university studies of 38 postgrads (nine PhD and 29 MSc) were supported.

Value drivers

Rice sector policies in sub-Saharan Africa have focused mainly on improving production and have paid less attention to demand factors and markets. However, because evidence in the region indicates that quality is an important factor in the demand for rice, the SARD-SC project has emphasized the quality of parboiled and milled rice in the innovation platforms.

The improved GEM parboiling system, which helps produce parboiled rice similar to premium imported rice, is a major success of the project. (See *A "GEM" for women rice processors* on pages 20-21 of *Rice Today*, Vol. 14, No. 4.) More than 2,560 rice parboilers (14% men and 86% women) were trained in the use of GEM in Benin and Nigeria, which raised their profit margins and led to the establishment of parboiling as a business to supply urban and rural markets.

"With GEM, we can process large quantities of rice in a relatively short time," said Badou Rachidatou, innovation platform facilitator in Malanville, Benin. "It is safer and easier to operate, particularly for women processors, and requires less fuelwood and water."

In innovation platforms in Malanville and Glazoué in Benin, the price of parboiled rice rose from USD 0.66 per kilogram before GEM was introduced to USD 0.94 per kilogram.

Similarly, the price of parboiled rice increased from an average of USD 0.63 per kilogram to USD 0.90 per kilogram because of the GEM parboiling center in the Lafia Innovation Platform in Nasarawa, Nigeria. The innovation platform actors sold about 440 tons of parboiled rice between July 2016 and March 2018, earning net profits of USD 101,200. About 1,800 parboilers are engaged in GEM parboiling service.

The benefits of GEM in the Lafia Innovation Platform have gone beyond parboiling: the actors were able to obtain loans, farmers now have better access to quality seed of the popular varieties FARO 44 and FARO 52, local artisans were trained in fabricating GEM components, and quality control was introduced throughout the value chain.

"This GEM technology is a great relief to Africa as we are now able to provide quality rice to Nigerian markets," declared Joshua Jonathan, Lafia Innovation Platform chairman.

"The project showed that market-driven technologies and innovations are the catalysts to sustainable technology adoption by smallholders and entrepreneurs, including youth, in the rice value chain," said Dr. Sanyang.

The next level

Building on the success of the SARD-SC project, the AfDB recently launched *Technologies for African Agricultural Transformation*, a new initiative on a knowledge- and innovation-based response to the recognized need for scaling out proven technologies across Africa.

"We have seen the potential of all the rice technologies and innovations," said Jonas Chianu, AfDB economist. "The future for us is to now take some of these technologies we have seen under the SARD-SC project to the next level for wider dissemination." ■

Ms. Mohapatra is the head of Marketing & Communications at AfricaRice.

Working with Cambodian rice farmers to combat a plague of rodents

by Rica **Flor**, Emily **Kraus**, Rathmuny **Then**, Parameas **Kong**, and Alexander **Stuart**

By adapting new rodent pest management strategies, Cambodian farmers are now able to defend their rice fields from their long-time adversary.

It is harvest time at the end of the 2016 dry season in Bati District in the Cambodian province of Takeo. Once again, Lay Nget is able to harvest only animal fodder from his rice field because of the heavy damage caused by rodents. Mr. Nget's story is a familiar one for many farmers in the area—a situation that can lead to unpaid debts and abandoned lands.

In Southeast Asia, rodents cause preharvest rice yield losses of 5–10% on average by feeding on the emerging panicles and maturing grains. In Cambodia, the extent of rodent damage varies depending on the season and location. In 1996, a major rodent outbreak in the country destroyed enough rice to feed more than 50,000 people for a year.[1] In Takeo, average rodent damage estimates of 22% for one season were recently recorded. Rodents not only reduce crop yields and damage stored grains; they also carry diseases that can spread to humans and other animals.

The race against rodents

In Cambodia, rice farmers use an array of techniques to manage rodent pests. Many rely on rodenticides or electric fences despite the associated risks to people and animals.

Electric fencing, powered by a 12V battery, is not only risky for humans but also a costly and time-consuming rodent management option. Farmers need to check the fencing regularly throughout the night to remove any animals killed by an electric shock that might cause a short circuit. In addition, some farmers may practice rat hunting and use traps. Farmers in Takeo, however, are still unable to effectively manage the rodent problem even with these methods.

An EPIC campaign against rice pests

To help rice farmers minimize yield losses from pests and diseases, a USAID-funded project, *Development of Ecologically Based Participatory Integrated Pest Management (IPM) Package for Rice in Cambodia* (EPIC), was launched in 2016. EPIC is a 4-year project led by the International Rice Research Institute (IRRI).

In collaboration with the Cambodian Agricultural Research and Development Institute, the General Directorate of Agriculture, and the Takeo Provincial Department of Agriculture, Forestry, and Fisheries, IRRI researchers and farmers established adaptive research experimental sites in Bati and Trang districts in Takeo Province. Following a focus group discussion, farmers from Takeo had prioritized rodents as their main pest of concern. Then, throughout two subsequent rice cropping seasons, researchers worked with cooperating farmers, in groups of 10–15, to implement ecologically based rodent management field trials across three 5-hectare treatment sites in each district. The management methods were adapted based on the local situation and preferred practices of farmers.

In Bati, farmers practice recession rice cropping during the dry season when the lake waters recede. This creates a situation in which rats have continuous access to rice crops by moving from one planted area in the wet season to another in the dry season and vice versa. Hence, a linear trap barrier system (LTBS) was set up in which rats move between these areas. The LTBS uses plastic as a fence with multiple-capture traps spaced every 20 meters along its length. This facilitates trapping early in the season before the rodents begin to breed. In addition, targeted and limited use of bromadiolone anticoagulant rodenticide was made to accommodate the farmers' request to use some form of chemical control. Anticoagulant rodenticides are safer than other chemical rodenticides because there is an antidote for people who are accidentally poisoned.

In Trang, the farmers plant three rice crops per year. They expressed their interest in testing

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[1] Jahn GC, Mak, S, Cox PG, Chhorn N. 1999. Farmer participatory research on rat management in Cambodia. In: Singleton GR, Hinds LA, Leirs H, Zhang Z, eds. Ecologically based management of rodent pests. Canberra (Australia): Australian Centre for International Agricultural Research. p 358–371.

the community trap barrier system (CTBS). This system uses a plastic barrier with multiple-capture traps surrounding a small ricefield plot. The enclosed plot is planted with rice 2–3 weeks earlier than the surrounding fields. The CTBS takes advantage of the highly attuned sense of smell of rats; it attracts rats from up to 200 m away, providing a halo of protection for approximately 8–10 hectares. In addition, the LTBS was installed near rodent refuge habitats, where no rodenticides were used.

Strategies for ecologically based rodent management also included maintaining basic hygiene in field margins, synchronous planting of rice crops, and community rat hunts early in the season. Electric fencing is not used. The key to successful implementation of rodent management is for farmers to work together and use the different techniques at the right time. Control is best applied early in the season before the rats begin to breed. Removing one female rat before it breeds is equivalent to removing 30 rats when the crop is maturing.

The results from the trials were extremely positive. More than 100 rats were trapped at each demonstration site and rodent damage decreased from 20–35% per site and season at nontreatment sites to less than 6% at the treatment sites. Rice yields at the treatment sites were 20–32% higher than at the nontreatment sites, which contributed to at least a 50% increase in farmers' net income.

Farmers experimenting with the technology

During the reflection meetings held at the end of each season, the farmers in Bati and Trang expressed their enthusiasm for the management options after observing that the experimental fields had less damage and considerably higher yields. A year later, following the end of the scientist-led trials, some farmers are leading their own learning experiments and adapting the techniques introduced through the EPIC project. One of them is Mr.

Rice tillers cut by rats right next to electrical wiring.

A CTBS set up in an intensive rice-growing area in Trang District, Takeo Province. Note that the crop inside the fence is two weeks more advanced than the surrounding crop.

Nget. He modified the trap barrier system (TBS) to completely surround his 2-hectare field with plastic fencing and 10 traps. For three hired laborers and the additional plastic to augment what was left from the project, he spent a total of USD 85. He also used rodenticide (zinc phosphide) for a short period.

"I am happy with my TBS," Mr. Nget said. "I think it provided 90% protection from the rats." He noted that the adjacent field, owned by his son-in-law, suffered from a lot of rodent damage. "In just three days, the rats had destroyed a majority of his field."

Mr. Nget said he would promote the technology to his son-in-law to prevent this from happening again.

Chan Penh, a 61-year-old farmer from Bati, had observed the experiments near his farm and adopted the TBS the following year. He set up a TBS around his 1-hectare field with the help of another farmer. Copying the technique used by Mr. Nget, he made and set up 20 traps.

During the season, Mr. Penh checked the traps twice per day and found 6–10 rats per day. He also used zinc phosphide mixed with crabmeat every 2–3 days.

"I am satisfied with the results," he said. "I spent only USD 75 and predict losses of around 30%. When I used electric fencing in the previous year, I spent around USD 135, with losses of 50%."

In Trang, Sou Sopheap, cooperating farmer of the EPIC project, tested the LTBS. He used the LTBS because his area is beside a forested area that provides a refuge for the rodents.

"The LTBS was cheaper than the CTBS," Mr. Sopheap explained. "I set up 50 meters of fence with three traps and caught around 100 rats in one season. Using only this technique, my yield increased from 4.6 tons per hectare in the previous season to 5.8 tons per hectare with the LTBS. I would use the technology again because it is a suitable management option for this environment."

These farmers and others continue to evaluate their options. Their positive experiences provide a good basis for other farmers to adopt the technologies and, hopefully, encourage them to work together on a community scale. The knowledge gained from the trials is also being shared in a cross-learning platform across Cambodia, for example, through exchange visits with farmer groups from other provinces.

The next steps for the EPIC project are to continue supporting this cross-learning platform and develop an integrated package of IPM recommendations for Cambodian rice farmers that can be adapted to the farmers' varied situations. Data are also being collected to assess the benefits from the adoption of ecologically based rodent management technologies to further understand the impact on farmers' livelihoods. ■

Dr. Flor is a postdoctoral fellow at IRRI, Ms. Kraus is a PhD student at Louisiana State University, Mr. Then is an agricultural research and development specialist at IRRI, Mr. Kong is a research assistant at the Cambodian Agricultural Research and Development Institute, and Dr. Stuart is a crop management and ecology scientist at IRRI.

Mr. Lay Nget and his wife work together to care for this rice farm where they have installed a trap barrier system to manage rodents.

A 120-m-long linear trap barrier system set up alongside recession rice fields in Bati District, Takeo Province. The use of unmanned aerial vehicle drone technology is being evaluated by Dr. Tri Setiyono (IRRI) and the IRRI Geospatial Science and Modeling team as a method to develop rapid assessments of rodent damage over a large scale. (Photos: EPIC project)

BREEDING THE NEXT MIRACLE RICE

by Paula Bianca **Ferrer**

A scientist's sharp eye and out-of-the-box approach to rice breeding have produced some outstanding varieties and one of them could be this generation's miracle rice

Jauhar Ali, a plant breeder at the International Rice Research Institute (IRRI), goes down to the experimental fields when the rice plants are flowering and starts selecting from thousands of rice cultivars.

"I spend a lot of time in the fields and I have been doing this for 7 to 8 years," Dr. Ali said. "The key to selection is the breeder's eye. A seasoned breeder can easily judge whether one selection is better than the others. This makes all the difference."

But, he is quick to point out that not all breeders are the same.

"Why did Dr. Gurdev Khush, a former IRRI plant breeder and also World Food Prize awardee, excel, while others did not?" he asked. "If all breeders were the same, then the problem of food security would have been easily solved a long time ago."

Out-of-the-box breeding

"I joined IRRI in 2000 as a postdoctoral fellow," recalled Dr. Ali. "Back then, IRRI had the International Rice Molecular Breeding Program (IRMBP), in which breeding was largely done on a massive scale."

Three years later, Zhikang Li, then head of the IRMBP, started a large backcross breeding program involving more than 200 varieties of rice. Dr. Ali started multiple stress screening for all the materials.

"It was something that nobody did before because everyone at IRRI was only practically screening for one single stress trait in rice," he said. "For example, if you were a drought breeder, you screened only for drought. It was the same for other stresses."

This was the beginning of a breakthrough that changed the history of rice—and the plight of millions of farmers who depend on it for food and livelihood.

Dr. Ali started screening the materials for high yield in irrigated environments. Then, the excitement of breeding began.

"We started subjecting the screened materials to different environmental stresses such as drought, flooding, salinity; you name it," he explained. "The stress eliminated many of the materials we had—about 80% of the job was done for us by the stress. Then, I started screening again for yield."

Subjected to at least three rounds of multiple environmental stresses, only 60 hardy survivors from more than 1,500 promising lines made it into the final stage of screening in the advanced yield trials.

"We returned all the survivors at every step to an irrigated environment to ensure their yields were stable," said Dr. Ali.

Out of 200 donor varieties comprising both landraces (140) and elite germplasm (60), only 50 donor varieties were kept for the molecular breeding program.

"We actually reduced them to 50. But, for practical reasons," Dr. Ali said, "we handled only 16 donor crosses for each recipient parent for a given year to make the breeding process more manageable. Otherwise, our lives would have been miserable. We simply focused on those 16 donors and crossed them with different recipient parents that were highly adaptable to Asia and Africa such as Huanghuazhan, Weed Tolerant Rice 1 (BRRI dhan69), TME50819, and Wanxian."

Dr. Ali (*right*) and Dr. Khush at a field evaluation during the Green Super Rice Asian Review in 2011. (Photo by Isagani Serrano).

Cream of the crop

Huanghuazhan is a high-yielding rice variety from China, where it is grown on about 6 million hectares in irrigated ecosystems. It was found to be adaptable in eight countries and was recently released as PR126 in Punjab, India, and as Impari 42 Agritan GSR in Indonesia.

"When Huanghuazhan arrived at IRRI, it was like any ordinary variety," Dr. Ali said.

But, the products that he and his team obtained from screening and crossing the carefully chosen varieties with Huanghuazhan were nothing short of extraordinary. Many of the materials were widely adaptable, had higher yield and better grain quality, and thrived with less fertilizer.

"We identified several promising lines with the Huanghuazhan background that showed high to moderate tolerance for drought, salinity, and flooding," Dr. Ali said. "Nobody understood the value of multiple stress screening at the time. Even our own results surprised us. Have you ever heard of 100% germination for rice seeds underwater for 21 days? The chance of survival for the best varieties is only up to 80%, but we got 100%. We published those results in 2006."[1]

The ability of rice seeds to germinate underwater, also called anaerobic germination, is crucial for farmers in the field who may want to opt for direct seeding to prevent losses due to sudden rains at the beginning of the season.

Promising resources

In 2003, Dr. Li returned to China to head the China National Rice Molecular Breeding Program at the Chinese Academy of Agricultural Sciences. He also took IRMBP with him, along with many of the materials, except for a few seed stocks that were left behind at IRRI.

"I knew the value of those seed stocks so I took them seriously," shared Dr. Ali. "I asked a PhD student to hold on to those materials. That was how we eventually bred the first generation of green super rice (GSR) varieties at IRRI."

"In 2011, we did a field trial of drought-tolerant GSR 2—released in the Philippines as NSIC Rc434—across six locations in different countries," Dr. Ali said. "We wanted to put it to the test to see if it was really good because field trials at IRRI showed that it had a yield of 3.2 tons per hectare under drought conditions compared with Sahbhagi dhan, a popular drought-tolerant variety, with a yield of 1.7 tons per hectare."

The top variety of the GSR 2 series surprisingly outclassed all the best performing varieties in those six locations by more than a ton.

"This was considered as breaking the 10-ton yield barrier for rice because normally you couldn't go beyond 10% increase in yield, " Dr. Ali explained.

Moreover, the same variety outperformed NSIC Rc238, considered as the best check in national Multi-Environment Trials (MET), by as much as 20%. Dr. Krishna Jagadish, an associate professor in the Department of Agronomy at Kansas State University and a former crop physiologist at IRRI, confirmed the finding.

This variety even outperformed Mestizo 6, a popular hybrid rice variety in the Philippines, by producing an average yield that was 8% higher.

"We were surprised by the results because hybrids conventionally have higher yields because of their tendency to exhibit qualities that are superior to those of both parents," Dr. Ali said.

[1] Ali AJ, Xu JL, Ismail AM et al. 2006. *Hidden diversity for abiotic and biotic stress tolerances in the primary gene pool of rice revealed by a large backcross breeding program.* Field Crops Research 97(1):66–76.

Setbacks and successes

Another variety, GSR 8, was one of the first varieties to go through the MET and the Philippines' national cooperative yield trials in the irrigated category.

"But, it was prematurely dropped from the list of the National Rice Cooperative Tests (NCT) because its yield was reportedly not significant over the best checks," Dr. Ali said. "It was only around 3–4% and not the required minimum of 5%. I explained that the variety doesn't work only in irrigated conditions, but also in conditions affected by drought, flooding, salinity, and other problems."

He requested NCT to put GSR 8 to the test again. GSR 8 was tested in national cooperative yield trials separately under two conditions: salinity and rainfed lowland dry seeded. The variety outperformed check variety NSIC Rc182 (saline) and PSB Rc14 (rainfed lowland dry seeded) by more than 15% in both categories.

"That was a significant achievement," Dr. Ali said. "It was the first time that a single variety qualified in two separate categories."

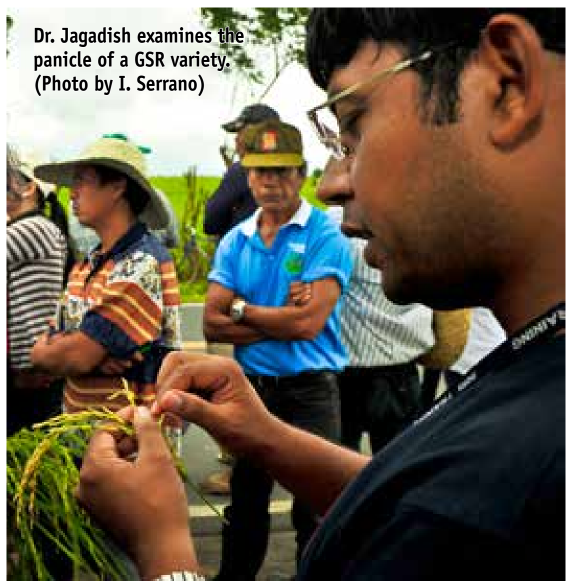
Despite the setbacks, GSR 8 rapidly spread to irrigated rice areas with almost 28,000 tons of GSR seeds produced in the Philippines alone. Currently, about 2.5 million hectares are grown to GSR varieties worldwide since the program started.

In another setback, although the protein content in GSR 11 was reported twice the amount found in other varieties, it was not advanced as a variety because of strict NCT guidelines. GSR 11, the first variety in the world tolerant of multiple environmental stresses, contains about 11% protein. Both GSR 11 and its sister line IR83140-B-28-B qualified in the NCT with yield advantages of 24% and 33%, respectively, over the check (PSB Rc90) under saline conditions. However, only IR83140-B-28-B was released as Salinas 19 per NCT guidelines, leaving GSR 11's dietary potential to help protein-poor countries untapped.

Rice's secret network

Dr. Ali and his team conducted a genotyping by sequencing analysis and visualization of all the GSR varieties to understand how these were performing exceptionally better than other rice varieties.

"We had introgressed and fixed many of the genes of our parental material into the backgrounds of our GSR materials," Dr. Ali explained. "But, the most surprising thing is that our parental materials were never really drought-tolerant, flood-tolerant, saline-tolerant, or anything else.



Dr. Jagadish examines the panicle of a GSR variety. (Photo by I. Serrano)

"We believe that there is a hidden genetic diversity in the germplasm, in the primary gene pool of rice," he noted. "But, this is unfinished or half-done; so, when we do this type of breeding, we are selecting the favorable genetic networks that do get complemented from different donor parents by way of stringent selection sieves. That's how you obtain all these tolerances. Very few people in the world know about or pay attention to this concept."

"Take, for instance, the low-yielding FR13A from which the popular flood-tolerant *SUB1* gene was found," Dr. Ali said. "Most people know only that FR13A is flood-tolerant but not saline-tolerant because, if you screen it under saline conditions, it will die. But, when FR13A comes into the background of IR64, another popular modern rice variety that is not saline-tolerant, the resulting variety becomes saline-tolerant.

"This was how we understood it at the time: each variety has a half-finished network," he explained. "When the networks came together, they produced a product that was completely different from the original. Something called epistatic complementation is taking place genetically. It's a topic that's very difficult for us to understand even now.

"We realized there are linkages between the networks within the system: it's not the major genes working alone, but a set of genes that triggers another set of genes," Dr. Ali pointed out. "If you pool them all together, you take advantage of not only the major genes but even the minor ones, too, so your varieties will be more successful in that sense."

The road to uncovering this knowledge had not been easy for Dr. Ali.

"We were doing something that fundamentally challenged the tenets of genetics or basic concepts of breeding," he said. "But, forget about our process; our products speak for themselves."

The next miracle rice?

"GSR would do the same for this generation as IR8 did for farmers in the past," Dr. Ali said. "GSR 8 and 11 will not be outpaced for another ten years. Even other top varieties will find it difficult to replace these once they become established in a specific area.

"We have a total of 104 promising cultivars in the pipeline for release in different countries," he added. "When those cultivars become released, who knows the kind of impact these will leave in farmers' fields?" ■

Ms. Ferrer is a former communication specialist at IRRI.

Women farmers' Crop Cafeteria serves practical rice science

by Swati **Nayak**, Deepti **Saksena**, and Manzoor **Dar**

PHOTO BY PRADEEP KUMAR SETHI

MAA THAKURANI HONORED BY THE GOVERNMENT OF ODISHA. For establishing a rice-farming evidence hub that has proved instrumental in cultivating, comparing, and identifying many potential varieties of stress-tolerant rice for the region, Maa Thakurani group was recognized at the 20th Kalahandi Utsav, Ghumura, in Bhawanipatna. The annual event is a platform for art, culture, music, drama, literature, and handicrafts. Mr. Prahalad Sahu, deputy director of Agriculture in Kalahandi, awarded the members. (Photo by Pradeep Kumar Sethi)

A women's self-help group in a small village in the Indian state of Odisha leads the way in innovative learning that could lead to higher benefits and profits for farmers.

Although rice breeding has undergone revolutionary changes, the new high-yielding and more robust varieties have yet to reach many of the small farmers who stand to benefit most from them. In addition, small and marginal farmers do not readily adopt the varieties and technologies developed by scientists even if these are available to them.

One factor in the slow rate of adoption is that farmers do not see the significant advantages in making that change. It is one thing for scientists and extension agents to champion the characteristics of a new rice variety but to see with their own eyes how many more benefits and profit farmers can obtain by growing that variety is quite another.

To bridge that gap, the government of Odisha and the International Rice Research Institute (IRRI) implemented a project for increasing the productivity of rice-based cropping systems and farmers' income in the state. The collaboration uses innovative extension approaches such as rice-farming "evidence hubs." Organized at the district level, evidence hubs provide farmers with proofs of the advantages of replacing older varieties with newly released stress-tolerant rice varieties. The method is known as evidence-based learning and it is revolutionizing the local varietal selection practices of local farmers.

Women farmers as in-field scientists

Kalahandi District is the seventh-largest district in Odisha. It is part of the Kalahandi-Bolangir-Koraput region, which is one of the poorest and most underdeveloped regions in the state. The area experiences wide variations in rainfall year after year and is categorized as drought-prone. Dry spells may occur even during the monsoon—the main cropping season—and cause frequent crop failure.

Because farmers are pivotal in achieving better varietal selection and a higher adoption rate, IRRI scientists are working with Maa Thakurani, a 17-member women's self-help group in Gananathpur in Kalahandi, to enhance understanding and knowledge through evidence hubs.

In the 2017 kharif season, the members of the Maa Thakurani group established and managed a "Crop Cafeteria" with 19 rice varieties comprising old and popular varieties grown by the local farmers and stress-tolerant rice varieties that could potentially increase the resilience of the farmers and stabilize grain production against climatic shocks. The Crop Cafeteria provided the women with the opportunity to carry out a systematic comparison of the varieties, identify the good traits of each, and, eventually, select their most preferred varieties.

They maintained multiple replication plots, managed each plot, and followed similar management practices for all the varieties. To compare the important yield parameters, they followed a staggered pattern of sowing so that the flowering of the different varieties would coincide.

The intensive and season-long exercise involved collective management, scientific learnings, and information and knowledge sharing through a participatory mode. This learning process led to collective evaluation and varietal selection, scientific understanding, and bargaining for consensus by the women.

Through detailed observation, accurate measurements, and discussions, the group confidently selected seven modern rice varieties (Bina-11; DRR-42, 43, 44, 46; and BRRI-71, 75) over the local varieties grown in the Crop Cafeteria. The members selected these varieties after determining their yield advantage of 1,250 kilograms per hectare over the locally grown varieties. The group was unanimously satisfied with the very good yield of DRR-44 and BINA-11 even with the low rainfall and frequent dry spells during the season.

With their growing confidence from their continuous evidence-based learning, the group members decided and planned to plant stress-tolerant rice varieties Bina-11, DRR-44, and BRRI-75 for grain as well as seed production in the coming seasons.

A platform for multiplying the impact

The Crop Cafeteria also acts as a medium for mainstreaming the women farmers' group and the preferred resilient, higher-yielding rice varieties.

The women meticulously organized a varietal exposition in which they engaged farmers from surrounding villages, local dealers, government officials, extension officers, agricultural researchers and scientists, representatives from nongovernment agencies, and public and private stakeholders in the seed sector. Visitors to the hub were able to observe the varieties "in action" over the entire cropping season and learn about the women's experiences and opinions.

Through the expo, the women farmers were able to discuss how they arrived at their decision for selecting appropriate traits and varieties for their area.

"It was an opportunity to interact, exchange ideas, provide feedback, and build rapport with them," said Hemalata Sabar, the secretary of the Maa Thakurani group.

The end goal was to get the seed producers to include the seeds of their chosen varieties in their catalog and make them readily available to farmers.

To encourage more innovations on the ground, Maa Thakurani was recognized by the government of Odisha for its contribution in demonstrating new varieties through innovation and collective participation.

"The evidence hub has given us a platform for learning about how to observe, make comparisons, and witness the results and build choices for making the right decisions," said Mrs. Sabar.

It is also giving the local farmers in Gananathpur renewed hope for a better future. ■

Ms. Nayak is the lead agricultural research and development specialist in the Seed & Delivery Systems Cluster at IRRI India. Ms. Saksena is a communication specialist for the Stress-Tolerant Rice for Africa and South Asia project in India, and Dr. Dar is the lead of the Seed & Delivery Systems and Germplasm Evaluation Cluster at IRRI.

Maa Thakurani group members assembling the crop cut for yield measurement. (Photo by Pradeep Kumar Sethi)

STEPPING UP EFFORTS FOR STRONGER SOUTH-SOUTH PARTNERSHIPS

by Nafees **Meah**

The newly established IRRI South Asia Regional Center (ISARC) in Varanasi, Uttar Pradesh. has created an exciting new opportunity to develop an even stronger partnership with India and other member states of the South Asia Association for Regional Cooperation (SAARC).

In August 2017, Matthew Morell, director general of the International Rice Research Institute (IRRI), and Sri Shobhana Pattanayak, secretary of the Department of Agriculture, Cooperation, and Farmers' Welfare of the Government of India, signed the historic Memorandum of Agreement for ISARC's creation.

ISARC will include a Center of Excellence on Rice Value Addition modeled after IRRI's research component at its Philippine headquarters. A node of the IRRI rice research and education program will be established at ISARC to provide training for strengthening the capacity of rice-growing countries in both South Asia and Africa, thus enhancing South-South collaboration. It will also have the capacity to conduct courses in other areas of relevance to the rice sector.

ISARC will provide a location to conduct and support broader programs of research in breeding, agronomy, and social sciences conducted by IRRI and its partners in India with the backing of the Government of India, states of India, SAARC member nations, international donors, the private sector, and philanthropists. To this end, we have developed a modular Resilient Rice Agri-Food Systems Initiative for South Asia to meet the needs of the region.

A goal-oriented effort

The rice agri-food sector underpins regional and national economic growth and food security in Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan, and Sri Lanka. Ensuring an adequate, affordable, and stable supply of rice remains a key policy goal of all governments in the South Asian region. Of the 2.5 billion people living directly from the food and agricultural sector in developing countries, 1.5 billion people live in smallholder households. Smallholders provide up to 80% of the food supply to Asia and sub-Saharan Africa. Despite an overall reduction in worldwide hunger since the 1970s, 159 million children under 5 still suffer from stunting as a result of inadequate nutrition. More than 61% of those children live in South Asia.

All South Asian countries are signatories to the United Nations' Sustainable Development Goals and have adopted a set of goals to end poverty, protect the planet, and ensure prosperity for all by 2030. However, rising populations, increasing economic inequality, and environmental challenges from climate change, land degradation, and water stress mean that achieving these goals for South Asia will need concerted and sustained effort by everyone working together.

Visible and impactful innovations

IRRI's vision in South Asia is that it is seen as a visible and impactful innovator across the rice-based agri-food sector and a key influencer on food and nutrition policy and strategy across the region. IRRI's germplasm is acknowledged as a vital resource for South Asian countries. The institute has a track record of producing game-changing rice science (e.g., IR8, IR64, drought-tolerant, flood-tolerant, salinity-tolerant, multi-stress-tolerant, and short-duration varieties) and delivering benefits to rice farmers in the region.

IRRI also brings a system understanding and interdisciplinary solution orientation to improving the economic, social, and environmental sustainability of the rice value chain. It has a strong track record of capacity development, having trained many of the leaders in rice research who currently hold senior positions across the region. It is for these reasons that IRRI remains a vital player in rice research, development, and innovation in the South Asian region.

ISARC aims to provide a state-of-the-art regional facility that supports research collaboration, training, and service provision to institutions, scientists, and other stakeholders from India and other South Asian and African countries through the following:

- Offices for staff, visiting scientists, and research scholars
- Facilities for visiting scientists, trainees, and research scholars, including facilities for meetings, workshops, and training
- Laboratories for seed quality, grain quality, and grain composition analysis, including analysis of heavy metals
- Field and greenhouse research facilities for germplasm development, and phenotyping facilities

A major step forward

An IRRI team has been busy getting the ISARC site ready for business since the end of 2017. The land has been cleared and crops planted. We have leased additional land next door from the State Government of Uttar Pradesh. Detailed design work is underway and the main refurbishment is about to commence.

We are planning for the facility to be operational after the summer season in July and to be formally opened by the prime minister of India. When that happens, it will represent a major step forward for IRRI in South Asia. ■

Dr. Meah is the IRRI representative for South Asia.

IRRI Pioneer Interviews by Gene **Hettel**

Making a difference (Part 2)

Noel Magor, Nollie Vera Cruz, Roland Buresh, and J.K. Ladha boxed their papers and passed the baton on to their successors in 2017. These Pioneer Interviews revisit their combined 119 years of service to IRRI. Here, in Part 2, I explored how Noel and Nollie made a difference during their days at the institute.

PHOTOS: GENE HETTEL, IRRI

Integrating agronomy with political science

Noel Magor spent the first 14 of his 24 years associated with IRRI in various projects in Bangladesh to improve that country's rice production and the livelihood of its farmers. He followed with 10 years at headquarters leading the Training Center and enhancing the Rice Knowledge Bank to help prepare the next generation of scientists to meet future challenges.

From a young age, he was involved in agriculture, growing up in Australia on his family's poultry and almond farm (see *Steinbeck and a calling* on pages 28-29 in *Rice Today*, Vol. 5, No. 3). "My father repeatedly won competitions with his chickens and produced beautiful almonds using green manure and irrigation," he said. "I helped with the almond harvest and gathering eggs, among other chores, which included growing my own tomatoes in the summertime."

After earning a bachelor's degree in horticulture from Adelaide University, Noel set off to Wollo Province in northern Ethiopia, where a devastating famine had struck the year before. As a volunteer, he assessed how the famine affected village families and sought ways to rehabilitate the most destitute by providing grain through food-for-work projects and by distributing seeds. Then, along with his wife Rose, he spent 7 years (1977-84) with HEED Bangladesh, a national NGO devoted to health, education, and economic development in the country. "I was interested in rural development in northeastern Bangladesh, but I didn't understand the rice system there and farmers' varietal choices," Noel said. "So, that led me to get a master's degree in agronomy via Sydney University, in which for my thesis I studied with farmers of the area their rice-based cropping patterns."

Knowing that there was a lot of work to do in Bangladesh, Noel took the opportunity to stay in the country by becoming associated with IRRI for the first time. "In 1985, I accepted the position of systems agronomist to work on joint research between IRRI and the Bangladesh Rice Research Institute (BRRI). During the next 7 years, I liaised with national institutions and worked with the national scientists at BRRI, where I learned a lot about farming systems principles."

Then, Noel went to Adelaide University to earn a PhD in political science in 1996. Why political science? Noel explained, "During my time with HEED, I had become very aware that the NGOs, on the whole, were focusing on landless and nonagriculture-based people while the extension services were focusing on the more well-to-do farmers. I felt that a political science background might help me better understand the vulnerability of neglected smaller farmers and how to find opportunities for them. A 3-year research fellowship with an Australian University Postdoctoral Award on small farmers and business added a further dimension to potential development options for small farmers."

After that, it was back to working for IRRI again in Bangladesh, when, in 1999, he was selected to manage the Poverty Elimination Through Rice Research Assistance (PETRRA) project. Funded by the U.K.'s Department for International Development, Noel managed the nearly 10 million-pound PETRRA project. "It involved IRRI and BRRI overseeing a unique competitive research process over 5 years that attracted around 400 concept notes, ultimately leading to some 45 projects that engaged around 50 organizations, including the private sector and NGOs," Noel said. "The projects involved social science research coupled with national rice policy dialogues, technology development with hybrid rice, salinity and flood tolerance, nutrient and water management, rice–duck farming, seed system development, rodent control, women in agriculture, and innovations in extension that were inclusive of marginal farmers. This all contributed to the development of Bangladesh's agricultural sector. I consider PETRRA to have really made a difference and it's one of the highlights of my career.

During his last 5 months before retirement, Noel returned to Bangladesh after a 10-year absence to serve as IRRI's interim country representative. "It was a priority to re-open the BRRI-IRRI Friendship Centre as a symbolic gesture to show how important it will be to engage with BRRI, an essential partner, to meet the future challenges."

In 2006, Noel moved to headquarters to head the Training Center, rebranded IRRI Education in 2016. "Some people forget that IRRI is both a research and training institution. Educating and training a new generation of rice scientists who can tackle the challenges of the future are incredibly important roles for IRRI," he emphasized. "When I was at BRRI, I saw the tremendous hopes that young scientists had as they went off to IRRI to do their thesis work, giving them the confidence they must have to meet the future. The short courses are like topping on the cake, adding tremendous value whether they are in specific skills in plant breeding or pest management or in terms of advances that may not have been covered during university studies."

During the last 10 years under Noel's guidance, the Training Center built a self-funding model with subsequent growth in the number of scholars. "We've offered exciting new courses, such as *Rice research to production*, *Rice survivor*, African extension and seed systems training, and advanced plant breeding, agro-ecology, and pest management, among others.

Noel capped his career at IRRI as head of the Impact Acceleration Unit. "Donor demand for impact is not a recent phenomenon, but rather a discourse that has strengthened for more than 30 years," Noel concluded. "Donors have become more demanding and IRRI has responded."

The best of both worlds

Hailing from Tanauan, Batangas, in the Philippines, Casiana "Nollie" Magpantay Vera Cruz spent 34 productive years at IRRI, primarily as a plant pathologist. "As you may know, Batangas was once famous for its coffee plantations," said Nollie. "But the trees were totally devastated by coffee rust (*Hemileia vastatrix*) toward the end of the 19th century." The oldest of five siblings, the other four being brothers, she was way too late to do anything about coffee diseases, but would be destined to fight the disease pantheon of an even more important crop—rice! "Initially, I was more interested in studying microbiology, which was my major as an undergraduate in agriculture at the University of the Philippines Los Baños (UPLB), but, ultimately, I got my M.S. degree in plant pathology at UPLB.

Starting at IRRI in 1975 as a research aide in the Department of Plant Pathology, she began her journey to gain a wide range of expertise that eventually included finding host-plant resistance to rice diseases, overseeing bacterial and fungal disease screening for the breeding programs for different rice ecosystems, managing rice seed health efforts, diagnosing seed-borne pathogens, and studying root health in aerobic rice.

She had the unique circumstance of experiencing firsthand two different worlds at the institute, having been both a nationally recruited scientist (NRS) for 16 years and a globally recruited scientist (GRS) for 18 years.

In one of his last functions as interim IRRI country representative for Bangladesh, Noel joined the ceremony that re-opened the BRRI-IRRI Friendship Centre in Gazipur on 16 January 2017. He stated then, "With increasing climate change threats and growing demand for rice in Bangladesh, we are really pleased to have such a deep and committed relationship with our essential partner in the country." Photo: IRRI.

As overall leader of the Heirloom Rice Project, Nollie worked to get some of the Cordilleras traditional rice varieties on the menus of Manila's finest restaurants. (Photo: Gene Hettel, IRRI).

"The dichotomy of the GRS and NRS is a given," Nollie said. "However, I think the relationships and level of respect that the NRS have among the entire staff are improving. Without the NRS, IRRI would not be the successful institute that it is today. The local staff members have channeled their energy and efforts to achieve IRRI's goals as much as anyone else."

Nollie is certainly among the pioneer female scientists at IRRI. By the time she had moved up the ladder among the NRS to the assistant scientist level in 1991, there were still only two female IRS at IRRI (see *Gender barriers and molecular maps* on pages 37-39 in *Rice Today*, Vol. 9, No. 2). "I left IRRI in 1991 to begin working on my PhD in plant pathology with Dr. Jan Leach at Kansas State University in the U.S., supported throughout by the Rockefeller Foundation Rice Biotechnology Program," Nollie said.

After earning her PhD, she did a stint as an associate professor of plant pathology at UPLB. By the time she rejoined IRRI as a plant pathologist at the IRS level in 2000, she was part of a growing group of globally recruited women numbering around 10 at the time. Of course, since then, the GRS female-male ratio has improved even more.

"I really didn't feel that being a female staff member as an NRS during the 1970s and '80s and later as a GRS after 2000 was any kind of problem for me," Nollie exclaimed. "I was given many opportunities. When IRRI was looking to increase the number of women in upper management in the mid-2000s, Achim Dobermann, then deputy director general for research, even asked me if I wanted to get into management. I said, 'no, I preferred working in science.'"

And work in science she did, studying a myriad of rice foliar, grain, and root diseases, but especially the two most insidious ones that have given Asian farmers headaches for many years—bacterial blight (caused by *Xanthomonas oryzae* pv. *oryzae*) and rice blast (caused by the fungus *Magnaporthe oryzae*). "I worked with the IRRI pathology team on bacterial blight for 15 years during my first stint at IRRI as an NRS," Nollie said. "Back then, my mentor, Tom Mew (see *The Tao of Tom* on pages 16-21 in *Rice Today*, Vol. 3, No. 2), and I found bacterial blight to be a model disease system to study for the cereals, especially because of its host-pathogen interactions. Our team learned about pathogen variability and identifying the diversity of pathogen populations to help develop rice plant resistance."

Perhaps the capstone of Nollie's pathology legacy at IRRI is her participation as a technical writer and editor, along with Dr. Mew and other pathologists, in the development of IRRI's online resource *Rice diseases: their biology and selected management practices* (see http://rice-diseases.irri.org). "Bringing up to date the classic 1985 second edition of the book *Rice diseases* by S.H. Ou, it covers the importance of 80 plant diseases in rice production," Nollie said. "The cleverness and beauty of this online resource are that any interested rice pathologist can add new information, make revisions, and improve it, and that users can be assured that what they are accessing is absolutely the latest information available."

In recent years at IRRI, Nollie also led the joint Philippine Department of Agriculture–IRRI Heirloom Rice Project, which aimed to raise productivity and enrich the legacy of traditional rice. "We began making a difference by empowering the communities in unfavorable rice-based ecosystems of the Cordilleras in the northern part of the country," she said (see *Women who moved mountains* on pages 22-23 of *Rice Today*, Vol. 13, No. 4).

"A very important part of the project's first phase was helping local farmers produce quality heirloom rice seeds to increase their harvests for selling to restaurants in Manila that are promoting unique rice dishes and the niche export market," Nollie said. "Because these heirloom varieties have special qualities different from common table rice, I see very high potential for them to be purchased by customers willing to pay more, thus significantly increasing farmers' income and perhaps even enticing the upcoming younger generation to stay on the farm."

Among the various heirloom rice varieties, Nollie likes the purple varieties most, especially the glutinous ones. "They are so different in terms of texture and probably nutrition as well," she said. "And, they are delicious."

Unlike her retiring colleagues, Noel, Roland, and J.K., Nollie will not be straying very far from IRRI by staying in the Los Baños area with her husband, Ver. So, she still can be seen on her old stomping grounds from time to time. Currently, she is serving as an IRRI consultant to complete a few ongoing projects. ■

Mr. Hettel is a senior consulting editor and content specialist at IRRI.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