rice TODAY

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INGER@40–and the Crossroads

Genome editing: rewriting the DNA code
Partnership-driven science
Stories from Africa

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About the cover

Now celebrating its 40th year (under various names), the International Network for the Genetic Evaluation of Rice (INGER) has released around 55,550 breeding lines that have been evaluated by hundreds of rice scientists at more than 600 research stations in 85 countries. Overall, more than 1,100 INGER-tested lines have been released as varieties in 74 countries. These pooled test materials from around the world have brought much needed genetic diversity to farmers' fields. However, after 4 decades, it is time to look at INGER in retrospect and reflect to review what has been achieved and to brainstorm for the future. See pages 24-27. (Photo by Isagani Serrano)

Rice Today is published by the International Rice Research Institute (IRRI) on behalf of the Global Rice Science Partnership (GRiSP).

IRRI is the world's leading international rice research and training center. Based in the Philippines and with offices located in major rice-growing countries, IRRI is an autonomous, nonprofit institution focused on improving the well-being of present and future generations of rice farmers and consumers, particularly those with low incomes, while preserving natural resources. It is one of the 15 nonprofit international research centers that are members of the CGIAR consortium (www.cgiar.org).

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From the editor's desk

A new look with great stories to tell

Rice Today has indeed evolved from an IRRI-centric magazine into a truly global magazine—as the official publication of the Global Rice Science Partnership.

Part of this evolution is the re-working of the magazine's masthead. The idea behind the "new look" is to make *Rice Today* more up-to-date, reflect new ways of finding solutions to the problems in rice production, and represent the advances in rice science. Along with the new look, we are expanding the magazine's reach through Facebook and Twitter, and our new online domicile (see ricetoday.irri.org).

We made these changes to bring you a better experience in accessing our information through the platform that best suits your needs. Whether you want to read about rice on paper or pixels, in your reading room or on mobile devices, our mission remains the same: tell great stories about the world of rice—from gene discoveries to the significant events in the global rice market.

And, in the new era of genomic research, we are featuring "genome editing" technology, the latest tool in the rice breeders' toolbox, which enables the rapid rewriting of the DNA code to produce better varieties in the shortest time possible (see pages 7-9).

An example of a new variety with a success story under its belt is the salt-tolerant Salinas 11. It is helping Filipino farmers in Bohol Province of the Philippines cope with seawater encroaching on their paddies (*See Rice against the tide* on pages 12-13).

The Bohol story may sound anecdotal on how the Philippines, where IRRI is located, is benefiting from the Institute. Despite these success stories remains the fact that the Philippines is still a major rice importer. So the question remains, *Is proximity to IRRI an advantage?* (Find the answer on pages 20-21.)

Citing India as an example, IRRI Director General Robert Zeigler explains how *High science and smart policies will alleviate hunger and poverty* (see pages 40-41).

Our Rice Map takes a first look at Asia's rice crop, with Sentinel-1A satellite imagery, which provides detailed information on area planted to rice, cropping intensity, and even area damaged by floods or drought (pages 36-37).

With increasing population and decreasing agricultural land area, the challenge for rice cultivation is to meet future food demand. One key strategy for obtaining sufficient future food production is to close "yield gaps." But what is a yield gap? What are the sustainability implications of closing rice yield gaps? Alex Stuart, IRRI postdoctoral fellow, answers these questions in his *Grain of truth* on page 42.

Closing yield gaps, among other goals, in the rice sector will not be possible without the support of partners around the globe. The good news is that IRRI's partners are taking it to the next level—from research beneficiaries to research investors. (See *Partnership-driven science* on pages 16-19.)

Speaking of partnerships, IRRI is working with the Odisha University of Agriculture and Technology in India through a scholarship program in *Developing the next cadre of scientists* (see story on pages 14-15).

In *How long can the rice market defy El Niño?* Dr. Samarendu Mohanty, IRRI senior economist, analyzes whether the rainfall disruption in India, Indonesia, and the Philippines will affect the direction of the rice market in the remaining months of 2015 (pages 38-39).

Then, we stepped back through time to look at the 40 years of contribution of the International Network for Genetic Evaluation of Rice (see *INGER@40—and the crossroads* on pages 24-27). Aside from the varieties released in 74 countries, the pooled test materials from different countries have brought much-needed genetic diversity to farmers' fields.

In Latin America, Edward Pulver, a renowned agronomist, has set an example and inspired young scientists around the world through his remarkable career. Dr. Pulver has dedicated his professional life to raising rice yields in the region with improved agronomic practices and "water harvesting." See pages 10-11.

Our features from Africa are about *The origins of Senegal's dependency on rice imports* (on pages 28-30), Côte d'Ivoire as an emerging rice powerhouse in West Africa (pages 34-35), and why Tanzania is poised to lead Africa's rice production (pages 31-33).

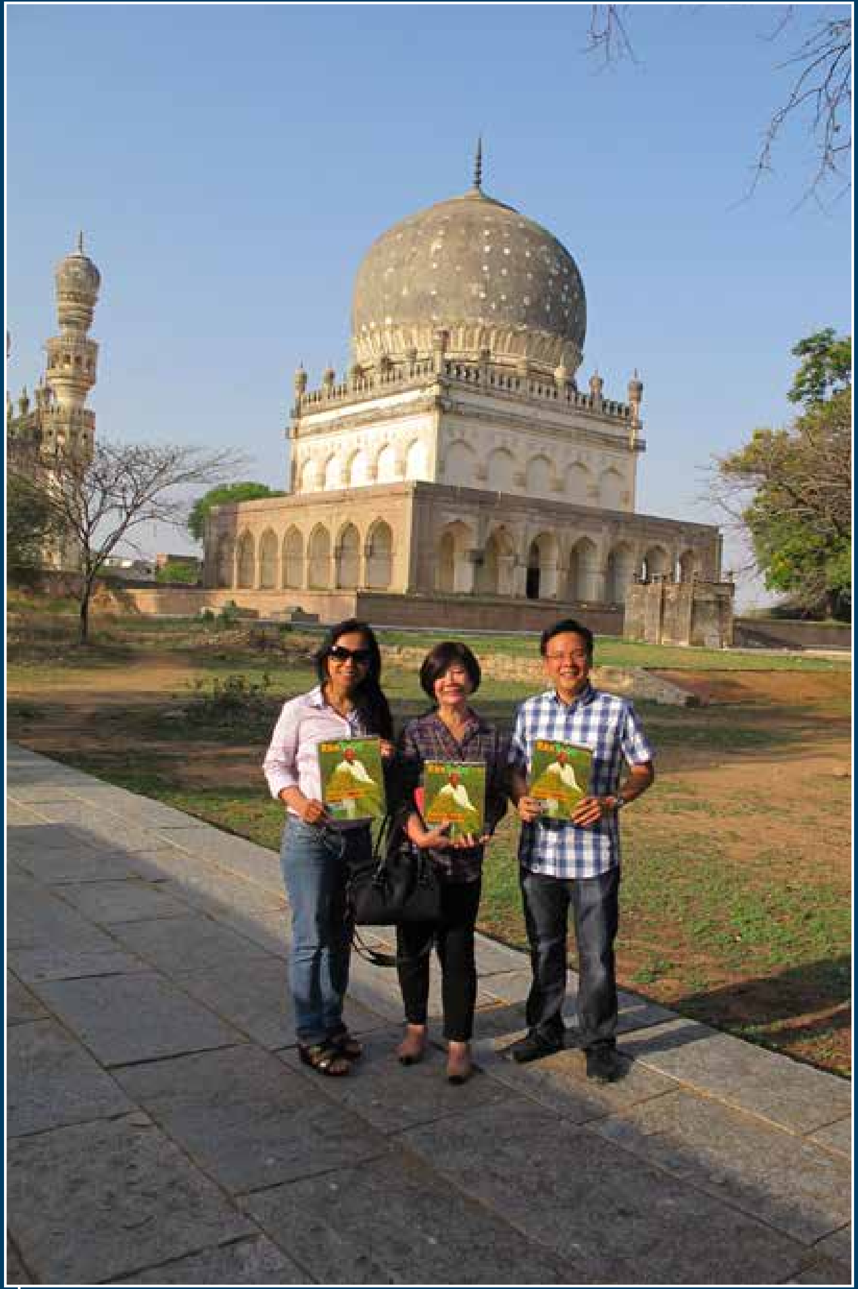
And, on a lighter note, there's a hearty debate on page 43 who makes the better Jollof, the Ghanaians or the Nigerians? You can taste one side of the good-natured debate by learning how to cook Ghanaian Jollof rice.

Happy reading!

Lanie Reyes
Rice Today managing editor

rice TODAY around the world

AGENT OF SUSTAINABILITY. Glenn Denning, professor at Columbia's School of International and Public Affairs, is one the leading experts on international agricultural development. A former senior manager at IRRI, he was honored by the governments of Vietnam and Cambodia for his contributions to agriculture and rural development.



THREE'S COMPANY. Corinta Guerta, IRRI director for External Relations; Tony Lambino, head of IRRI Communication; and Lanie Reyes, *Rice Today* managing editor, hold up the magazine's special issue on India at the tombs of the seven Qutub Shahi rulers in Hyderabad. India is one of the biggest success stories when it comes to attaining food security. From a country with a severe food deficit, it has become a major grain exporter.

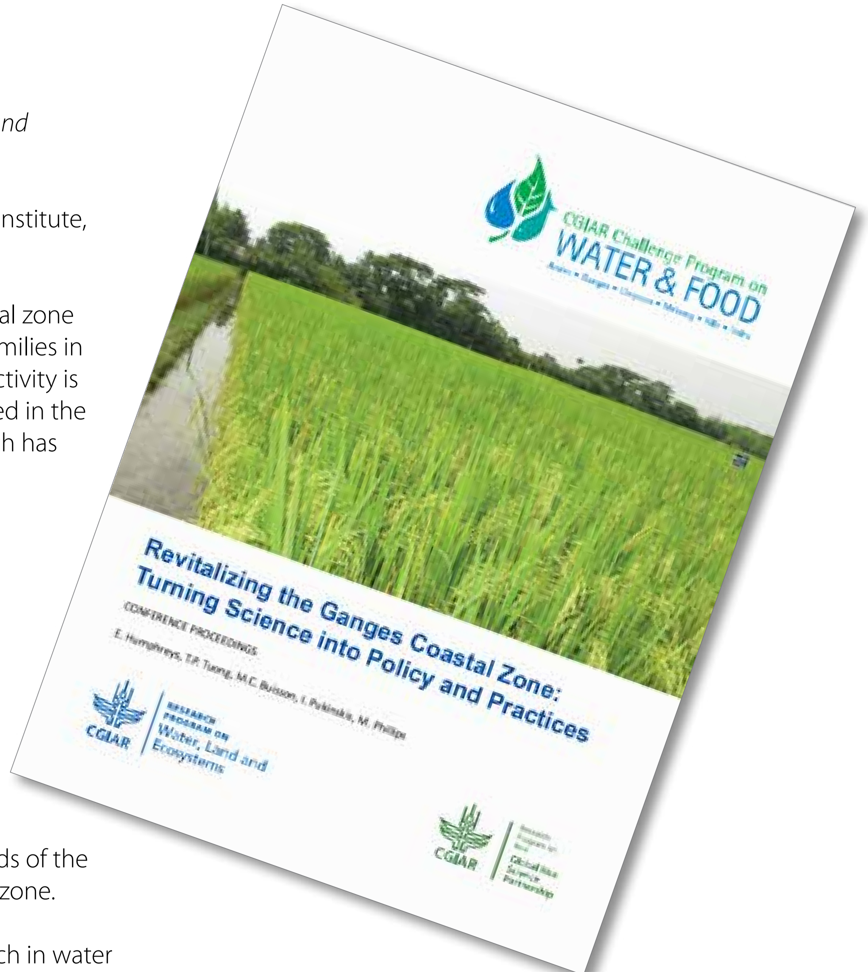
IN SEARCH of the grain of truth. Award-winning Filipino journalist Sheila Coronel and *Rice Today* share a common passion: finding the truth. Prof. Coronel is the director of the Toni Stabile Center for Investigative Journalism and dean of Academic Affairs at Columbia Journalism School.

Books

Revitalizing the Ganges coastal zone: Turning science into policy and practices

by E. Humphreys, T.P. Tuong, M.C. Buisson, I. Pukinskis, and M. Phillips

Published by the International Water Management Institute, 598 pages.



Despite the huge investment in the Ganges coastal zone over the past 50 years, the poverty of farming families in the region remains extreme. Land and water productivity is very low, and agricultural practices have not changed in the last half-century, unlike the rest of Bangladesh, which has surged ahead.

In relation to this, more than 200 researchers, development project personnel, donors, and policy makers gathered together in an international conference, *Revitalizing the Ganges Coastal Zone: Turning Science into Policy and Practices*, in Dhaka, Bangladesh on 21-23 October 2014.

The resulting proceedings are a unique, up-to-date and comprehensive account of the current status of water resources, and opportunities for increasing productivity and improving the livelihoods of the millions of poor rural families of the Ganges coastal zone.

Contrary to the belief of many, the coastal zone is rich in water resources, and these water resources are vastly underutilized. However, there is huge potential for greatly increasing agricultural and aquacultural productivity through cropping system intensification and diversification.

The topics covered by the 41 peer-reviewed papers include: coastal water resources and environment, water governance, rice-based cropping system intensification and diversification, homestead production systems, aquaculture, and outscaling and extrapolation domains.

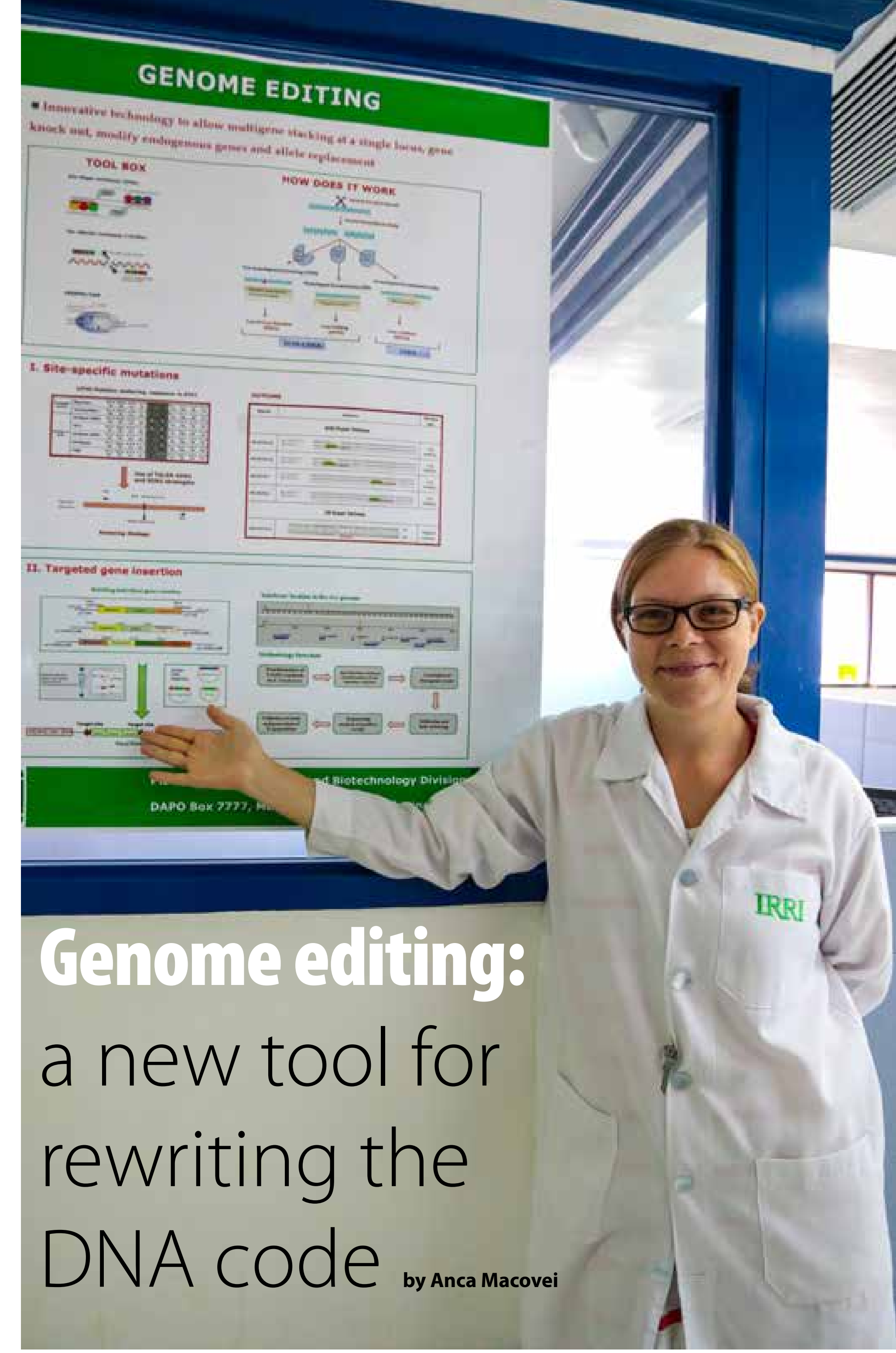
The conference was hosted by the CGIAR Challenge Program on Water and Food (CPWF) and was sponsored by the CGIAR Research Program on Water, Land and Ecosystems (WLE) and the Global Rice Science Partnership (GRiSP), which is the CGIAR research program on rice. ■

See: https://cgspace.cgiar.org/handle/10568/66389.

TRAINING COURSES AT IRRI

Course title	Date	Application deadline
Molecular Breeding Course	28 September – 9 October	28 July
Rice: Post-production to Market (2nd offering)	12-23 October	12 August
Basics of Rice Production (2nd offering)	27-29 October	27 August
Ecological Management of Rodents, Insects, and Weeds, in Rice Agro-ecosystems	2-13 November	2 September
Basic Scientific Writing Course	9-13 November	9 September
Advanced Applications of ORYZA V3 in Rice Research	9-13 November	9 September
Research Data Management	24-26 November	24 September
Effective Presentation Skills Workshop	3 December	3 October

For inquiries, contact IRRITraining@irri.org, m.maghuyop@irri.org, or a.aquino@irri.org. Phone: (63-2) 580-5600 ext 2538 or +639178639317; fax: (63-2) 580-5699, 891-1292, or 845-0606; mailing address: The IRRI Training Center, DAPO Box 7777, Metro Manila, Philippines (Attention: TC Course Coordinator); Web site: www.training.irri.org.
Note: Fees and schedules are subject to change without prior notice.



Genome editing: a new tool for rewriting the DNA code

by Anca Macovei

(Photos by Jec Narciso)

In the new era of genomic research, "genome editing" technology has been developed, consisting of new tools that enable not only rapid alterations in the DNA code but also precise targeting within genomes. In a sense, genome editing is effectively rewriting the DNA code.

Since scientists unraveled the mysteries of DNA, many technologies and applications have been developed to speed up the process of evolution and natural selection. In plants, traditional breeding takes advantage of existing natural genetic variation to introduce desirable traits into cultivated crop varieties. But conventional breeding methods are no longer sufficient for improving crops to keep up with rapid environmental changes. Thus, new biotechnology methods have become necessary. Mutagenesis is one of the options for creating genetic variation.

Gene mutation—a natural process that creates random but permanent alteration in the DNA sequence that makes up a gene—is considered as the raw material of evolution. Since the 1940s, breeding programs used chemical mutagens or radiation treatments to induce random mutations in a genome. These methods produced huge mutated populations, which had to undergo rigorous selection to identify plants with desirable traits.

Molecular scissors

"As sequencing whole genomes has become cheaper and faster, we can now use genome engineering to introduce desired changes in the DNA sequence and carry them out precisely and rapidly," said Dr. Prabhjit Chadha-Mohanty, who is among the first scientists at the International Rice Research Institute (IRRI) to use this technology.

In contrast to conventional genetic modifications, in which external DNA is randomly inserted in the genome, genome editing tools are like molecular scissors, allowing scientists to make cuts at predefined sites. Subsequently, the break is repaired by the internal DNA repair systems of the plant.

An option for genetic engineering

Similar to genetic engineering, genome editing also requires carrier vectors to deliver these tools into plant cells. But, unlike genetically modified organisms, which have attracted a fair amount of controversy, the vectors' transferred DNA will eventually be eliminated during allele separation in the next generations. Thus, any crop mutation generated in this way is no different

A BACTERIAL growth medium is prepared to assist the Agrobacterium-mediated rice transformation.

from crop mutations occurring naturally or induced via mutagens.

The advantage of genome editing is that new crops obtained this way may not have to be subjected to the strict regulatory constraints implemented for genetically modified organisms. This is the case in the U.S., where authorities already declared that these crops do not fall in the GM category, although the EU is still debating the issue. In addition, the time required to obtain a new, improved variety is considerably shorter than with traditional breeding or even genetic engineering.

Powerful tools

The most used tools in genome editing are zinc finger nucleases (ZFNs), transcription activator-like effector nucleases (TALENs), and clustered regularly interspaced short palindromic repeats (CRISPRs). These are all special combinations of species-specific DNA (or RNA in the case of CRISPRs) and enzymes that can be used to edit instructions in gene sequences.

This idea began in the early 1990s when bacterial type II enzymes were first used to target a specific region within the genome. However, only in the last 5 years, tremendous breakthroughs have been achieved in this field. The application of this technology covers broad fields of research, from medicine to agronomy.

In 2007, Mario Capecchi, Sir Martin Evans, and Olivier Smithies won the Nobel Prize for Physiology or Medicine for safely applying targeted genome modifications in mice. Moreover, at Beckman Research Institute of the City of Hope National Medical Center in California (U.S.), a clinical trial showed that gene editing techniques can be safe and effective in humans. In a paper published in the *New England Journal of Medicine* in 2014 by Dr. Pablo Tebas and his team, ZFNs were used to target a gene in the immune cells of 12 people with HIV, thus increasing their resistance to the virus.

Researchers did not wait long to test these new powerful tools in the field of crop improvement. In March 2014, the Canadian company Cibus released the first commercial crop using genome editing, a herbicide-tolerant canola variety. Scientists at Rothamsted Research Institute (UK) developed a variety of wheat resistant to powdery mildew by disrupting the activity of six alleles of a resistance gene, all at the same time.

Editing the rice genome

In the last 2 years, several research groups successfully tested the efficacy of genome editing tools in rice. With the sequencing of 3,000 genomes, recently achieved by the 3K Rice Genomes Project, the potential use of these tools becomes even more appealing. The search of DNA regions to be targeted within all these accessions is a milestone worth pursuing (see *Dawn of a new era in rice improvement* on pages 24-27 *Rice Today* Vol. 13, No. 3).

IRRI scientists are fully aware of these opportunities. And, several groups have started tapping into these innovative techniques. The detection of quantitative trait loci (QTLs) in rice breeding, one of the major research programs at IRRI, offers a direct advantage relevant to crop improvement. Dr. Tobias Kretzschmar, a molecular biologist in the Institute's Plant Breeding, Genetics, and Biotechnology Division, and his team are working on gene validation by looking at essential QTLs. By inducing targeted mutations, they are turning off specific genes in order to test their functions.

Meanwhile, Ricardo Oliva and his group from the Plant Pathology Department in the Crop and Environmental Sciences Division are studying genes with susceptibility to bacterial blight, one of the most serious rice diseases. It can cause yield loss up to 70% in susceptible varieties and the pathogens quickly adapt in resistant varieties as well.

"Broad-spectrum resistance can be created if several gene family members are targeted at the same time, limiting in this way the bacterium's access to alternative nutrient sources," said Dr. Oliva. "Whether we exploit the genes with resistance or susceptibility to broaden the spectrum of resistance, it is clear that genome editing tools are important assets for next-generation resistance breeding."

In another project funded by the Global Rice Science Partnership's New Frontiers Program, Dr. Inez Slamet-Loedin and Dr. Chadha-Mohanty in the Plant Breeding, Genetics, and Biotechnology Division are applying several genome editing tools to produce IR64 rice that is resistant to rice tungro spherical virus. They are working closely with Dr. Daniel Voytas from the University of Minnesota (U.S.), one of the leading pioneers of this technology.

"We are excited to see promising results being brought to life with these new tools," said Dr. Slamet-Loedin."The applicability is not restricted to just inducing mutations, but it can be expanded to allow multiple genes to be stacked at a single locus, though there is still much to learn."

And yes, there is still a lot to learn for rice scientists since the applications of genome editing are still in the early stages. Nonetheless, targeted manipulation of genes for desirable agronomic traits can potentially revolutionize how new rice varieties will be bred. Genome editing techniques promise to improve the disease resistance and nutritional value of rice. These techniques could also produce crops that require fewer inputs and that could thrive under unfavorable conditions. Genome editing could be another major tool in the race to feed the ever-increasing population of the world.

Dr. Macovei is a postdoctoral fellow at the Plant Breeding, Genetics, and Biotechnology Division at IRRI. She is involved in a project designed to test the genome editing tools in rice, under the supervision of IRRI scientists Drs. Slamet-Loedin and Chadha-Mohanty.

DR. RUDI Trijatmiko, a project scientist at IRRI, is preparing a polymerase chain reaction or PCR to test whether the TALENs constructs have all the desired components.

(Photos by Neil Palmer)

Edward Pulver

Searching for the heart of yield

by **Ximena Escobar**

Dr. Pulver is a scientist with a global mission: improve farmers' lives by raising crop yields. His accomplishments range from increasing Peru's national rice production, to developing a system for evaluating rice resistance to blast in Colombia. From reducing yield gaps in the irrigated rice production of Venezuela and Brazil, to improving agricultural productivity in Nicaragua and Mexico.

"The simplest solution is always the best," Edward Pulver likes to say, when explaining his approach to solving agricultural problems in the tropics. Through four decades of dedicated effort with a half dozen international organizations, this multifaceted agronomist has acquired an almost legendary reputation in many parts of the world for his ability to deliver development impact through innovations in the production of various crops, but especially rice.

One of Dr. Pulver's favorite songs is the 1972 hit single *"Heart of Gold"* from Neil Young's *Harvest* album. This is hardly surprising, as Young was an outspoken advocate of farmers. The song's refrain, "keeps me searching for a heart of gold," perfectly captures the restless and uncompromising spirit that has guided one successful career in music and another in agriculture.

Dr. Pulver is a straight talker, says what he thinks, and does what he says. He does science, and communicates it through debates, arguments, and critiques. He has worked with rice, soybean, banana, citrus, vegetables, and, most recently, oil palm. Diverse international development agencies—including the World Bank, Food and Agriculture Organization of the United Nations, U.S. Agency for International Development, World Wildlife Fund, and UN Common Fund for Commodities— have contracted him as a consultant for projects in Asia, Africa, and Central and South America.

Two heads are better than one

In 1972, a young Pulver arrived in Colombia to work with the Instituto Colombiano Agropecuario (ICA), the national agricultural institute, as a volunteer with the U.S. government's Peace Corps program. While serving as a crop physiologist at ICA, Dr. Pulver met Peter Jennings, who became his mentor and friend (see *Luck is the residue of design* on pages 10-11 of *Rice Today* Vol. 7, No.1). Dr. Jennings had joined ICA as a rice breeder following a period of extraordinary achievement in Asia, where he contributed importantly to the development of the rice variety IR8 at the International Rice Research Institute in the Philippines. Referred to as "miracle rice," this variety was instrumental in fostering Asia's Green Revolution (see *Breeding history* on pages 35-38 of *Rice Today* Vol. 5, No. 4).

"At the end of each day, Peter would come to my office and we would talk about ways to increase rice yields; this was the perennial topic of our discussions," Dr. Pulver recalled. Their long conversations were rich in ideas and highly innovative, combining two complementary perspectives, from Dr. Jennings' experience with genetic improvement and that of Dr. Pulver in agronomy.

After completing his 2-year mission in Colombia, Dr. Pulver went to the International Institute of Tropical Agriculture in Nigeria to work on soybean. Dr. Jennings kept in contact with Dr. Pulver and, in 1981, appointed him to work on a project with the Colombia-based International Center for Tropical Agriculture (CIAT, its acronym in Spanish). The project's aim was to promote irrigated rice as an alternative to clearing the Peruvian rainforest.

"It was a great experience!" Dr. Pulver said. "In 4 years, we were able to increase national rice production by 35%, reduce forest clearing, and improve incomes for farmers in the region."

RAIN WATER-harvesting reservoirs in Nicaragua, piloted by Dr. Pulver, provide farmers with water for their crops even during prolonged droughts.

Through his friendship with Dr. Jennings, Dr. Pulver—the man of a thousand stories—came to know a lot about genetic improvement. He and Peruvian rice breeder Carlos Bruzzone developed a system for evaluating rice for resistance to *Pyricularia oryzae* (the pathogen responsible for rice blast, a major disease of the crop worldwide). Later, they transferred the system from Peru to the Santa Rosa Experiment Station near Villavicencio, Meta Department, which is a "hot spot" for the disease in Colombia's Eastern Plains. The new system came to be a central feature of CIAT's Rice Improvement Program, as did Dr. Pulver's early work on cold tolerance in rice, using anther culture.

A FARMER watering his crops during the dry season in drought-affected Nicaragua, made possible by reservoirs filled with rainwater collected during the rainy season.

Making an agronomy revolution

In search of a means to consolidate and build on the achievements of these early years, CIAT, together with several national partners, established FLAR (the Latin American Fund for Irrigated Rice) in 1995. This is a public-private partnership for rice research with member organizations in 17 countries of Latin America and the Caribbean. Soon after FLAR was set up, it contracted Dr. Pulver to take on a significant challenge: to coordinate a new project aimed at reducing yield gaps in the irrigated rice production of Venezuela and Brazil's state of Rio Grande do Sul.

From 2003 to 2006, average rice yield in Rio Grande do Sul had increased from 5.2 to 7.5 tons per hectare, while in Venezuela it had risen from 4 to 6 tons per hectare—over a total area, in the two countries, of more than 1 million hectares. Improved agronomic practices were also extended to Argentina and Uruguay, with similarly positive impacts on yield. Firmly grounded in science, the solutions were transferred from farmer to farmer through a simple formula consisting of six steps for improved agronomic management: planting date, planting density, seed treatment, weed control, fertilizer application, and water management.

"I learned that farmers understand clearly when the message is simple," Dr. Pulver said. "Farmers are quick to learn when you address problems in a way that fulfills their desire to be more productive. Farmers, like many people, have to see to believe, and this is the basis for on-farm demonstration plots."

Focused on raising yields

Turning his attention to Central America some years later, Dr. Pulver realized that 80% of the farmers in this region grow rainfed rice under harsh conditions. Far from being discouraged by the resulting low productivity, he was inspired to propose an alternative.

"We tried water harvesting on a pilot basis," he said. "We weren't interested in constructing hundreds of dams but only 10 to demonstrate what could be done."

The project improved agricultural productivity and the quality of life for farmers in Nicaragua as well as Mexico by providing an option to cope with prolonged drought. What began as a rice project led to the diversification of agriculture, as water harvesting enabled farmers to grow other crops, such as beans, maize, fruits, vegetables, and sugarcane. After the project came to a close in 2012, the two countries obtained new resources to expand water harvesting.

Driven by an almost obsessive desire to raise crop yields, Dr. Pulver relishes a challenge. Few people know more than he does about the rice sector in Latin America and the Caribbean, and he's convinced that rice farmers in this region have plenty to offer their counterparts in Asia and Africa, especially in improved agronomy for high productivity.

Speaking his mind, as always, Dr. Pulver insists that "selection of new varieties should not be the priority in the majority of countries. The focus should be on getting high yields and improving water management."

Ms. Escobar is a communications specialist for FLAR, based at CIAT headquarters in Cali, Colombia.

RICE AGAINST THE TIDE

by **Paula Bianca Ferrer**

A new breed of rice is helping Filipino farmers in Bohol cope with seawater encroaching on their paddies. But in the race against climate change impacts such as rising sea levels, will rice scientists be able to stay one step ahead of the game?

By some twist of fate, Felixberto Rosales's luck changed during the wet season of 2014. Mr. Rosales, a farmer in the province of Bohol in Central Philippines, found himself needing to replant his field after golden apple snails damaged his rice seedlings. He asked a lady farmer he met at a seminar in Talibon, Bohol, if she could spare him some seedlings of the salt-tolerant rice varieties that she had obtained from her extension officer. What he did proved to be a turning point in his life.

For almost 10 years, Mr. Rosales had been struggling with problems of salinity on his 1.25-hectare farm—especially in those parts near the shoreline where seawater comes in during high tides. Like him, Antonia Quimson, the lady farmer who shared her rice seedlings with him, couldn't make use of some parts of her land because of salinity.

"That was how I got Salinas 11 seedlings from the municipal agriculture office in the first place," explained Mrs. Quimson, who is also a village councilor. Salinas 11 is one of the 15 climate change-resilient rice varieties developed by the International Rice Research Institute (IRRI), the Philippine Rice Research Institute, and the Bureau of Agricultural Research, for areas affected by saltwater intrusion.

According to IRRI's online Rice Knowledge Bank, millions of hectares in the humid regions of South and Southeast Asia are suitable for rice production but are not cultivated or suffer from very low yields because of salinity and problem soils. Encroaching seawater in low-lying areas is making the soil too salty to grow crops. Reduced river flows and rainfall during the dry seasons can further increase saltwater intrusion, as seawater during high tides move farther upstream. "Of the 25 villages in Talibon, 17 grow rice and 8 of these are in coastal areas," explained Mr. Lito Oroyan, a municipal extension officer who provides improved rice varieties to farmers like Mrs. Quimson.

"It was the best among the salt-tolerant rice varieties I have tried!" she said. "Now, we've had extra areas near a fishpond cleared so we can also grow rice there."

Currently, Mr. Rosales is seeing Salinas 11 "in action" on his farm. "What's good about this variety is that the plants looked good even when there was seawater," he said. "But they looked and performed even better when there was none."

Balancing genes and farmers

As much as rice is an important food staple consumed by more than half of the world's population, it is also the most susceptible to salinity among all cereal crops. But, not all rice types are created equal. Some of them can, in fact, tolerate salinity—just not in the same way, because different genes work differently.

The most popular and commonly used gene for rice breeding, *Saltol* (short for salinity tolerance), allows a rice plant to block the entry of too much salt into the plant through its roots. Other genes allow a rice plant to "sense" when too much salt is getting into the plant, and then sends the excess to old leaves, the stem, or storage bubbles found in cells (vacuoles)—the parts of the plant that are least sensitive to salt. Some genes enable rice plants to neutralize excess salt inside them with potassium. However, breeding for salinity tolerance is not as straightforward as one might think, as most rice types, which naturally have the trait, are also either low-yielding or have poor eating quality.

"Contrary to popular belief, breeding isn't simply about crossing rice types with the same set of ideal traits together," said Glenn Gregorio, former plant breeder at IRRI who led the development of salt-tolerant varieties. "It's getting the right combination of ideal traits in a plant, and ensuring that those really do get expressed when the plant is under stress.

"It's very rare for farmers to consider only one or two traits when thinking about adopting a particular rice variety. Oftentimes, they also check how long it takes to produce grains, how tall it grows, or how resistant it is to pests and diseases," Dr. Gregorio added. "That's why it also takes several years of crossing generations of rice types before you get to that stage where a variety can already be released by the national system to be adopted by farmers."

Salinas 11 is a perfect example of a rice variety that not only has the right genes but appeals to farmers as well. "I didn't mind the faint reddish color of the grains. I still like the eating quality," said Mrs. Quimson who is used to varieties with white grains.

"Now, even farmers in other provinces in the Philippines with no problems with salinity are growing Salinas 11, preferring it over popular varieties, because they're selling it as gourmet rice, which fetches a higher price," Dr. Gregorio added.

More than one way to beat salinity

In 2014, Apolinar Asa, another farmer from Bohol, tried 18 different salt-tolerant rice varieties, but none of them survived in his field located in Boyoan, Candijay. "I guess salinity was just so high that the rice plants couldn't stand it," Mr. Asa remarked.

Twenty years ago, farmers such as Mr. Asa benefited from an irrigation system running from Gabayan Lake all the way to 13 different villages in Candijay, including Boyoan, located at the farthest end of the irrigation line. The freshwater from the lake helped flush out the salt that encroaching seawater brought into the fields.

"Since the irrigation system broke down, we've been able to farm rice only inland," he said. "We can no longer use what once were productive areas near the coast when our irrigation system was running. The high tide was never a problem then, so long as freshwater was coming out of the irrigation system, which decreased salinity in the fields."

Since even salt-tolerant rice varieties failed, Mr. Asa and his fellow farmers were forced to adapt to their situation. "Now, we typically delay planting until August, when more chances of storms are brewing on the horizon," he said. "Some people pray for storms not to happen; we farmers pray otherwise. We have to rely on storms because strong rains—and sometimes floods—help flush away the excess salt."

ANTONIA QUIMSON (*right*) **is now able to grow rice in the saline parts of her farm using Salinas 11 that she obtained from municipal extension officer Lito Oroyan** (*left*)**. (Photo by Paula Bianca Ferrer)**

SALINAS 11 or IRRI 169 (*left*) **is a superior variety especially bred for salt-ridden areas. It is also sold as gourmet rice in some parts of the Philippines because of its high quality, reddish grains. (Photo by Glenn Gerogorio)**

But, the changing and erratic climate pattern is taking its toll as well. "Sometimes our little weather predictions don't come true," he said. "The storms won't push through, for example, so 70–75% of our crops fail. But, a new variety called Green Super Rice, which an extension officer asked me to try, was able to survive."

Green Super Rice (GSR) varieties are a mix of more than 250 different promising rice varieties and hybrids. They have combined tolerances for different stresses and other useful traits so that they can adapt even in harsh conditions.

"I was able to harvest 47 sacks (a sack weighs 45–50 kilograms) from one of the five GSR varieties I tested on the 0.6 hectare of farmland that I own," Mr. Asa said. Like Salinas 11, the GSR variety that Mr. Asa planted has more going for it than just salt tolerance. "The eating quality was also good and it didn't spoil as easily as my other varieties," he said.

"Several farmers here in our village already asked me for some seeds," Mr. Asa added. "I think GSR varieties might be able to give us a fighting chance against climate change."

Ms. Ferrer is science communication specialist at IRRI.

by Gladys Ebron

The future of agriculture lies in the next generation of leaders who will face the tough challenges of poverty and hunger, limited natural resources, and the impact of climate change.

Developing the next cadre of SCIENTISTS

One of the essential resources in agriculture is water. For instance, it takes about 2,500 liters of water to produce 1 kilogram of rice. With climate change, water supply of farmlands will be greatly affected. By 2025, 15–20 million hectares of irrigated rice will suffer from some degree of water scarcity. Given this adverse scenario, managing water resources will be a tough challenge and improved water management through water-saving practices will be vital in safeguarding agricultural production in the future.

Empowering young people to be catalysts of change can help solve many challenges in the future. Young scientists must play a leading role in such efforts to help shape a new image for modern agriculture.

Bibhu Prasad: a passion for working with Odisha's farmers

Born in the coastal Puri District of Odisha, Bibhu Prasad was introduced to agriculture early on in life. His father worked in an agricultural company marketing pesticides. Driven by his ambition to serve people in farming communities through rural development, Mr. Prasad received his bachelor's degree in agriculture from the Orissa University of Agriculture and Technology (OUAT). His interest in working with farmers in rural areas grew upon moving to the rice belt of Sambalpur in Odisha after graduation. He is pursuing his master's degree in extension education at the same university.

Mr. Prasad is one of the nine students who received a research grant under the collaborative research activities of the Cereal Systems Initiative for South Asia (CSISA) and OUAT. Funded by USAID and the Bill & Melinda Gates Foundation, CSISA makes use of strategic partnerships, participatory technology development, future-oriented cropping systems, research, and capacity building to catalyze locally appropriate, sustainable change in rural communities within and across South Asia. In 2013, the university sought the support for capacity building a cadre of young scientists who will conduct their research and catalyze its delivery process.

RESEARCH SCHOLARS engaged with collaborative activities of the CSISA project with OUAT are (*from left*) Subhshree Kar, Madhusmita Panda, Suchismita Mohapatra, Jyostna Pradhan, Jijanasa Mishra, Abinash Jena, and Bibhu Prasad. (Photos by CSISA)

Since January 2014, Mr. Prasad has been studying the adoption behavior of rice farmers toward alternate wetting and drying (AWD) technology in Puri.

"AWD is a new technology for Odisha. It's interesting as it is a very simple and low-cost technology," Mr. Prasad beams. "It is beneficial for Odisha farmers during the *rabi* season when irrigation is a major constraint."

His goal is to advance research on AWD in Odisha and develop extension models for dissemination of the technology. "We are trying to disseminate the AWD technology to the farmers and study their adoption behavior in terms of their knowledge and attitude, as well as constraints in adopting AWD," he adds. "Along with this, we will observe the operational efficiency of the technology for the microfarming situation in Odisha."

Farmers were exposed to the technology through awareness meetings, field days, information materials (fact sheets), and face-to-face interaction. Mr. Prasad is also conducting a survey to assess some socioeconomic parameters.

"After working with CSISA for more than a year through this scholarship program, I became familiar with new technologies, experienced hands-on training, and was exposed to research," he said. "I get an opportunity to work directly with the grassroots farmers. I am confident that this experience will help me in the future to solve some problems of rice consumers and producers. I am now aware of different resource conservation technologies, which will help the lives of poor and smallholder farmers."

Ipsita Kar: overcoming poverty through rice science

Ipsita Kar finished her schooling in Delhi Public School, Nalco, and pursued her bachelor's degree at OUAT. She moved to Meghalaya to obtain her master's degree at Central Agricultural University. Now, she is studying for her PhD in Agronomy at OUAT under the CSISA-OUAT collaborative project.

"Working with CSISA has opened my mind and broadened my view toward practical research, which would help people," Ms. Kar shares.

In 2014, the scholarship program gave her the opportunity to attend the *Rice Research to Production* training at IRRI headquarters.

"The qualitative work being done at IRRI motivated me to gain more insight into my research," she says. Her research on water management aims to minimize water use without yield loss. "When I become a rice scientist, I will use what I've learned from my training and visits to advance agricultural research, to help overcome poverty."

Ms. Ebron is public relations officer at IRRI.

Partnership-driven SCIENCE

by **Alaric Francis Santiaguel**

Many countries have greatly benefitted from the agricultural technology developed at IRRI with the support of traditional donors. In recent decades, India and the Philippines have transitioned from being solely research beneficiaries to partners by financing some of their own research activities at the Institute. This new kind of partnership, which IRRI wants to explore and grow with many other nations, could fund the next-generation of rice science.

In March 2014, the Philippine Department of Agriculture launched a project to conserve heirloom rice of the Cordillera Region in northern Luzon (see *Women who move mountains* on pages 22-23 of *Rice Today* Vol. 13, No. 4. The Heirloom Rice Project aims to shine the spotlight on obscure indigenous varieties in lucrative local and international premium food markets. By creating a demand for them, much like with basmati and jasmine rice, heirloom rice could sustain the region's struggling upland farmers.

That the Philippines' Department of Agriculture is collaborating with the International Rice Research Institute (IRRI) to provide the research backbone of this project is not new. However, something is fundamentally different about the Heirloom Rice Project. It is an example of a new partnership setup between IRRI and the Philippines in which traditional donor agencies do not provide the funds to carry out the activities.

Powered by philanthropy

From its founding, IRRI has been sustained by the deep pockets and generosity of donor agencies. In December 1959, the Philippine government and the Ford and Rockefeller Foundations signed a memorandum of understanding in New York establishing "an organization to do basic research on the rice plant and applied research on all phases of rice production, management, distribution, and utilization." It was essentially a declaration of war against starvation in Asia, where the production of rice—the staple for most of the continent—lagged dangerously behind its population growth.

Powered by philanthropy, the Institute developed some of the most potent weapons against hunger and poverty from its experimental fields in the Philippines. The Institute's first director, Robert Chandler, Jr. put together a team of rice scientists to breed a new kind of rice that overcame the yield limits of all existing varieties. That variety is the famous IR8—a semidwarf rice known as "miracle rice" for its ability to produce twice the yield of traditional rice varieties and, in some places, setting unheard of yield ranging from 6 to 10 tons per hectare (see *Breeding history* on pages 35-38 of *Rice Today* Vol. 5, No. 4).

IR8 (and all the high-yielding rice varieties that came after it), the modern technologies, and the scientific advances that changed the course of rice production are all knowledge-based public goods available to every country, regionally or even globally, that needs them. Certainly, none of those would exist today without the funding provided by philanthropic foundations, international organizations, and governments of mostly Western countries.

In the past decades, however, the focus of the aid architecture on the development landscape has been gradually shifting from Western-centric to various emerging medium-sized and small development partners.

And, the development activities funded by emerging research investors known as "partner countries" are rapidly growing in importance.

"Traditionally, IRRI has worked with countries to conduct research and training on the basis of grants from various agencies or from the CGIAR fund," said Matthew Morell, IRRI deputy director general for research. "But, increasingly, as countries become richer and have a higher technical base, they are coming to us to fund joint programs targeted to their specific interests. We have strong examples of projects like that in India and the Philippines."

A new phase of partnership

One of the most spectacular cases of how donor investments in IRRI's rice research have had an impact on a beneficiary country is India (see features on *Celebrating 50 years rice research in India* in *Rice Today* Vol. 14, No. 2). India has come a long way from a country with a severe food deficit to being a major grain exporter, according to Samarendu Mohanty, head of the Social Sciences Division at IRRI.

"Indian rice and wheat production in the past five decades rose by more than three- and eightfold, respectively. During this period, per capita availability increased by more than 10 kilograms for rice and 50 kilograms for wheat," Dr. Mohanty said. "The rise in grain production eventually transformed India from a grain importer to an exporter in the mid-1990s. Since then, grain exports (rice, wheat, and maize) have steadily increased, reaching 24 million tons by 2012-13. The transformation of the rice sector was even more startling, with India dethroning Thailand to become the largest exporter of rice in 2012."

The government of India has been funding some of IRRI's research collaborations with the Indian Council of Agricultural Research (ICAR). It is the apex body for coordinating, guiding, and managing research and education in agriculture in the country. With 99 institutes and 53 state agricultural universities spread across the country, ICAR is one of the largest national agricultural research systems in the world. For more than 50 years, IRRI and ICAR have been partners in rice research activities focusing on outcomes to benefit farmers and consumers.

"IRRI-India collaboration has matured and so have the needs, expectations, and environment of doing business in relation to what is happening not only in India but also regionally and globally," said Jagdish K. Ladha, IRRI scientist and country representative for India and Nepal. "India has a strong national rice research program with increasing participation by the private sector and civil society organizations."

In 2013, under the ICAR-IRRI Work Plan 2013-16, the collaboration yielded several solid achievements: 12 rice varieties released as well as drought-, flood-, and salinity-tolerant rice lines developed and now used in several breeding programs.

The Philippines emerges

The Philippines has rice research and development collaboration projects under the Food Staples Sufficiency Program (FSSP) of the Philippine Department of Agriculture. The FSSP is the country's strategy to achieve rice self-sufficiency and maintain it. Aside from the Heirloom Rice Project, other FSSP activities in which IRRI plays a pivotal role are the Accelerating the Development and Adoption of Next-Generation Rice Varieties for the Major Ecosystems in the Philippines (NextGen) project and the Philippine Rice Information System (PRISM) project.

NextGen aims to accelerate the introduction and adoption of higher-yielding rice varieties and hybrids that can withstand flood, drought, and salinity in order to raise current yield in rice production. PRISM is developing a monitoring and information system for rice production in the country.

The Philippine government is footing the bill for all these projects as the country has been assuming a greater partnership role with IRRI.

"Countries like the Philippines are starting to invest in rice research for their own benefit. The Institute supports such a move," said V. Bruce J. Tolentino, IRRI deputy director general for communication and partnerships. "We are now working with the Philippine Rice Research Institute (PhilRice), the University of the Philippines Los Baños, and the regional offices of the Department of Agriculture to bridge the gap between local rice production and consumption."

It is not only the national government collaborating with IRRI. In May 2015, Ilocos Norte Governor Imee Marcos visited IRRI to find viable interventions to climate-related challenges facing rice farmers in her province. Ilocos Norte, in the


1. **INDIA AND THE PHILIPPINES, new players in the agriculture aid landscape, fund respective research activities with IRRI. Hon. Shri Ashish Bahuguna (*left*), former head of the Department Secretary of Agriculture and Cooperation in India, meets IRRI Director General Robert Zeigler during his visit to IRRI in 2012.**
2. **NATIONAL FOOD Authority Administrator Renan Dalisay (*left*) and Dr. V. Bruce J. Tolentino, IRRI deputy director for communication and partnerships, discuss improving rice quality in the Philippines. (Photos by Isagani Serrano)**

northern part of Luzon, has a total of 66,000 hectares of upland and irrigated rice areas and is one of the top rice producers in the country. In recent years, however, drought has affected more than a thousand hectares of rice fields.

"In the last four years, extreme drought has hit the province, causing significant production losses," Gov. Marcos said. To address this concern, she has allocated funds for science-based agricultural interventions and solutions.

Under the FSSP, IRRI and its partners will work together to enhance Ilocos Norte's rice production system to better cope with drought. IRRI will provide the provincial government with rice seeds tolerant of environmental stresses, which the regional agriculture office will distribute to drought-prone areas. PhilRice will provide training on dry seeding and advice on setting up water-harvesting stations.

Gov. Marcos also requested a blueprint of a mechanized seed driller developed at the Institute. The seed driller, designed by IRRI agronomist Yoichiro Kato and his team, provides farmers with an option to directly sow the seeds of rice and other crops in dry soil so that their fields are ready when the rains come. This eliminates the need to prepare nursery beds and transplant seedlings that simply wither and die when rains do not come. IRRI will provide training as well as the blueprint for its fabrication in the province.

"There is always a package, a set of interventions, that can improve farm productivity and farmers' income. What is crucial is to focus available budgets on those actions that make a positive difference," Dr. Tolentino said. "We hope to ensure that we're able to put options on the table and you can make choices."

The Philippines is even going beyond rice productivity. The National Food Authority (NFA) signed a memorandum of understanding with IRRI on improving rice quality in the Philippines. Under the agreement, signed in June 2015, the NFA and IRRI will promote and accelerate research on rice and rice-based farming systems toward establishing international standards for rice quality. Rice quality encompasses farming technologies and practices that help ensure sustainable agriculture, improved farmer welfare, higher grain quality, and dietary practices that support improved nutrition and health among consumers.

"Through this agreement, the NFA hopes to maximize IRRI's research in achieving our food security mission of providing the country's rice requirements in terms of volume and quality," said NFA Administrator Renan Dalisay. "This will also guide us in our decision-making, not only in our operational activities but also in policy formulation, in anticipation of future developments such as infrastructure buildup."

From beneficiaries to clients

The Philippines and India have been recipients of assistance programs since the beginning of IRRI. Judging from the success of the Green Revolution, both countries greatly benefited from the development aid provided by IRRI's donors. Why institutionalize their aid efforts?

For one, they can decide on their own research agenda from their own perspective. They can pursue activities of their own national economic interest with no strings attached and interference built in the assistance policies of traditional donors.

Traditional donors are very focused on meeting the needs of particular disadvantaged groups within a country that might be facing a particularly difficult poverty or production environment, according to Dr. Morell. "But there are areas where a country might identify that it has a specific need," he said. "It may have a particular area that it wants to focus on, which is not a donor priority. That might be the basis of the relationship with IRRI to provide research support. Countries have an opportunity to influence the research agenda so that IRRI does focus on research that is primarily important to them.

"It also means that, if the whole research is done in collaboration with a national partner, the research can be adapted and tailored to meet local requirements as quickly as possible," he added.

Dr. Tolentino also sees a significant change in the dynamics of the partnership between an emerging research investor and IRRI. Funding and justification for the research become the responsibility of the collaborating government and institution so they can also set their own mutually agreed-upon accountability measures.

"By funding the research activities themselves, they shift from beneficiaries to clients," he said. "Scientists now care more about the country-investor instead of satisfying the requirements of the traditional donors. It becomes a partnership of equals."

Under the evolving partnership with India, Dr. Ladha described IRRI's role as a facilitating international organization, not an organization that tries to take over the functions of the public or private sector.

THE HEIRLOOM Rice Project is one of the IRRI activities outside the traditional donor system. The project is funded by the Philippine Department of Agriculture through the Food Staples Sufficiency Program.

"Our comparative advantage is in strong science and innovation, looking at the big picture, and training in the frontier areas," he added. "But also in catalyzing technology transfer to farmers and others in the value chain."

Compounding research interest

However, the funding needed for a country-level research agenda could easily run into several millions of dollars, seemingly beyond the reach of some of IRRI's partner countries. Dr. Tolentino does not think this is a hindrance for countries to provide such significant amounts of funding, emphasizing that rice science has the nature of being a global public good.

"Partner countries can pool their resources and invest in IRRI," he said. "IRRI has the expertise, the experience, the laboratories, and experiment stations—the critical mass to successfully undertake such research for the benefit not only of one country, but for all countries. Investment in IRRI is much more efficient than each country building its own laboratories and research systems with many scientists working in isolation. Global public goods, once developed and introduced, benefit all countries."

Dr. Morell hopes that IRRI's partner countries will appreciate the international influence that their funding has and that, by each contributing to this process, they will benefit from the investments that the others make. "It's an important enabling relationship," he said.

This enabling relationship is very true for India.

"IRRI in partnership with Indian institutions should play a major role in implementing an upstream research agenda that includes targeted breeding and systems agronomy research, and a training program in frontier areas," Dr. Ladha said. "These will have a spillover benefit for other member countries of the South Asian Association for Regional Cooperation (SAARC)."

SAARC is an economic and geopolitical organization that involves Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, Sri Lanka, and Afghanistan.

"India, with its large diversity of soil and climate, provides unique opportunities to develop situation-specific rice varieties that will be relevant to not only India but also other neighboring countries such as Nepal," continued Dr. Ladha. "In genomics and bioinformatics, for which Indian institutions have strong programs, India could play a key role in supplementing IRRI's global agenda."

Engaging emerging research investors

Beyond the two countries, IRRI has embarked on a series of bilateral relationship strengthening exercises with ministries of agriculture and rice departments across Southeast and South Asia and Eastern and Southern Africa. To do this, IRRI appointed different scientists to serve as "country coordinators."

"There will be no partnership if our research is not relevant to country needs," said Dr. Tolentino. "Their role is to know the latest situation and developments in the rice sector in their assigned country. They have to make annual status reports, prepare a collaborative research agenda, assess results, and plan for the next steps. They have to engage the government."

"This is really an important way to be well connected to the regions so that we understand their issues and problems; thus, we can provide the science and technology," said Dr. Morell. "The test of the value of the collaboration and the relationship is when people are willing to sit down together and combine their attention and capacities to work on a focused set of questions. This is an important way of enhancing IRRI's relationship with the regions and improving the ability of science to reach the maximum number of people who need that science across a region."

With 16 partner countries, IRRI certainly has plenty of engaging to do. But Dr. Morell isn't daunted by the tasks ahead.

"There are clearly important and significant differences between all of our partner countries and that's part of the richness and excitement of working in rice," he said. "IRRI is still very much respected as an honest broker in providing impartial advice. We hope that we have earned their trust from a very strong relationship and a long period of interaction. There is also recognition that we deliver what people are looking for."

Although the overall spending of IRRI's partner countries pales in comparison with that of traditional donors today, what are the expectations from them in the future? Will IRRI run solely on this type of funding?

"Traditional donors have continuing interest in a whole range of concerns in various countries and we certainly will be continuing to work with them," said Dr. Morell. "But, as the national institutions in the countries that we are dealing with develop, we will continue the strong collaboration and engagement with them as they go on their journey. We think this is a very interesting and exciting way for partnerships to grow in the future."

Mr. Santiaguel is an associate editor of Rice Today.

Is proximity to IRRI an advantage?

by **Lanie Reyes**

Empirical evidence shows that being near IRRI has an advantage. Seventy percent of all varieties released in the Philippines were strongly linked with IRRI between 1985 and 2009. IRRI has also contributed to improving rice yield in the country. In fact, Filipino rice farmers have higher average yield than their counterparts in some top rice-exporting countries.

According to social psychologist Theodore Newcomb's proximity principle, individuals tend to form interpersonal relations with those who are close by. Although the proximity principle was initially applied for attraction and acquaintance, could it answer the question, "Do Filipino farmers benefit much from the presence of IRRI in the country?"

The answer is "yes," according to an Australian Centre for International Agricultural Research (ACIAR) impact study. The study showed that, between 1985 and 2009, improved varieties from IRRI increased the profit of Filipino farmers by USD 52 per hectare. And, the IRRI link to rice varieties developed in the country was strong throughout the period—averaging 70% of all varieties released. IRRI has contributed to improving rice yield in the country by 11% or USD 1.017 billion in 2009—an annual average of USD 625 million.

In fact, Filipino rice farmers have higher average yield than their counterparts in some top rice-exporting countries. In 2014, the average yield of the country was 3.96 tons per hectare, higher than that of Thailand (2.85 tons per hectare), Myanmar (2.69 tons per hectare), and Cambodia (2.51 tons per hectare).[1]

Yet, those figures seem incongruous with the fact that the Philippines is a rice importer.

"Why does the Philippines import rice?" asked Robert Zeigler, IRRI director general. "After all, IRRI is based in the Philippines and has been working to help raise rice production worldwide for 55 years. So, why haven't we been able to help the country become self-sufficient in rice? This is a question I often get asked. Nine years ago, IRRI and the Philippine Rice Research Institute (PhilRice) published a book with the same question in the title, *Why does the Philippines import rice?"*

USD 1.017 billion

Amount of IRRI's contribution to improving rice yield in the Philippines as of 2009.

The fault is in the geography

The country is archipelagic—composed of more than 7,100 islands," said Ludovico Jarina, deputy administrator of the Phillippine National Food Authority, as he shared similar arguments found in the book during his presentation at the Global Rice Market and Trade Summit in Thailand held on 28-29 October 2014. "The country is at a disadvantage compared with Thailand and India, which have flat lands that seem to go on and on."

According to David Dawe, FAO senior economist and one of the authors of the book, *Why does the Philippines import rice?*, "rice-importing countries such as the Philippines, Indonesia, and Malaysia are islands or peninsulas." On the other hand, a common feature of rice-exporting countries such as Thailand, Vietnam, and Myanmar is that they are all located on the mainland of Southeast Asia.

"Geography is the reason why some countries have more land suitable to growing rice," said Dr. Dawe. "The countries on the mainland have dominant river deltas that provide ample water and flat lands. These flat lands are important

MANY OF IRRI' s new technologies are tested in the Philippines first and made available to Filipino farmers ahead of the rest of the world. (Photos by Isagani Serrano)

[1] World Rice Statistics.

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Average number of typhoons that invade the Philippines annually.

for easier water control. And, it also helps to have access to river systems, making the cost of transportation low, which helps in facilitating exports."

"The country is frequented by an average of 22 typhoons in a year," according to Mr. Jarina. "Within 3 years (2011-13), a total of about 1.6 million hectares of area planted to rice were affected by various calamities, with an an average loss of 597,375 tons per year."

He also cited the high population of around 100 million rice consumers as one of the challenges in the country's domestic supply. A gap exists between the annual increase in rice consumption, which is 4.59%, and the increase in local rice production, which is 3.68%.

For Dr. Dawe, the supply side also has something to do with the Philippines being a rice importer. "The proportion of land devoted to rice tells the story," he said. "Thailand devotes 56% of its crop area to growing rice, compared with just 32% in the Philippines."

Ask history

"The geographical pattern of exporters and importers has been consistent over time," said Dr. Dawe. The Philippines, just like Indonesia and Malaysia, has been importing rice for more than a hundred years, and the exporting countries have been similarly consistent for most of that time. Although the Philippines and Indonesia became self-sufficient in the 1980s, and even exported small amounts of rice, this happened because of the Green Revolution package of high-yielding varieties, irrigation, and fertilizer, which was adopted earlier by these two countries than by the exporting countries. The Green Revolution probably would not have taken place earlier in the Philippines if IRRI had been located in Thailand or Vietnam.

The quest for home-grown rice

Understandably, the Philippine government is determined to attain rice self-sufficiency. "The rice traded in the world market is relatively thin, averaging 7–8% of the world's production," Mr. Jarina explained. "Rice can be bought from only a few sources—81% of world rice exports are controlled by five countries: Thailand, Vietnam, India, Pakistan, and the United States."

Rice demand is growing sharply with nontraditional rice-eating countries, which are contributing more to the global demand, he added. Lastly, climate change causes low global production.

For the Philippine government, the way to get there is through the country's Food Staples Sufficiency Program (FSSP), anchored on improving farm productivity and making Filipino farmers globally competitive.

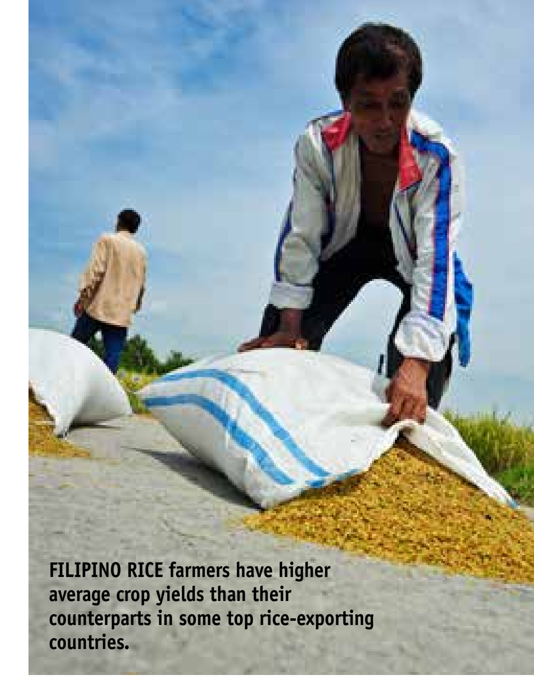
"The Institute supports such a move," said V. Bruce J. Tolentino, IRRI deputy director general for communication and partnerships. "IRRI is presently working with PhilRice, the University of the Philippines Los Baños, and the regional offices of the Department of Agriculture to bridge the gap between local rice production and consumption." This is being carried out under the project Accelerating the Development and Adoption of Next-Generation Rice Varieties for the Major Ecosystems in the Philippines, or simply called "the Next-Gen project."

"We are not just helping farmers increase yield; we are also helping the country's rice industry cope with climate change," Dr. Tolentino added.

IRRI has worked with the Philippine Department of Agriculture to develop and test climate-smart rice varieties. Examples of these are Submarino, Katihan, and Salinas, varieties that can withstand flood, drought, and salinity, respectively.

Beyond high-yielding varieties

"ACIAR, in its evaluation of IRRI's impact in the Philippines, did not include other areas of the Institute's activities; if they had, the impact and value of benefits would have been much more," Dr. Zeigler said.



FILIPINO RICE farmers have higher average crop yields than their counterparts in some top rice-exporting countries.

"IRRI helps Filipino farmers improve their management practices," Dr. Zeigler said. "For example, we have alternate wetting and drying technology that can reduce the water need of farmers by 30%. The Nutrient Manager for Rice Mobile helps Filipino rice farmers identify how much fertilizer to use, which type, and when to apply it.

"We have been working with the Philippines since our establishment in 1960," continued Dr. Zeigler. "Many of our new technologies are tested here first and made available to farmers here ahead of the rest of the world. And, because of our location, Filipino scientists can select from our potential new rice varieties much more easily and cheaply than our other Asian partners."

IRRI also contributes to the capacity building of the country. Through 2014, the Institute had a total of 3,398 trainees and scholars. Within Asia, the Philippine universities enjoyed a sizable share, ranging from 38 to 96% of IRRI scholars' enrollment.

Truly, the proximity principle is true when it comes to the impact of IRRI in the Philippines.

Ms. Reyes is the managing editor of Rice Today.

Rice fields below the Dhauladhar range of the southern branch of the main Himalayan chain of mountains above Kangra Valley, Himachal Pradesh, India.
(Photo by ©Anshul Soni/Himalayan Panoramic Studio)

INGER@40—and the CROSSROADS

by **Gene Hettel**

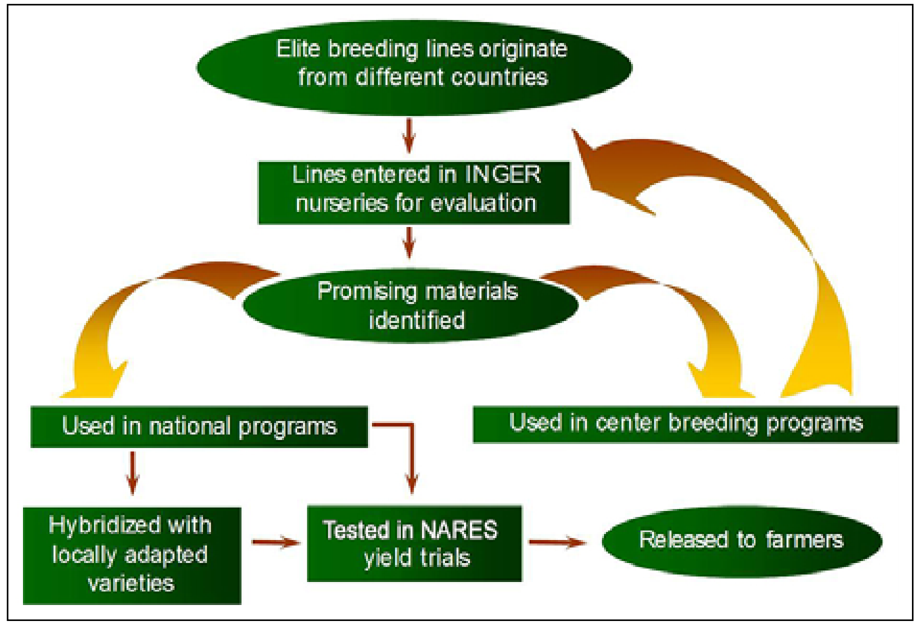
INGER, the world's largest agricultural research network, has a long history associated with milestones in rice breeding. Overall, more than 1,120 of its tested lines were released as varieties in 74 countries. Now celebrating its 40th year, INGER faces a different kind of challenge: its own sustainable future.

Research at the International Rice Research Institute (IRRI) and other international agricultural research institutes (ARIs) is about discovery—and sharing those discoveries with partners in the national agricultural research and extension systems (NARES) to alleviate hunger and poverty in the world. One research partnership that has been truly successful in such sharing is the International Network for Genetic Evaluation of Rice (INGER), founded by IRRI in 1975 and celebrating its 40th anniversary this year.

According to Ed Redoña, who served as INGER coordinator at IRRI from 2006 to 2014 and currently a rice breeder at Mississippi State University's Delta Research and Extension Center, INGER—known as the International Rice Testing and Improvement Program (IRTIP) prior to 1989—has been one of the longest-running germplasm networks in CGIAR.

"Through its primary mechanism of international nurseries (see figure), over the past four decades, nearly 3 million seed samples representing around 55,500 entries of advanced lines have been shared for evaluation by hundreds of rice scientists at more than 600 research stations in 85 countries (see map)," says Dr. Redoña.

Currently, nine international nurseries are in the network (four observational ecosystem-related for the irrigated, temperate, rainfed lowland, and upland environments and five stress-related for heat, soil, blast, bacterial blight, and brown planthopper) and two special nurseries (irrigated and rainfed) for Green Super Rice. "INGER is the world's largest agricultural research network and an epitome of veritable synergy," says D.V. Seshu, who was associated with INGER for more than 20 years while at IRRI. And, as its second coordinator in 1982-93, he coined "INGER" to be the network's new name in 1989. "Thanks to INGER, we have been able to obtain significant information on the nature of biotype and pathogenic variation in major rice pests and diseases and on the interaction of rice with major weather variables. The pooled test materials from different countries have brought in much-needed genetic diversity."



INGER's primary mechanism: international nurseries.

INGER test locations have involved hundreds of rice scientists, 600 research stations, and 85 countries.

Global impact—some examples

Overall, more than 1,120 INGER-tested lines have been released as varieties in 74 countries. In addition, cooperators in 51 countries have made more than 20,000 crosses using genetic donors from 68 countries. Some 1,129 breeding lines extracted from these crosses have been released as varieties in 21 countries.

In 1997, Yale University economists Robert Evenson and Douglas Gollin affirmed INGER to be a high-payoff activity. They estimated that each released rice variety contributes, on average, USD 2.5 million (1990 dollars) annually to the global economy. They maintained then that this annual value continues into perpetuity because varietal improvements are considered to be additive.

India. According to V. Ravindra Babu, director of the Indian Institute of Rice Research (IIRR), varietal improvement in India has involved the pooling of breeding material generated in more than 100 regional rice-breeding stations across the country. "The greatest advantage has been the free exchange of genetic material both nationally and internationally through INGER," he says.

N. Shoba Rani, retired head of IIRR's Crop Improvement Section, agrees with Dr. Babu on INGER's significance. "INGER has been immensely beneficial to India from many IRRI-bred lines released and becoming popular, resulting in enormous gains in rice production," she says. "About 43% of Indian rice varietal releases have been introduced through INGER." Some 252 varieties with INGER-derived parents have been released in 24 Indian states. "India, too, has contributed valuable rice genetic resources to global rice breeding efforts through INGER," Dr. Rani points out.

China. "From 1981 to 2012, around 16.6 million hectares were cumulatively planted with INGER materials," says Shihua Cheng, director general of the China National Rice Research Institute. "These materials resulted in the harvesting of 6.2 million more tons of rough rice with an economic benefit of around USD 530 million." And just like with India, INGER provides a two-way conduit in China. "At least 2,500 INGER entries were used as parents, restorers, and/or disease and pest-resistant donors in national and regional rice breeding programs," says Dr. Cheng. "On the other hand, around 560 outstanding Chinese rice varieties have been nominated to INGER over the years for global evaluation and use in other countries."

Philippines. To date, just over half of the varietal releases in the Philippines have been introduced through INGER. "The network's approach of providing free access to germplasm has substantially increased rice genetic diversity in the Philippines," says Thelma Padolina, coordinator of the National Cooperative Testing for the Philippine Rice Research Institute. "For more than three decades, INGER has provided Filipino rice scientists with elite genetic materials, nursery results, and reports of monitoring visits," she adds. "Annually, since 1982, INGER has enriched the country's breeding program with materials, which have proven useful in improving the genetic structure of Philippine rice varieties. Many varieties have been commercialized and a majority have been selected as donor parents for disease resistance and grain quality."

Turkey. "The network must be continued for the next generation," pleads Halil Sürek, a botanist known as Turkey's *Father of Rice* who has been testing and using INGER materials since 1979. "I have been working as a rice breeder for 36 years," he says. "And it is difficult to get genetic material from foreign sources. Using INGER material in crossing programs makes it possible to enhance genetic variation and solve biotic and abiotic constraints.” Dr. Sürek points out that he can obtain information on the performance of Turkish materials as well under different biotic and abiotic conditions through INGER. “Using INGER material, we have developed five Turkish varieties,” he adds.

LAC. “INGER has been a cornerstone for the development of rice varieties in Latin America and the Caribbean (LAC),” says Edgar Alonso Torres, head of the Rice Breeding Program at the International Center for Tropical Agriculture (CIAT) in Colombia. “Since 1976, this network has been effective in disseminating improved materials. Around 115 rice varieties released in LAC originated from elite INGER lines. This germplasm also provides valuable donors for blast resistance and cold tolerance, among other key traits. For the future, with adequate intellectual property (IP) protection, I hope that INGER will continue to be an important player in distributing genetic variability in rice.”

Elsewhere. INGER’s impact is even more pronounced in smaller and newer breeding programs. This is according to Glenn Gregorio, outgoing IRRI plant breeder and acting INGER coordinator for a time in 2014-15. “For example,” he says. “Varietal releases directly or indirectly traceable to INGER are 73% for Nepal, 72% for Myanmar, 61% for Indonesia, and 51% for Cambodia. INGER has helped IRRI generate impact even in countries not covered by major projects such as Stress-Tolerant Rice for Africa and South Asia. To date, 507 of IRRI’s breeding lines have been released as 914 varieties in 78 countries on five continents.

Social and cultural values

Over the years, a favorite topic of Gelia Castillo, Philippine National Scientist and IRRI consultant, is espousing the social and cultural values of INGER. “Beyond the genetic lingo of B2161C-MR-57 and P901-22-11, people actually lie at its heart,” she says (see *Cultural diversity through genetic diversity* on page 31 of IRRI’s 1997-98 annual report, *Biodiversity: Maintaining the balance*). “The network fosters participation in a culture of cooperation, consciousness of sharing, and exchange—not only of breeding lines, but of information, insights, and experiences toward a shared objective.”

According to Dr. Castillo, rice seeds share a common food value and “speak” a common language that transcends politics, geography, and culture. In Africa, for instance, INGER helped break a barrier in rice science between English-speaking and French-speaking countries. She maintains that INGER is a beautiful illustration of humanity working together for our common future in a world filled with social conflicts, tribal wars, and fierce competition over the control of natural resources.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INGER staff members perform a variety of processing tasks

1. LEEANNE BAUTISTA (foreground) measures traits and collects data on lines in the INGER demonstration plots at IRRI headquarters.
2. ALLAN SALABSABIN makes a final cross-checking of seed lists prior to dispatch.
3. MELINDA GIBE and Jose Angeles test seed germination.
4. ERNESTO SUMAGUE does efficient, mechanical sorting of treated grain using a seed separator.

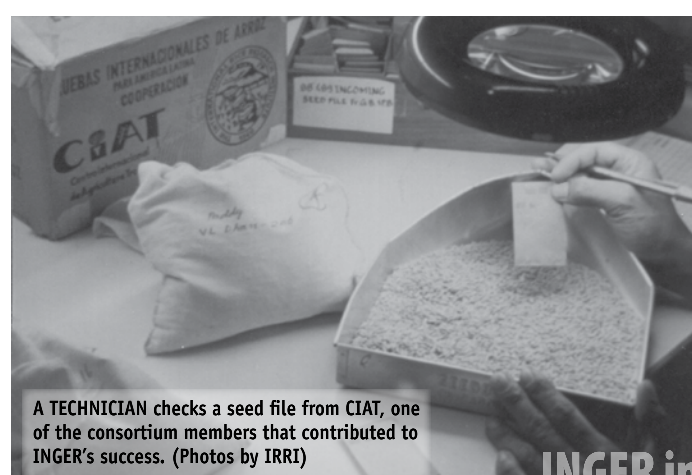
(Photos by Isagani Serrano)

The funding rollercoaster

A number of donor agencies, seeing the importance of INGER’s germplasm- and information-sharing activities, have supported INGER over the decades, most notably the United Nations Development Programme (1975-96); the World Bank (1991-96); the Swiss Agency for Development and Cooperation (1995); the German Federal Ministry for Economic Cooperation and Development (1995-97); and, to varying degrees after 2000, Korea’s Rural Development Administration; the Bill & Melinda Gates Foundation; the Japan Ministry of Agriculture, Forestry, and Fisheries; and the UN’s Food and Agriculture Organization, among others. However, periodically, donor priorities shift and INGER has had to tighten its belt, relying mainly on IRRI’s own unrestricted funds. In 1992, INGER merged with IRRI’s Genetic Resources Center because of budget-related downsizing. In the early 2000s, E.A. Siddiq, renowned Indian rice breeder and IRRI Board member (2000-06), recalls that, while serving on the Board, the body was contemplating terminating INGER because of the budget cuts of the time (see *Celebrated Indian scientist speaks his mind* on pages 16-18 of *Rice Today*, Vol. 14, No. 2).

“I impressed upon my fellow board members that it was INGER that provided IRRI with true visibility in the rice world,” Dr. Siddiq recollects. “Connecting almost all rice-growing countries through international testing and exchange of germplasm, it was INGER that enabled rice-growing countries to strengthen their rice-breeding research and develop varieties suited to their own different ecosystems. I emphatically said, ‘Don’t prune INGER because what you are spending on it is not that much, but what you gain is much more.’ Luckily, I and other INGER proponents on the Board won out and INGER continued.”

In 2002, as a solution to keep the network viable, INGER was transferred to IRRI’s Plant Breeding, Genetics, and Biotechnology (PBGB) Division where it became an integral part of PBGB’s seed exchange and germplasm distribution activities.



A TECHNICIAN checks a seed file from CIAT, one of the consortium members that contributed to INGER’s success. (Photos by IRRI)


TORIBIO EBRON, senior research assistant, checking seed for discoloration.

INGER in the 80s

INGER at the crossroads

“Breeders have a never-ending job to develop new varieties, but often encounter the problem of having a narrow genetic base,” says Bert Collard, IRRI rice breeder and acting INGER coordinator. “INGER nurseries provide this critical infusion of genetic diversity and new genes to rice breeders. So, as a breeder, it is a no-brainer that INGER must continue in some form. However, the direction that the network will take post-40 is unclear.”

IRRI foots a significant bill for all INGER costs in processing incoming seeds from NARES and ARIs (around 12 steps that include seed health and quality evaluation, planting, crop health inspection, data collection, harvesting, and cold storage) and then dispatching these seeds to various cooperators (another 10 or so steps that include viability testing, cleaning and grading, manual sorting, fungicide treatment, fumigation, and seed packing). The current funding to pay for all of this voluminous cost is not sustainable, and thus has to change. “A leaner, market-driven, and more precise and efficient INGER that will emphasize elite line quality over quantity is the only way to go,” opines Dr. Collard.

Although funding shortfalls may be a great obstacle, INGER has to contend with two other issues. “One involves IP concerns that have forced many NARES cooperators to submit fewer and fewer materials or none at all.” Dr. Collard points out. “There are competitive advantages at stake and all sorts of IP implications that were not scrutinized 40 years ago. So, often, many of our cooperators are now merely recipients of lines that are mostly from IRRI.”

The second issue is that partners tend to return less and less data. “These data are very precious to IRRI and have been a key pillar of INGER’s past success,” says Dr. Collard. “Accurate data will be all the more important in the future as we attempt to sort out unpredicted adverse effects of climate change around the world.”

Dr. Collard, his two INGER predecessors, Drs. Redoña and Gregorio, and other IRRI breeders have been contemplating options for INGER’s future. “The costly open-access status quo is probably least likely,” speculates Dr. Redoña. “A not-for-profit, self-sustaining model (e.g., full cost recovery) is being considered.”

The future probably lies somewhere in between,” surmises Dr. Gregorio. This might involve, among other ideas, access to the most advanced and well-characterized germplasm coming out of the newly organized and effective multi-environment rice varietal testing (MET) system, cost recovery charges for cooperators and joining fees for the private sector and ARIs, and a system of rewards and benefits for breeders of most-used or released materials.

A long-overdue retrospective

So, after 40 years, it is time to look at INGER in retrospect and reflect. “IRRI plans to invite key INGER partners from around the world—both veteran and new—to a comprehensive, no-holds-barred workshop to brainstorm about INGER’s next 40 years,” says Dr. Collard. “I’m optimistic and excited about what we will come up with. Stay tuned!”

Gene Hettel is editor-in-chief of Rice Today.

Visit INGER’s website at http://inger.irri.org for more information and to access current and historic nursery data.

The origins of Senegal's dependency on rice imports

by **Adam John**

Senegal's dependence on imported rice is not only about preference toward a more convenient food. It is also about the neglect of domestic food production, which is exacerbated by urbanization.

Imported rice is the main staple in the West African nation of Senegal. But not because it's cheap. On the contrary, rice in the country is "priceless." In December 1994, the government devalued Senegal's currency, causing the cost of all imported products to double overnight. The government was hoping consumers would replace imported rice with domestically produced foods to stimulate the agricultural sector and reduce the country's dependency on imported rice. However, the demand for imported rice in Senegal after the devaluation did not change. This was quite remarkable considering that Senegal is one of the poorest countries in the world, where the most impoverished groups spend as much as half of their income on food. The devaluation did, however, have an undesirable effect on consumers' diets. In order to be able to buy imported rice at inflated prices, they bought less meat and other foods, which adversely affected the nutritional status of millions of Senegalese.

Rice and urbanization

Changes in food preferences, in which diets shift from traditional coarse grains and other locally sourced starchy foods to wheat and rice, have long been associated with urbanization across the developing world. The reason is straightforward and comes down to individuals' opportunity costs. A growing urban population means changes in working patterns: people move away from agricultural activities in pursuit of off-farm work. More time away from home increases the opportunity cost for preparing traditional staples, which are relatively time-consuming to prepare. Millet, for instance, is still covered with husk so consumers need to remove it themselves. It also requires several washings, grinding into flour, rolling by hand to form small pellets or couscous, and, finally, steaming the millet a couple of times before it is ready to be served. In contrast, imported rice is easy to prepare and cook.

However, urbanization alone does not tell the whole story. When Senegal became independent in 1960, it was a largely rural-based society. Three-quarters of its population lived in the countryside. Although traditional staples such as millet and sorghum played a more important role in the Senegalese diet back then, imported rice was already a major source of nutrition in Senegal.

STANDARD RICE from the Senegal River Valley attempts to mimic 100% broken rice, but typically contains a heterogeneous mix of fine and medium broken grains, a mix of varieties and a lot of impurities (husks, stones, dust, etc.). Imported 100% broken rice from Thailand has more homogenous grain size, but still contains impurities. Upgraded rice from the Senegal River Valley, as processed by the women association Khar Yalla Gueye in Pont Gendarme, Senegal, has the highest grain homogeneity and purity. (Photos by Matty Demont)

Asian rice for the Peanut Coast

European traders named some coastal regions of West Africa after their primary export. Though the term was never used to refer to Senegal and neighboring Gambia, the "Peanut Coast" would have been an accurate description of the Senegambian region from the mid-19th century onward.

The peanut, introduced to Senegambia by Portuguese traders in the 16th century, prospered in the country's volatile and drought-prone Sahelian and Sudanic northern and central regions. It was quickly adopted as a supplemental food crop to millet. This emergency food crop turned into farmers' primary cash crop when French industrialists discovered that peanut oil could be used to produce an acceptable soap for the French market—speeding up the adoption of peanut cultivation in Senegambia. Farmers began allocating more land and labor to cultivating peanuts. Because the adoption of peanut cultivation was so widespread, and with less focus on food crops and dwindling trade sources of food staples in neighboring kingdoms, food shortages became more common and prolonged.

There was no millet or sorghum in international markets from which Senegalese farmers could purchase their food supplies. However, French Indochina in the Mekong Delta had surplus rice, which was already being exported to Europe largely for industrial use. The French redirected cheap broken Asian rice to Senegal and neighboring Gambia. As peanut production expanded, so did the region's dependency on imported rice to balance the food deficit.

Preference for broken grains

Senegal's rice preferences, along with Gambia and Mauritania, are quite peculiar in the sense that broken rice is actually preferred to unbroken rice. Broken rice is perceived as having low quality in most countries. But colonial administrators were keen to find the cheapest source of food to import to Senegal in order to feed the burgeoning peanut industry workers while maintaining a trade surplus.

However, this does not explain why broken rice is still preferred over higher-grade rice today.

"Rice is essentially a substitute for millet in Senegal," says Matty Demont, a senior economist and leader of the value chain research team at the International Rice Research Institute. "Lunch, the most important meal of the day, was originally based on millet with fish. But millet has been gradually replaced by 100% broken rice, which blended nicely with the dish. This explains the preference for 100% broken rice."

Consumers are recruited in the market of Saint-Louis for an experimental auction during which their willingness to pay for upgraded rice is elicited.

Volatile rice market

Although imported broken rice has provided a solution to Senegal's food deficit throughout the last century and a half, imported rice supplies have at times been unstable. The 2008 rice price crisis is one of a string of such events that had a dire impact on Senegal. Others occurred in the 1930s, after World War II, the early 1950s, and the early 1970s.

Likewise, volatile peanut export revenues have at times crippled the country. International peanut prices halved within six years in the 1880s and international markets were also deeply affected during the First World War and during the 1930s, so much so that Senegalese peanut farmers were forced to abandon their cash crop and resort to subsistence farming to make ends meet.

Imported rice at any cost

Today, Senegal continues to rely on imported rice. Although the country has a population of only 14 million, it was the third-largest rice importer in Africa in 2014, behind Nigeria and South Africa.

The Senegalese government still wants to end the country's dependency on rice imports.

EXPERIMENTAL AUCTIONS enable eliciting consumers' willingness to pay for rice with upgraded intrinsic quality attributes (grain quality, aroma, taste, etc.) and extrinsic (packaging, labeling, and information) quality cues. From left to right: Matty Demont, former agricultural economist, Africa Rice Center (AfricaRice) and is now at IRRI); Caitlin Costello, former visiting research fellow, AfricaRice; Khady Diagne, student, University of Gaston Berger, Saint-Louis, Senegal; Maïmouna Ndour, sociology assistant, AfricaRice, Saint-Louis, Senegal; Alioune Gueye, student, University of Gaston Berger; and Rougui Diop, teacher, Saint-Louis, Senegal.

However, after the riots in Dakar caused by rising food prices in 2008, the government made a renewed attempt to become self-sufficient in rice. Yet, despite numerous efforts to increase domestic rice production, overall yields have remained fairly flat. The larger concern, Dr. Demont believes, is that "infrastructure first needs to be upgraded for complying with quality standards before increased productivity can really replace imported rice."

Meanwhile, not only has Senegal become more dependent on rice imports, it has also become more dependent on rice as the primary source of nutrition for its inhabitants. At the inception of its independence, rice represented 20% of the average Senegalese calorie intake and 66% of this rice was imported. By 2011, the share of rice had increased to 31% of the calorie intake and 75% of this was imported.

Beyond imported broken rice

Senegal's dependence on imported rice was not just a question of changes in food preferences toward more convenience foods but the neglect of domestic food production and overspecialization in a single cash crop. A lack of domestic food industries, which offer food staples accepted by Senegalese consumers, fuels the cycle of food import dependency. This vulnerability continues to deepen with urbanization.

The historical trend would suggest that reducing rice import dependency in Senegal is irreversible. But research conducted at the Africa Rice Center has already shown that urban consumers are willing to pay premium prices for high-quality local rice, suggesting that the urban bias toward imported rice can be reversed.

Since the introduction of fragrant rice varieties in the Senegal River Valley, Senegalese rice farmers have dramatically increased their access to urban markets and local rice varieties are becoming more available in Dakar markets, according to Dr. Demont. An interesting aspect of rice preferences in Senegal's primary urban center is that, although expectations about the quality of rice continue to grow because imported Asian rice sets the benchmark, it is the fragrant 100% broken rice that is highly sought after because of its historical roots.

Dr. Demont believes that adapting to Senegal's peculiar demand for broken rice is a major challenge for the local rice industry. The question arises whether attempts should be made to develop more efficient processes for producing high-quality broken rice or whether efforts should be made to modify consumer preferences for whole-grain rice or even other staple foods. However, while imported broken rice remains available—and unless there are feasible alternatives—it would be surprising if Senegalese consumers willingly changed their preferences.

Mr. John is an independent researcher and was a Young Rice Scientist awardee at the 4th International Rice Congress.

Tanzania to lead rice production in Africa

by **Lanie Reyes**

Tanzania is poised to meet the growing demand for rice in Eastern and Southern Africa. It can potentially double or even triple its production through a strategy that combines improving agronomic practices, delivering improved high-yielding rice varieties, capacity strengthening in research and outreach, and a good strategy for seed production and distribution.

"Tanzania is set to become the next rice granary in Africa," said Abdelbagi Ismail, principal scientist at the International Rice Research Institute (IRRI). "It has great potential to expand as it has advantages of having ample suitable lands and water resources, and a good climate."

Add the two IRRI-bred rice varieties jointly released as Komboka and Tai by the National Rice Research Program-KATRIN Research Centre and IRRI-Tanzania two years ago. "These will greatly help boost the country's productivity," Dr. Ismail said.

The names of the varieties seem to represent how the Tanzanian government views its future rice sector. Komboka means "to be liberated" and is telling of the government's desire to be free from the problem of low rice production. Tai, which means "eagle," seems to speak of the country's desire to take its rice production to greater heights in both quantity and quality and be the leading rice exporter in Africa and even in the Middle East.

IRRI SCIENTISTS and their partners work together to improve Tanzania's rice sector. (*From left*) Dr. Rosemary Murori, IRRI rice breeder; Dr. Joseph Bigirimana, IRRI coordinator in Eastern and Southern Africa; Dr. Matthew Morell, IRRI deputy director general for research; Mr. George Iranga, head of Chollima Research Centre; Dr. Mohammed Mkuya, IRRI researcher; Mr. Joel Absalum Zakayo, agronomist, Chollima Research Centre; Abdelbagi Ismail, IRRI principal scientist; Dr. Zak Kanyeka, IRRI rice breeder; and Dr. Setegn Gebeyehu, IRRI agronomist and seed specialist. (Photos by IRRI)

Superior performance of new varieties

These visions did not come out of thin air. The yield potential of the two new varieties is twice to almost thrice the average rice yield of the country, which is 2.0 tons per hectare. Komboka can yield 6.5–7 tons per hectare while Tai can yield 7.5 tons per hectare. Komboka is aromatic and can thrive well in water-stressed rainfed lowland ecosystems, which cover most rice area in Tanzania.

Komboka and Tai can be grown twice a year—during the rainy season from January to June and during the dry season from August to December. Farmers can cash in on their crop early because both varieties mature faster, 5–14 days compared with Saro 5, a local variety. Also, the two varieties have moderate resistance to diseases such as bacterial leaf blight and leaf blast.

Tanzanian farmers are pleased with the superior performance of Komboka and Tai. A rice farmer-cooperator, Israel Mwakyange in Kyela, said that he had replaced his local variety with Komboka. What's more, he readily agreed to let IRRI use part of his land for research and demonstration purposes.

A focus on quality

Rice is both a cash crop and food crop in Tanzania so farmers are very critical when it comes to quality. The two high-yielding varieties meet the grain quality demand of the market. Aroma is a big factor in the marketability of Komboka. On the other hand, Tai caters to consumers who consider aroma less important.

"The two varieties are in demand for their long, slender, translucent grains, and the soft texture of the cooked grains, which remain soft even when stored overnight," explained Dr. Zak Kanyeka, IRRI rice breeder, who actively participated in the evaluation and selection of the two IRRI varieties from 2008 until their release in 2013.

"Marketing of these new varieties is demand-driven and price-sensitive, and is influenced by millers and traders," said Fermin Mizambwa, the chief executive officer of the Agriculture Seed Agency (ASA). ASA, through a joint demonstration with farmers, millers, and traders to identify preferred varieties, learned that yield, aroma, and grain quality are key attributes for the marketability of a variety. This demonstration resulted in millers and traders selecting TXD 306 (Saro 5) for production and branding. "In fact, a miller has a contract with 1,000 rice farmers to produce Saro 5," added Dr. Mizambwa. "Based on our experience, Komboka has all the necessary attributes over Saro 5 for such a business model."

Beyond improved varieties

"In addition to improved varieties, capacity building is a key area for IRRI to contribute," said Mr. Nkori Kibanda, coordinator for the National Rice Research Program-KATRIN. IRRI has provided, on the ground, a scientist with expertise in agronomy and seed systems and a local liaison. To make sure that the potential of the new varieties is fully exploited, IRRI is working closely with the Regional Rice Centre of Excellence (RRCoE) and other local institutions for the development of improved agronomic management practices and good seed systems for high-quality seed production and delivery to farmers. Moreover, Dr. Rosemary Murori, IRRI rice breeder stationed in Kenya, is overseeing the breeding activities.

"We are also looking to support mechanization in Tanzania," said Dr. Joseph Bigirimana, IRRI coordinator in Eastern and Southern Africa.

In Tanzania, crop establishment is mostly through direct seed broadcasting, with some transplanting. Farmers usually experience serious weed problems, which are exacerbated by deficiencies in land preparation and bunding.

"A substantial percentage of the time, investment in rice production in Tanzania was used for weed control," said Mr. Kibanda. "Another aspect that needs attention is farm equipment maintenance because skills are insufficient in this area."

He also pointed out a need for local credit to support purchase and maintenance. "Mechanization will solve problems of labor shortage for land preparation, weeding, and harvesting," he added. "Losses incurred during harvest and postharvest activities will also decrease."

A stronger partnership

"The good relationship between the government of Tanzania and IRRI has been an enabling factor in ongoing research activities in the country," said Dr. Kanyeka. "The two new varieties came into being through the synergistic team effort between IRRI scientists based in Tanzania and the country's National Rice Research Program coordinated at the Agricultural Research Institute-KATRIN."

Dr. Bigirimana concurred. "The development of Komboka and Tai would have never been possible without the significant support from our partners in Tanzania," he said.

IRRI's research sites, at Dakawa in Morogoro and, in the near future, in Kyela for the Southern Highlands and at Ukirigiru for Lake Victoria Zone, will help in the wide-scale diffusion of these new varieties. Within 2015, two more varieties are likely to be released in Tanzania.

The relationship between Tanzania and IRRI is on the right track because "IRRI's activities are all aligned with the national strategy of the country," said Dr. Bigirimana.

For Dr. Ismail, the initial success of the rice sector in Tanzania will be a model for other countries in Eastern and Southern Africa. "As of now, we are focusing our limited resources on Tanzania, Mozambique, and Burundi, and then we'll expand to other countries such as Uganda, Malawi, Kenya, and Madagascar."

"I believe that these aspirations can be a reality," said Dr. Bigirimana. "We have a clear vision for our strategy in Africa, that is, to improve rice production and contribute to improved livelihoods and growth of the rice sector in sub-Saharan Africa through high-yielding, locally adapted varieties as well as efficient sustainable management practices.

"This we will do in joint efforts with the Africa Rice Center, our national partners, and other regional initiatives," Dr. Bigirimana added. "But, of course, we should always ensure that deliverables are market-oriented, socially and gender-sensitive, and environment-friendly."

Ms. Reyes is the managing editor of Rice Today.

RICE FARMER Israel Mwakyange shares his experience on adopting Komboka, an IRRI-bred new variety, with IRRI principal scientist Abdelbagi Ismail.

DR. MATTHEW Morell, IRRI deputy director general for research; and Dr. Rosemary Murori, IRRI rice breeder; visit the IRRI research site near the town of Bagamoyo, Tanzania.

Côte d'Ivoire

An emerging rice powerhouse in West Africa

by **Savitri Mohapatra**

Once a rice exporter, Côte d'Ivoire has spent in recent years nearly USD 500 million annually on rice imports. Now, the country has set its sights on becoming West Africa's rice granary through a program estimated to cost more than USD 1.3 billion from 2012 to 2016.

Often called "the jewel of West Africa" because of its strong economy, Côte d'Ivoire is widely known as the world's top producer of cocoa. Now, the country has launched an ambitious program for agricultural diversification and has set its sights on becoming West Africa's rice granary.

"We want to produce enough rice not only to supply for our own needs but also for the import needs of the subregion," said Yacouba Dembélé, director of the National Office for Rice Development.

The country seems to be making great strides toward achieving this goal. In March 2015, Ivorian Agriculture Minister Mamadou Sangafowa Coulibaly expressed his happiness over the spectacular growth of rice production in the country. "Milled rice production jumped from 550,000 tons in 2011 to 984,000 tons in 2012. It is estimated to have reached 1.3 million tons in 2014."

FAO's *Rice Market Monitor* of April 2015 indicates that rice imports to Côte d'Ivoire dropped in 2014 compared to 2013, thanks to a generally favorable climate combined with state support and special attention paid to the rice sector as part of the country's self-sufficiency drive.

AFRICARICE DIRECTOR General Dr. Harold Roy-Macauley visiting AfricaRice M'bé station in Bouake, Côte d'Ivore. (Photos by R. Raman, AfricaRice)

Importance of rice in Côte d'Ivoire

Rice is a staple food in the diet of most Ivorians, with average annual consumption of 70 kilograms per person. "The current annual consumption of rice is at about 1.7 million tons," said Minayaha Siaka Coulibaly, cabinet director of the Ivorian Agriculture Ministry.

Côte d'Ivoire was once a rice exporter but, with progressive disengagement of the government from the rice sector, it has not been able to meet its own requirements and has been importing huge quantities of rice, spending nearly USD 500 million annually on rice imports in recent years.

As in the food crisis in 2008, this is a risky strategy that led to riots in some African countries. Since then, the Ivorian government has made active efforts to improve domestic rice production and prevent such emergencies in the future.

A national rice development strategy (NRDS) was formulated in 2008 under the Coalition for African Rice Development framework, with technical support from the Africa Rice Center (AfricaRice). To further boost the rice sector, the government revised the NRDS to cover the period 2012-20.

A new vision and strategy for the country's rice development

The vision of the revised NRDS is to meet national consumption requirements through local production of 1.9 million tons of good-quality milled rice by 2016, to increase to 2.1 million tons by 2018. This will help the country build a buffer stock and export surplus production.

The NRDS emphasizes that the country can achieve its goal as it has abundant lands suitable for growing rice, favorable climate with ample rainfall, trained farmers, promising technologies, good market potential, and a favorable economic and institutional environment.

The new strategy focuses on the entire value chain—from seed to production, processing, and marketing. Priorities include development of a seed sector, rehabilitation of irrigation sites, mechanization, support for processing and marketing of local rice, improving the institutional framework along the rice value chain, and an information system to provide business operators with reliable data.

The entire program is estimated to cost more than USD 1.3 billion over four years (2012-16). This is being mobilized through a rice development fund and from development partners and the private sector. The government is also trying to attract international investors to set up joint rice projects in the country.

Partnership with AfricaRice

The government is very keen on the return of AfricaRice headquarters to Côte d'Ivoire. AfricaRice, which the country recognizes as a major partner in the strategy, has been asked to work with the national agricultural research center to provide rice knowledge and technical assistance, especially in making quality seed available to farmers.

"The lack of quality seed is a major bottleneck in realizing our goal," said Minayaha Siaka Coulibaly. "Therefore, we are very happy that AfricaRice will have a strong presence in Côte d'Ivoire and can help us with this aspect."

The partnership between AfricaRice and Côte d'Ivoire dates back to 1988, when AfricaRice headquarters was established in M'bé, some 350 km north of Abidjan. But, because of a political crisis in the country, AfricaRice had to temporarily relocate its headquarters to Cotonou, Benin, in 2005.

With stability returning to Côte d'Ivoire, the AfricaRice Board of Trustees in its March 2015 meeting decided that the center's headquarters will be moved from Cotonou to Abidjan. The Center will also start to re-use its 700-hectare research complex at M'bé, which encompasses all the main rice-growing environments.

"This will help us deliver on and expand the Center's research agenda and realize greater impact on the ground, especially through activities relating to gene discovery, prebreeding, breeding, and agronomy," said Marco Wopereis, deputy director general of AfricaRice.

Already, agronomic studies—including trials on rice-based cropping systems with a focus on conservation agriculture—are being conducted at the M'bé station. This is part of a joint project between AfricaRice and the French agricultural research for development organization (Cirad).

AGRONOMY EXPERIMENTAL field in M'bé.

"These studies will help us develop cropping systems that can provide plant protection with minimum input, reducing both the dependence of African farmers on chemical inputs and the environmental impact of these chemicals," said Olivier Husson, Cirad systems agronomist and agroecologist working with AfricaRice.

For the past few years, the station has been used for the production of foundation rice seed in response to demand from several AfricaRice member countries. Quality seed for rice farmers in Ebola-affected countries is now being produced with support from several donors, notably Japan, the United States Agency for International Development, the World Bank, and the Economic Community of West African States.

"The station has also started offering seed-production courses for national partners," said Amadou Beye, regional representative of AfricaRice for Côte d'Ivoire. "We also have several joint projects in the country, such as the African Development Bank-supported one, Support to agricultural research for development of strategic crops in Africa."

According to AfricaRice Director General Harold Roy-Macauley, with the return of AfricaRice headquarters to Côte d'Ivoire, the country will benefit not only in terms of rice technologies but will also have easy access to training opportunities for strengthening the capacity of the various actors involved in the rice value chain that will contribute to boosting the rice sector.

The Ivorian government has generously offered to AfricaRice a building in Abidjan to house the new headquarters in recognition of the pan-African status of the center. "The government has pledged strong support to AfricaRice, and this is of mutual interest," stated AfricaRice trustee Séraphin Kati-Coulibaly, director general for scientific research and technological innovation of the Ivorian Ministry of Higher Education and Scientific Research.

Thanking the Ivorian government and people, Dr. Roy-Macauley said, "We are equally committed to helping the country achieve its objective of rice self-sufficiency."

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

Maps

A first look at Asia using Sentinel-1A satellite imagery

by **Andrew Nelson, Francesco Holecz, Massimo Barbieri, Luca Gatti, Francesco Collivignarelli,** and **Jeny Raviz**

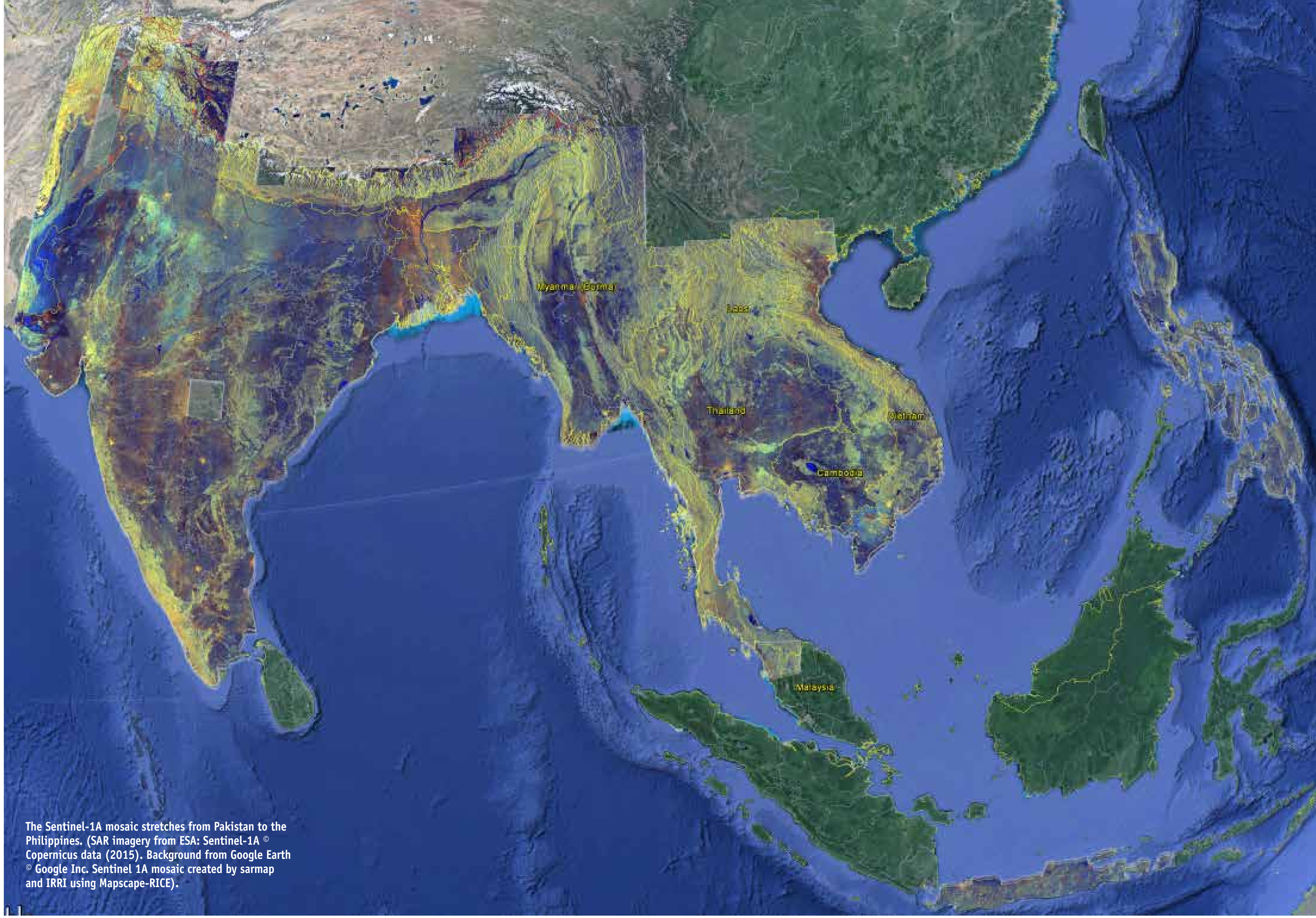
Sentinel-1A, a radar imaging satellite, is an important tool for rice mapping and monitoring. It can provide detailed information on Asia's rice crop, such as planted area, seasonality, cropping intensity, and damaged area due to floods or drought, as well as information on rice crop growth.

The International Rice Research Institute (IRRI) and its partners use remote sensing imagery from satellites to generate information on the rice crop, such as planted area, seasonality, cropping intensity, and damaged area due to floods or drought. Information on crop growth from such imagery can also be used with crop growth simulation models to estimate yield.

In recent years, we have been working with partners across Asia to develop and test methods for mapping rice using Synthetic Aperture Radar (SAR) imagery. SAR is particularly suited for rice crop mapping and monitoring because of the unique temporal signature of lowland rice, which can be extracted from multiple SAR images throughout the season. SAR systems can penetrate through clouds, which is an additional factor in their favor, since most rice in Asia is grown in the cloudy monsoon season that makes remote sensing with optical imagery challenging.

To date, our work has been limited to pilot sites because of both the complexity and cost of obtaining and processing SAR images. However, a long-standing collaboration with sarmap has solved the "complexity" part of the problem through the development of automated processing chains, which can be run locally or hosted on cloud-computing facilities.

The "cost" part also changed recently with the launch of the European Space Agency's (ESA) Sentinel-1A satellite in 2014. Sentinel-1A will become a major source of SAR imagery from 2015 onwards. Sentinel-1A data are freely available and will cover much of the rice-growing areas of Asia, with a spatial resolution of 20 meters. Sentinel-1A will be joined by Sentinel-1B, which is scheduled for launch in 2016 or 2017. The two-satellite system will shorten the potential revisit time to 6 days, thus enhancing the ability to regularly monitor the crop and improving the detection capabilities through the use of interferometric correlation (coherence).



The Sentinel-1A mosaic stretches from Pakistan to the Philippines. (SAR imagery from ESA: Sentinel-1A © Copernicus data (2015). Background from Google Earth © Google Inc. Sentinel 1A mosaic created by sarmap and IRRI using Mapscape-RICE).

To show the potential of the Sentinel program, sarmap and IRRI have generated mosaics composed of many Sentinel-1A images that cover 7 million square kilometers of South and Southeast Asia. The mosaics are composed of images taken in February and March 2015. These cloud-free mosaics show the value of SAR imagery for detailed monitoring of agriculture and natural resources across Asia.

SAR imagery must be interpreted differently from imagery seen in Google Maps and other mapping services. In these mosaics, we have processed the images, in which dark blue represents water or other flat surfaces (such as airport runways), orange and white represent built-up areas and human settlements, light blue represents bare soil, and brown and green show vegetation at different growth stages. The mosaics are a snapshot of Earth's surface, and have not been interpreted for rice mapping purposes.

Sentinel-1A will continue to acquire images over the region, and these images will become increasingly useful as they reveal the progress of the rice crop over time, season after season. The ESA Sentinel program has a big role to play in the future of satellite-based remote sensing for rice crop applications.

Dr. Nelson is geographer in the GIS lab at IRRI. Dr. Holecz is the chief executive officer and geographer of sarmap. Mr. Barbieri, Mr Gatti, and Mr. Collivignarelli are remote sensing specialists for sarmap. Ms. Raviz is assistant scientist in the GIS lab at IRRI.

Rice facts

How long can the rice market defy **EL NIÑO?**

by **Samarendu Mohanty**

The extent of rainfall disruption in El Niño watch countries—India, Indonesia, and the Philippines—could affect the rice market in late 2015 as Thai rice stocks battle to keep the market in check.

The above-normal rainfall during June in India forecast to be one of the hardest-hit countries along with Indonesia and the Philippines, has definitely put the fear of El Niño on the back burner. The global rice market has more or less ignored these predictions in the past few months because of surplus rice in Thailand and other key exporters. Last year's forecast miss of a probable El Niño has also been playing in the minds of many in the rice market.

The kharif (monsoon) planting in India has been surging ahead on the back of good pre-monsoon rainfall in April and May and 16% above-normal monsoon rain in June. As of 3 July 2015, the planting of all field crops has been ahead of schedule, except that of paddy because monsoon arrived late in Bihar and Uttar Pradesh. July and August are still key months in terms of paddy transplanting in the majority of rainfed regions of Eastern and Central India. There have already been indications of patchy rainfall in the past 10 days (last week of June and first week of July) in many parts of India. The Indian Meteorological Department now forecasts 8–10% deficit rainfall in July and August. If the deficit occurs in the irrigated belt of Northwest India, then the impact will be minimal. However, deficit rainfall in Eastern and Central India could have an adverse impact on the size of the rice crop.

Unlike in India, El Niño-induced drought in other Asian countries has already affected the rice crop. Thai authorities recently lowered the estimate of the 2015 main paddy crop by around 2.5 million tons (10%). Similarly, in the Philippines, below-average rainfall in the past 2 months may have delayed planting and reduced sowing of the just-completed main rice crop for the rainfed region (FAO GIEWS country brief for the Philippines, 15 June 2015). The rainfall in the next few weeks will be critical in determining the size of the rice crop in the Philippines. In Indonesia, the main rice crop season, which is 95% of the annual production, starts in November and planting continues until January. The possibility of El Niño in those months will be critical for the 2016 main rice crop in Indonesia.

Where is the market headed?

So far, the market has been quite indifferent to the possibility of a strong El Niño. Rice prices continue to remain weak on the back of surplus Thai and Indian rice in the market. In the past 4 months, the Thai 25% broken price has declined by nearly 10% from USD 400/ton in March to USD 365/ton in June (Fig. 1). Close to 100 million tons of global rice stocks, incuding 9 million tons of Thai stocks, have been supporting the market by acting as a buffer against any irrational market sentiment and speculation.

But, the market sentiment can change quickly as we pass through the planting season and crop growth stages of the main crop in many rice-growing countries. Although the current global stock is 25 million tons higher than what it was during the 2007-08 rice price spike, in terms of its share as total use (stock-to-use ratio), the current level of nearly 18.8% is more or less the same as what it was during the 2007-08 rice price spike (Fig. 2). The ratio has steadily declined in the last few years, from 23.7% in 2011-12 to 18.8% now.

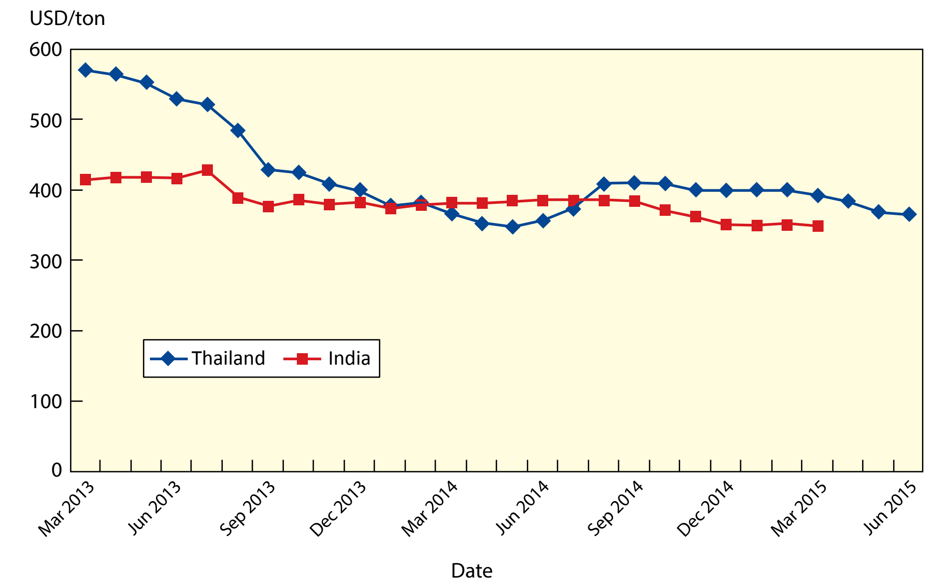


Fig. 1. Price for 25% Broken (March 2013-June 2015).
Source: Pink Sheet, World Bank and FAO Rice Market Monitor.

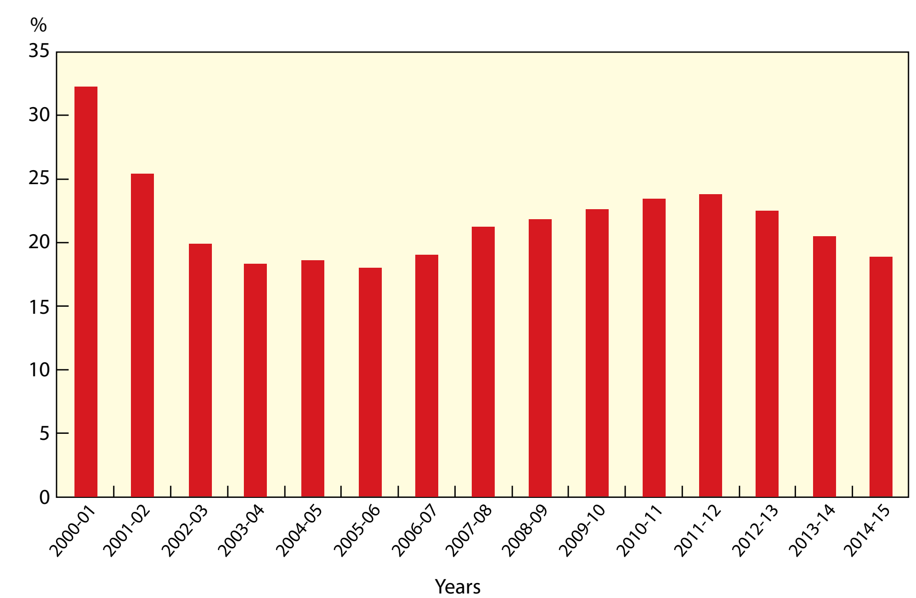


Fig. 2. Global rice stock-to-use ratio.
Data source: PSD Online Database, USDA (Accessed on 5 July 2015).

India's monsoon situation in the next couple of months will be key in influencing market sentiment. Its influence on the rice market has never been more than what it is now, with 7 million tons of nonbasmati exports and 3–4 million tons of basmati exports. India's basmati exports will not come under the radar in case of a drought. However, nonbasmati exports will certainly be the target of policymakers to ensure domestic food security. Indian public-sector rice procurement stocks through the Food Corporation of India (FCI) and state agencies are much higher than the strategic stock requirement, but the current procurement stock is much lower than what it was during the same time last year. Based on the data available on the FCI website, total rice stocks as of 1 June 2015 stood at 22.6 million tons of rice vis-à-vis 28.6 million tons at the same time last year and 34.7 million tons the year before.

Apart from India, the rainfall during November-December, the planting season of Indonesia's main crop (95% of total annual production), could play a critical role in influencing the market. By that time, the size of the Indian rice crop will be a lot more certain. A poor Indian crop, plus drought in Indonesia by the end of 2015, could rattle the market.

At this point, the market is poised to remain rational and driven by market fundamentals as long as exporting countries remain open for business and refrain from making unilateral decisions to restrict rice trade flows and importing countries refrain from panic buying for domestic stockpiles. The major worry for the market is the countries in the El Niño watch, which include the second-largest exporter, India, and three large importers: Indonesia, Malaysia, and the Philippines. If these countries are affected by drought in the coming season, this could spell trouble for the market. On the one hand, India will be pulling out of the nonbasmati market to meet the local shortfall and, on the other hand, demand from importing countries will be rising. If this happens, the 9 million tons of Thai rice stocks could come in very handy in keeping the market in check and ensuring that importers not resort to panic buying.

Dr. Mohanty is the head of the Social Sciences Division and program leader (Targetting and policy) at the International Rice Research Institute.

High science and smart policies will alleviate hunger and poverty

by Robert S. Zeigler

Science-based improvements in agricultural technology have contributed significantly—across two Green Revolutions—to alleviating hunger and poverty in most of Asia. For example, the first Green Revolution that started in the 1960s—what I call GR1.0—converted India from a basket case to a breadbasket. The science of GR1.0 basically built a high-yielding semidwarf rice and wheat plant architecture adapted to low-stress environments, which benefited mostly farmers in favorable irrigated areas.

The science of the second Green Revolution (GR2.0) has gone one better on GR1.0 by "leaving no farmer behind," especially those poor rice farmers growing their crop in marginal environments (see *Green Revolutions 2.0 & 3.0: No farmer left behind* on pages 32-35 of *Rice Today*, Vol. 14, No. 2). I maintain that GR2.0 in rice started in 2008, when farmers began adopting one of this revolution's first new technologies, flood-tolerant rice, which can withstand total submergence for more than 2 weeks! Since then, these Sub1 varieties (such as Swarna-Sub1 in the photo)—the gene discovered and deployed by IRRI and partner scientists that enables the plant to survive complete submergence is named *SUB1*—have spread like wildfire in eastern India and in other regions where flooding is a perennial problem.

The Sub1 technology can be attributed primarily to high-level and top-quality science—science conducted in some of the finest laboratories in the world and published in top scientific journals (such as *Nature*)—to solve the problems farmers face in their fields. One scientific study[1] reported that India's scheduled castes—among the nation's most underprivileged—are likely to be a major beneficiary of the spread of the flood-tolerant rice varieties. If this is not a scientific revolution helping to transform society, I don't know what is.

Photos by IRRI

I also envision that, sometime around 2030, a third Green Revolution (GR3.0) will commence when farmers start planting yield-plateau-busting C_4 rice (see *Mapping the crop of the future* on pages 22-23 of *Rice Today*, Vol. 12, No. 4) and nitrogen-fixing rice. These varieties will be extraordinarily environmentally friendly as, to produce higher yield, they will need only half the amount of water and nitrogen that is currently used. By this time, as well, consumers should have been benefiting for years from more nutritious rice with higher quality, fortified with iron, zinc, and pro-vitamin A, in the marketplace. However, I fear that this vision could be delayed or thwarted altogether.

The anti-science, anti-technology, and anti-GMO movements, which are hindering the use of transgenic crops, such as *Bt* brinjal (eggplant) in India and pro-vitamin A-fortified Golden Rice in a number of Asian countries, are having a chilling effect on our students. Some brilliant students are wondering whether they should devote any time at all to studying agriculture and biology. Maybe it is not worth the effort if they are unable to fully apply their ingenuity to the tools that they learned in school. This is indeed troubling because the future of agricultural science, in general, and rice science, specifically, is at stake if we cannot nurture the next crop of vibrant, intelligent, and caring young scientists. We want these people to be attracted to agriculture and to work on something that contributes to food security, sustainability, and improving our environment.

In addition to giving students second thoughts about what to study, the anti-GMO movement is obstructing the delivery of much-needed products. For example, India is home to the world's largest population of vitamin A-deficient people, most of whom are children and pregnant women, many of whom are dying or going blind without the vitamin in their diet. So, it is an incredible act of negligence to keep Golden Rice from a needy and deserving population just because the anti-science clique doesn't like it. I was shaken to the core about 2 years ago when opponents in the Philippines—where approval to distribute Golden Rice seeds to farmers has been led by the Philippine Rice Research Institute and monitored by Philippine regulatory bodies—ripped up experimental plots of the crop. What were they trying to accomplish? I suspect that they willfully destroyed the very experiments that would have proven that Golden Rice was a safe and effective food!

India, Bangladesh, Nepal, and IRRI sign a revolutionary agreement to fast-track germplasm exchange across the three countries.

It is disappointing that the approval of *Bt* brinjal has been delayed in India. When one considers the large amount of pesticides applied to brinjal in the country, the release of the *Bt* version of the crop would bring tremendous environmental benefits by greatly reducing excessive and broadly toxic pesticide applications that indiscriminately kill organisms and harm the environment. However, anti-GMO activists again continue to block release because they think GM is evil in and of itself. They try to balance hypothetical, even fantastical, risks of a technology against known, demonstrated, and massive positive benefits. And, they confound arguments around science and technologies with selected multinationals they choose to demonize.

Although still on hold in India, *Bt* brinjal has been released in Bangladesh. Interestingly, Bangladesh approved *Bt* brinjal based on the data generated in India, which illustrates a concept that I would like to promote further. Many countries already have rigorous approval processes for genetically engineered products, crops, and food, among other things. Countries in South Asia, for example, could mutually recognize those approval processes as much as they recognize the food standards in the *Codex Alimentarius*[2] rather than insisting that each test be repeated locally. This would be a responsible way to accelerate the adoption of high science and biotechnology—including crop varieties.

Bangladesh's release of *Bt* brinjal is one excellent example. Perhaps an even better proof of concept is when, in October 2014, the secretaries of agriculture of India, Bangladesh, and Nepal and I, representing IRRI, signed an agreement to fast-track the release of any rice variety undergoing proper evaluation protocols in any one of their countries (see *Regional cooperation speeds up the release of rice varieties* on pages 14-15 of *Rice Today*, Vol. 14, No. 2). Acting rapidly on this revolutionary and courageous agreement, India has already directly released four rice varieties from Bangladesh and two from Nepal for Indian farmers growing rice in similar agroecosystems. This historic agreement will not only fast-track varietal releases but will also bring huge savings of time and resources to the three countries.

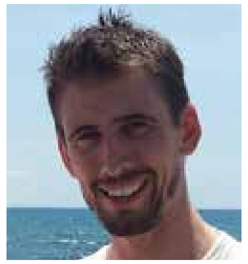
Just think of what could be achieved if other countries decided to go the same way and put into place, as a matter of routine, accepting a neighbor's already thorough approval processes and protocols as one of the pillars of their own policies and regulatory frameworks—and then truly act on it! We really don't have time to keep re-inventing the wheel. The world's poor are depending on us, scientists and policymakers alike, to work together to get the results of high science to those who can use them—rapidly and efficiently. If we don't, shame on us!

And, at the same time, GMO opponents and anti-technology lobbyists need to change their ways and learn to embrace science, not fear it!

Dr. Zeigler is director general of the International Rice Research Institute. Excerpted from an op-ed article that appeared in The Economic Times, *India.*

[1] www.ncbi.nlm.nih.gov/pmc/articles/PMC3837307/

[2] A collection of internationally recognized standards, codes of practice, guidelines, and other recommendations relating to foods, food production, and food safety.



What are the sustainability implications of closing rice yield gaps?

BY ALEXANDER M. STUART

With increasing human population and decreasing agricultural land area, there is worldwide pressure to increase food production in remaining agricultural land. Agricultural intensification, however, is associated with a number of environmental threats, including climate change, a degrading natural environment, and biodiversity loss. Thus, the challenge for global rice cultivation is to meet future food demands sustainably while reducing the environmental footprint.

One key strategy to meet future food production is to close "yield gaps." A yield gap is defined by the Global Yield Gap Atlas (www.yieldgap.org) as the difference between "potential yield" and "actual yield." "Actual yield" is the mean yield achieved by farmers in a given region under dominant management practices while "potential yield" is the yield of the crop cultivar when grown with nonlimiting water and nutrients and biotic stress effectively controlled. Yield gaps can be measured using a variety of methods including crop growth simulation models, field experiments in which yield constraints are eliminated, and by the yield taken from the upper 10 percentile ("best farmers' yield").

The first two methods attempt to measure the maximum potential yield in a perfect growing environment with no constraints aside from climatic constraints, whereas "best farmers' yield" is related to the best available and affordable technologies to the farmers at a given time.

Yield gap analysis is increasingly being used to identify the potential to increase food supply within a given area, as well as to understand important yield constraints. However, yield gaps should be interpreted with caution. To begin with, we need to understand the limitations and caveats associated with the various methods of analysis. We also need to consider the environmental, economic, and social consequences of closing yield gaps.

For example, a study by Witt et al. (1999) published in *Field Crops Research* demonstrated that the most efficient use of nutrients would only produce rice yields at 70–80% of the maximum potential yield, after which the yield response to additional nutrient inputs diminishes. To gain the additional 20% in yield to close the gap, a disproportionate 70–90% increase in nutrient inputs are required—and that is in a perfect growing environment that rarely exists on a large scale. Such unsustainable use of resources to reach maximum potential yields would reduce profits as well as increase greenhouse gas emissions and pollution of waterways. This would be further exacerbated in cases where nutrient inputs are applied in excess of the plants uptake.

To address this issue, an "attainable (or exploitable) potential yield" set at 80% of maximum potential yield has been defined. This is certainly a step in the right direction towards identifying sustainable yield targets in underperforming areas. But there is still a need to identify whether the management practices applied to meet these targets are sustainable, especially in areas where attainable yields are already being achieved. For example, in China and Vietnam, overuse of fertilizers and other inputs in rice cultivation recently resulted in the introduction of national best management approaches (Three Controls Technology and One Must Do Five Reductions, respectively) that aim to reduce input use. These strategies led to reductions in fertilizer inputs and a simultaneous increase in yields through reduction in lodging and pest and disease outbreaks, realizing benefits for both the farmer and the environment.

To identify yield targets that are sustainable under current and future growing conditions, scientists from the Closing rice yield gaps in Asia with reduced environmental footprints (CORIGAP) project are working closely with rice farmers through household surveys, farmers' diaries, and on-farm farmer participatory research. Differences in field characteristics, agronomic and postharvest practices, and socioeconomic issues between "best" yielding farmers and mean yielding farmers over time are being investigated to identify yield constraints, and whether yields achieved by the "best" farmers are indeed sustainable.

To conclude, we should only aim to close yield gaps in rice cultivation to levels that are sustainable, using best management practices such as optimizing nutrient and water use and minimizing other inputs that harm the environment and human health. This is expected to be most profitable to the farmer as well as address issues relating to food security and environmental health.

Dr. Stuart is a postdoctoral fellow who is involved in adaptive research on natural resource management of rice in the Crop and Environmental Sciences Division at IRRI.

What's cooking? by **Eugenia Manful**

Ghanaian Jollof rice

Jollof rice is a popular dish generally served on special occasions in many West African countries, especially in Ghana and Nigeria. It is a favorite meal of children in particular, and is often the main dish on the menu of children's parties. Jollof rice has several variations, but the common ingredients are rice, tomatoes, and meat. One can use chicken, beef, ham, sausage, shrimp, fish, or pork, and vegetables such as beans, carrots, mushrooms, and bell peppers.

Jollof rice dish, as prepared in Ghana, has lots of vegetables as well as meat, according to Dr. John Manful, grain quality scientist at Africa Rice Center, making it a complete meal in itself.

The dish requires about 15 minutes of preparation and an hour and half of cooking time.

Ingredients

- 1 kg boneless beef, cut into small pieces
- 1 kg nonsticky rice
- 5 cups of water or stock
- 200 grams tomato paste
- 10 green beans, cut into pieces 5 cm long
- 6 large fresh tomatoes, chopped or blended
- 4 carrots, peeled and chopped
- 2 onions, chopped
- 1 large bell pepper, cut into pieces
- 6 tablespoons cooking oil
- 1 tablespoon garlic-chili paste
- salt to taste
- spices (optional)

Preparation

- Heat the oil in a large pot.
- Add the beef and fry until brown on all sides.
- Remove the beef and set aside.
- Add the onions to the pot and sauté for 2 minutes.
- Add the garlic-chili paste and sauté for 1 to 2 minutes.
- Add the tomato paste and fresh tomatoes.
- Cook for 5 to 7 minutes.
- Pour water or stock and add the fried beef, rice, and spices (optional).
- Add salt to taste.
- Cook for 10 minutes on low heat.
- Add vegetables and cook for another 10 minutes.
- Stir from time to time until rice is cooked.
- Serve with cooked vegetables, grilled chicken, or fried fish, tomato, or pepper sauce.

This serves 4–5 people.

Bon appétit!

Mrs. Manful is a Ghanaian national. She lives with her family in Tema, a town which is located 25 km east of the national capital, Accra, and works as chief revenue officer under the Ghana Revenue Authority. She likes cooking traditional dishes from Ghana.

Watch Ms. Manful demonstrate how to prepare this delicious dish in a 7-minute video on YouTube at https://youtu.be/hqjQBRiLnhU.

Creating the Future
SATAKE

The changing market in Myanmar

Traditionally rice was a crop consumed locally in the country of production. However, in the last 20 years this trend has been changing rapidly. Exports of rice have doubled, reaching over 40 million tons in 2012. Among the already well-known exporters of rice (such as Thailand, India, and Vietnam) Myanmar has also shown a tremendous growth with exports of 800,000 tons in the year 2010 rising to 1,200,000 tons by the year 2014.

Under such a trend, the rice mills in Myanmar are rapidly transforming themselves to highly efficient, more modern production facilities. One such state of the art rice mill adopting the latest technologies from Satake has been completed in Naypyidaw, the capital of Myanmar. This was the first private rice mill to adopt the modern rice milling system in the region but many are set to follow. The rice mill includes complete processing lines from pre-cleaning, paddy husking, milling, fine grading, sorting and packing. Color sorters employed are of the latest model manufactured in Japan. The laboratory room is also equipped with a full set of laboratory equipment to control the product quality.

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