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Nourishing a nation

In search of a perfect grain
Catching up in southwestern Bangladesh
Game changers in the global rice market
Decoding patterns of climate change and rice diseases

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About the cover. Like most Asian countries, the Philippines basically runs on "rice energy." It is the one food that Filipinos cannot do without. But what is rice's health quotient? Can it be part of a healthy diet? What about its glycemic index or recent reports of traces of heavy metals found in rice? These are some of the questions asked by consumers and nutritionists alike. Because of its importance to billions of people, scientists are working so that rice will remain a healthy, delicious and satisfying meal with more nutrients. (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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International Rice Research Institute
DAPO Box 7777, Metro Manila, Philippines
Web: www.irri.org/ricetoday

Rice Today editorial
telephone: (+63-2) 580-5600 or (+63-2) 844-3351 to 53, ext 2725;
fax: (+63-2) 580-5699 or (+63-2) 845-0606; email: l.reyes@irri.org, info_ricetoday@irri.org

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Rice nutrition and quality: getting to the truth

July is National Nutrition Month every year in the Philippines. This year's theme is *Together we can end hunger and malnutrition*. To help kick off this important event, *Rice Today* is featuring rice nutrition and quality, not just where it pertains to the Philippines but to the rest of the rice-eating world as well. The importance of rice in relation to improving human health cannot be overemphasized as more than three billion people in the world eat rice every day.

When we talk about the merits of rice with those who are diet conscious, chances are the arguments will be split between those who think rice is healthy and those who advise keeping rice dishes at bay. But, what's the truth? Our cover story on rice and nutrition, beginning on page 11, sheds light on how rice can be part of a healthy diet.

Recent media reports about arsenic and lead contamination of rice also have some consumers asking, "Is it still safe to eat rice?" Dr. Sarah Beebout, soil chemist at the International Rice Research Institute (IRRI), answers the question with a clear and succinct *Yes* in her *Grain of truth* contribution, *Rice, health, and toxic metals.*

Speaking of rice consumers, a story, *In search of a perfect grain*, looks into how IRRI scientists are studying the traits of rice grains to produce a higher-quality product more acceptable to consumers. They are contributing their expertise to ensure consumers get the type of rice they enjoy eating and help farmers benefit from the increased commercial value of high-quality rice varieties.

ISAGANI SERRANO

On other topical fronts, rice farmers in Bangladesh's southwestern coastal region are still struggling to catch up with the productivity of the rest of the country. Thankfully, they are getting some much needed help to tackle water and salinity problems and optimize crop and fish production. (See *Catching up in southwestern Bangladesh*.)

The Africa Rice Center (AfricaRice) is carrying out a 3-year project to determine what diseases of rice exist, where and when they occur, and if climate change has any effects on their severity. Eventually, this project will develop rice varieties that are resistant to strains of blast and bacterial leaf blight, and concomitant management practices. (See *Decoding patterns of climate change and rice diseases*.)

What happens when a diverse array of rice scientists steps into a field to actually grow a crop of rice? Twenty IRRI staff members took on the challenge—a first for many of them—to compete for the highest yield and profit from a rice crop that they grew themselves, start to finish! Read some interesting anecdotes and lessons learned in *Rice Survivor: IRRI's own reality show.*

Our map feature, *A year in the life of rice,* zooms in on how major rice-growing areas change during the wet and dry season on the island of Luzon, Philippines—an interesting and revealing 12-month cycle.

In his *Rice facts* column, Sam Mohanty points out that India and China are forces to reckon with and could be real *Game changers in the global market*. He says that, if the current trend continues, India will likely become the world's top rice exporter and China the top importer by the end of 2013.

As food for thought, a Liberian rice fable, *Give me some more,* tells how rice mythically saved the Vai people, and how *kolo,* their word for rice, came to be.

Also, read the story behind the story in *Rice Today and Uruguay's President*. This is a great follow-up on President José Mujica getting hold of a *Rice Today* article, *Uruguay: a small country, big in rice* (pages 21-23 in *Rice Today*, Vol. 12, No.2), which had been translated into Spanish, and reading it, from start to finish, during one of his national radio addresses.

And finally, visualize a world 50 years from now in which rice farmers are no longer poor and hungry. *Fields of plenty* transports you to an imaginary, but very possible farming household in 2063. Here, an Indian lady farmer is running a profitable and environmentally friendly rice farm, thanks to new tools and technology that emanated from research being done by IRRI and its partners in 2013.

We'd love to hear from you on our choice of stories in this and other recent issues. Happy reading!

Lanie Reyes
Rice Today managing editor

News

Africa gets rice varieties with higher yields

ARICA, a new generation of high-performing rice varieties.

R RAMAN, AFRICARICE

A new generation of high-performing rice varieties, branded as ARICA (Advanced Rice Varieties for Africa), has been launched by the Africa Rice Breeding Task Force. Five ARICA varieties (three lowland varieties and two upland varieties) outyielded the most popular check varieties in the trials. The three lowland varieties have a yield advantage of 30–50% over NERICA-L19 while the two upland varieties can yield 15% more than NERICA 4.

"Unlike the NERICA varieties, the ARICAs are not restricted to interspecific crosses,"said Dr. Marco Wopereis, deputy director general at the Africa Rice Center (AfricaRice). "Any line that shows promise, regardless of its origin can become an ARICA variety as long as the data that are collected are convincing."

"The ARICA varieties offer promising opportunities to Africa's rice sector and can make a difference to the lives of Africa's rice farmers, who do not have access to new varieties that are better adapted to their growing environment and likely to sell well," said Dr. Papa Seck, AfricaRice director general.

The Breeding Task Force, which was set up in 2010, comprises international and national rice breeders from 30 African countries and operates as part of the Japan-funded project, *Developing the Next Generation of New Rice Varieties for Sub-Saharan Africa and Southeast Asia*.

It has adopted a systematic and multi-environment testing approach to increase its efficiency and efficacy. In addition to rice breeders, farmers, members of national variety release committees and other stakeholders participate in the evaluation. The breeding lines that enter the Task Force are provided by many institutes that are part of the Global Rice Science Partnership, which is the CGIAR Research Program on Rice.

"This will contribute to faster, better documented and better targeted releases of new climate-resilient and stress-tolerant rice varieties for major production systems in Africa," said Moussa Sié, Africa Rice Breeding Task Force coordinator. Dr. Sié is a senior rice breeder who developed the lowland NERICAs for which he received the Japan International Koshihikari Rice Prize in 2006.

He added that the Task Force helps strengthen breeding capacity and ensures that national breeders can use the materials from the Task Force not just to evaluate, but also to develop or improve their own varieties to get a better fit with their consumers' preferences and ecologies.

Rice varieties released in Tanzania

Tanzanian farmers can now boost rice production by adopting two IRRI-bred high-yielding rice varieties, Komboka (IR05N 221; photo below) and Tai (IR03A 262). The new varieties are highly preferred by farmers for their long, slender, and translucent grains and soft texture for cooking. Both varieties can be grown twice a year.

IRRI

Super salt-tolerant rice bred

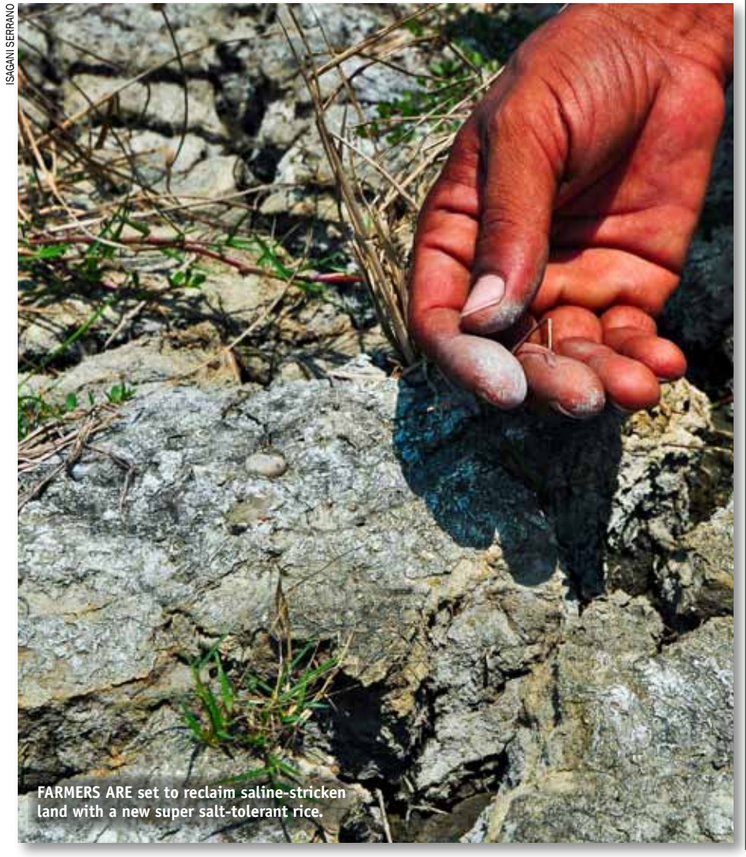
Farmers are set to reclaim salt-ravaged land—thanks to a single rice plant born of two unlikely parents that is spawning a new generation of rice that has double the salinity tolerance of other rice.

"This will make saline-stricken rice farms in coastal areas usable to farmers," said Kshirod Jena of the International Rice Research Institute (IRRI). "These farmlands are usually abandoned by coastal farmers because the encroaching seawater has rendered the soil useless. That means livelihood lost for these communities."

The new rice was bred by successfully crossing two different rice parents—the exotic wild rice species *Oryza coarctata* and rice variety IR56 of the cultivated rice species *O. sativa*. What is extra special about this breakthrough is that *O. coarctata* is extremely difficult to cross with cultivated rice varieties. The first sign of good news came when, out of 34,000 crosses made, three embryos were successfully "rescued." Of these three, only one embryo germinated to produce a single plant.

Dr. Jena's team is still perfecting their new doubly salt-tolerant rice and will test it widely to ensure it meets the needs of farmers and consumers. They hope to have the new variety available for farmers to grow within 4–5 years.

ISAGANI SERRANO



FARMERS ARE set to reclaim saline-stricken land with a new super salt-tolerant rice.

Climate change research hub opens in Vietnam

A new reseach hub of the CGIAR Research Program on Climate Change, Agriculture, and Food Security has opened in Vietnam. The goal is to develop technologies that reduce the impact of climate change on food production in Vietnam and the rest of Southeast Asia. It will support the work of many research and development partners in helping farmers face climate change.

Scholarship for rice scientists

A US$3 million donation has established the Lee Foundation Rice Scholarship Program to educate and train a new generation of rice scientists in Asia. The scholars will work on four strategic themes at IRRI: gene discovery and bioinformatics, modern rice breeding, future rice systems to ensure food security, and economics and policy.

Chinese rice terraces now a World Heritage site

The cultural landscape of the Honghe Hani Rice Terraces in China has been listed as a UNESCO World Heritage Site. Covering 16,603 hectares in southern Yunnan, the area is marked by spectacular rice terraces. The land management system was described by UNESCO as a demonstration of "extraordinary harmony between people and their environment."

Source: http://whc.unesco.org

Rice research investment delivers sixfold return

A US$12 million investment in rice research has returned more than $70 million in benefits to rice farmers and national economies in Bangladesh, Indonesia, Vietnam, and the Philippines, according to a new report.

Meta-Impact Assessment of the Irrigated Rice Research Consortium (IRRC) evaluated a selection of technologies rolled out by the International Rice Research Institute (IRRI) through the IRRC. It aimed to determine whether the technologies delivered benefits such as increased productivity for rice farmers, improved livelihoods and food security, and bolstered social cohesion.

The report shows a sixfold return on the investments made by the Swiss Agency for Development and Cooperation (SDC) over 16 years. This is likely a conservative return estimate since only a subset of the farming technologies funded was assessed. Moreover, by 2016, the return on investment could skyrocket to 25 times the original investment.

The report shows a sixfold return on the investments made by the Swiss Agency for Development and Cooperation (SDC) over 16 years.

"We greatly appreciate the evidence of impact provided in this report," said Carmen Thoennissen, senior SDC advisor. "It substantiates the effectiveness of SDC's focus and IRRI's work on natural resource and crop management research, its 'global public good nature,' and will definitely guide SDC's future investment on system productivity enhancement to sustainably close yield gaps."

Dr. Grant Singleton, an IRRI senior scientist and IRRC coordinator, says "We're immensely grateful to the SDC. Without their support, all of those positive impacts would not have taken place. Through them, IRRC was able to help countries identify their rice research needs or extension priorities, and then IRRC made sure to help them achieve those."

Find a copy of the report at http://sn.im/irrc-impact.

DONNA CASIMERO

WHEN FARMERS adopted alternate wetting and drying system of irrigation, they reduced their water use by up to 30% without compromising yield.

Rice blast invasion tactics revealed

An international team of researchers has shed light on how *Magnaporthe oryzae*, a rice blast fungus, invades plant tissues. The finding is a step toward learning how to control the disease, which destroys enough rice to feed 60 million people each year.

The team, led by Barbara Valent, a plant pathology professor at Kansas State University, found that the fungus has evolved two distinct secretion systems that facilitate its invasion into rice plants.

Prof. Valent said that knowing these secretion systems is significant, because it means we can block them without harming other fungi that are critical for healthy ecosystems.

In addition to researchers from Kansas State University, the team includes Professor Nicholas Talbot, from the University of Exeter in the United Kingdom, and his students, as well as scientists from the Iwate Biotechnology Research Center in Japan.

Source: http://www.ksre.ksu.edu

A new opportunity for training the next generation of rice scientists

The Lee Foundation Rice Scholarship Program is offering scholarship grants to students pursuing their PhD.

Research areas
- Gene discovery and bioinformatics
- Modern rice breeding
- Future rice systems to ensure food security
- Economics and policy

Types of scholarship
- 3-4 years for a full PhD program
- Up to 3 years for a PhD Sandwich degree program

Scholarship benefits
- Round-trip airfare and related travel expenses
- Monthly stipend with local medical and accident insurance
- Research support
- Leadership and professional development funds
- University fees (with an upper limit)

Eligibility requirements
- South or Southeast Asian national
- Engagement in the field of rice science and related systems research
- Willingness to work on any of the identified PhD research area
- Great potential for scientific achievement
- About to enroll in a PhD program or have gained admission to an approved course in a designated institution or have completed all PhD coursework requirements
- Endorsement from university supervisor
- Adequate proficiency in English
- Not more than 35 years old at the time of application

A portion of these fellowships would provide opportunities to enroll at the Department of Crop Sciences, University of Illinois at Urbana-Champaign (cropsci.illinois.edu and plantbreeding.illinois.edu).

Potential applicants may seek co-funding for their study fees from different sources, which may provide more flexibility in their choice of university.

The Lee Foundation Rice Scholarship Program aims to educate and train a new generation of young rice scientists and researchers to help feed Asia. This exciting new program offers young South and Southeast Asians a unique opportunity to gain excellent education from reputable academic institutions. It is anticipated that they will be part of a new science leadership in the region and build key partnerships for over 20-25 years.

For more information, please visit

www.training.irri.org

email: irritraining@irri.org

Deadline for applications
15 August 2013

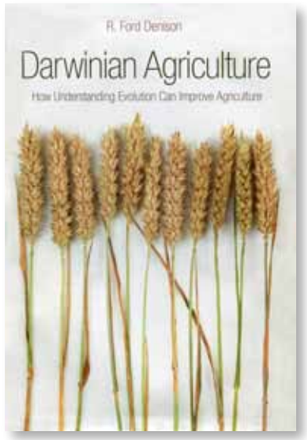
IRRI

Books

Darwinian Agriculture: How Understanding Evolution Can Improve Agriculture

By R. Ford Denison

Published by Princeton University Press, New Jersey, USA. 248 pages.



As human populations grow and resources are depleted, agriculture will need to use land, water, and other resources more efficiently and without sacrificing long-term sustainability. *Darwinian Agriculture* presents an entirely new approach to these challenges, one that draws on the principles of evolution and natural selection.

R. Ford Denison shows how both biotechnology and traditional plant breeding can use Darwinian insights to identify promising routes for crop genetic improvement and avoid costly dead ends. Prof. Denison explains why plant traits that have been genetically optimized by individual selection—such as photosynthesis and drought tolerance—are bad candidates for genetic improvement. Traits like plant height and leaf angle, which determine the collective performance of plant communities, offer more room for improvement. Agriculturalists can also benefit from more sophisticated comparisons among natural communities and from the study of wild species in the landscapes where they evolved.

Darwinian Agriculture reveals why it is sometimes better to slow or even reverse evolutionary trends when they are inconsistent with our present goals, and how we can glean new ideas from natural selection's marvelous innovations in wild species. ■

In March 2013, Prof. Denison gave a series of lectures, based on this book, at the International Rice Research Institute. To watch the complete lecture series, go to http://sn.im/darwinian-agriculture.

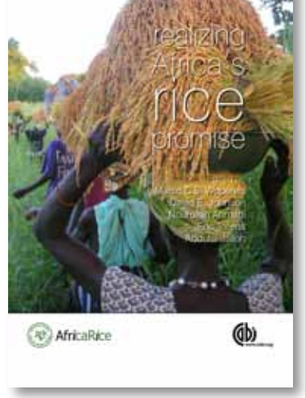
For more information on how to order the book, visit http://press.princeton.edu/titles/9777.html.

Coming soon…

Realizing Africa's Rice Promise

Edited by M. Wopereis, D. Johnson, N. Ahmadi, E. Tollens, and A. Jalloh

Published jointly by the Africa Rice Center and CABI. 512 pages.



Rice is a strategic and political crop in many African countries. The hikes in rice prices since 2007 have shown the vulnerability of many African countries that depend on the world market for rice imports and the need to boost Africa's domestic production. The purpose of this book is to provide a comprehensive overview of Africa's rice sector and ongoing rice research and development activities, and indicate priorities for action on how to realize Africa's rice promise, that is, the notion that Africa has sufficient land and water resources to produce enough rice to feed its own population and, in the long term, generate export revenues.

The critical challenge facing the African rice sector is to enhance performance in production, processing, and marketing to respond to a major concern that needs to be turned into an opportunity: the growing demand for rice as a preferred staple. *Realizing Africa's Rice Promise* discusses challenges and opportunities related to (i) sustainably increasing rice production and rice productivity; (ii) enhancing rice quality and marketing; (iii) promoting conducive policies for small-holder and agribusiness development; and (iv) strengthening impact-oriented rice research, extension, and knowledge management.

The analyses and case studies presented in this book will be a valuable resource for researchers, development agents from public and private sector, rice value chain actors, and policymakers concerned with *Realizing Africa's Rice Promise.* ■

For more information, visit http://bookshop.cabi.org/?page=2633&pid=2377&site=191.

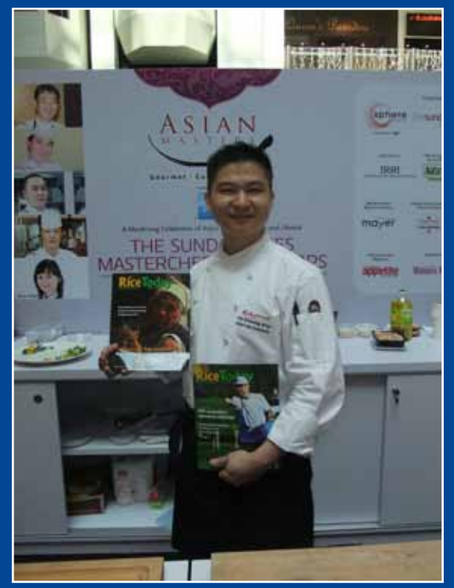
TRAINING COURSES AT IRRI

Course title	Date	Venue
Rice: Research to Production	20 May-7June	IRRI, Philippines
Training Workshop on Rice Technology Transfer Systems in Asia	10-21 June	Rural Development Administration, South Korea
Season-long Rice Farming Training	17 June-18 October	PhilRice and IRRI, Philippines
Rice Production Course for Iran	24 June-5 July	Regional Research and Training Center for West Central Asia, Iran
Phenotyping for Abiotic Stresses	1-12 July	IRRI, Philippines
Rice Production Techniques for Research Technicians	12-30 August	IRRI, Philippines

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.

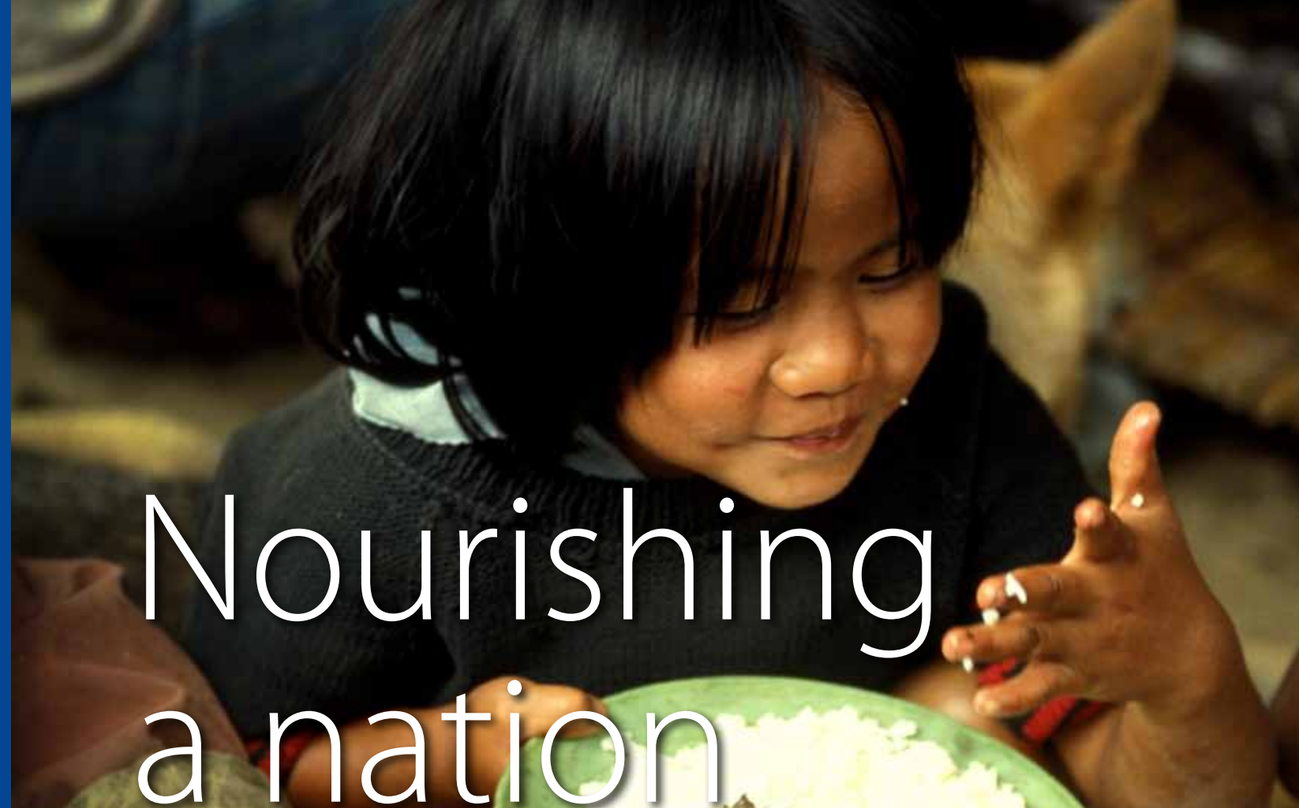
Rice Today around the world

RELAXING IN Reno. Ara and André, daughters of IRRI Assistant Manager Gigi Caballero, enjoy the great outdoors—with *Rice Today*—away from the flashing screens, shuffling cards, and ringing bells of Reno's famous casinos. ◀



HAIL TO the chef! As chef de cuisine at Resorts World Sentosa in Singapore, Yip Chueng Shui uses his skills to please the palate of guests from all over the world. Despite his busy schedule, chef Yip found time to savor *Rice Today*. ▶

FUTURE INVESTMENTS. IRRI and Landbank, a financial institution of the Philippine government, recently launched a scholarship program for the next generation of rice scientists. In photo: (*second from left*) Land Bank President and CEO Gilda Pico, IRRI Deputy Director General for Communication and Partnerships V. Bruce J. Tolentino (*third from left*), Landbank senior representatives, and IRRI staff.



Nourishing a nation

by **Alaric Francis Santiaguel**

More than an agricultural commodity, rice is the Filipinos' must-have food and primary source of nourishment

IRRI

This year, the Philippines is celebrating its National Year of Rice, which is focusing on achieving rice self-sufficiency, improving the income of rice farmers, and promoting better health among rice consumers. As part of the National Year of Rice, the Philippine government is encouraging Filipinos to eat "just the right amount of rice" and expand their diets to include bananas, sweet potatoes, and maize.

Also, in July, the country celebrates Nutrition Month when there is added attention on reducing hunger and malnutrition. The slogan for Nutrition Month is "Together we can end hunger and malnutrition," a clear demonstration of their commitment to improving nutrition among Filipinos.

So, what does rice have to contribute towards a healthy diet?

Rice is the leading source of sustenance for all Filipinos. In 2009, the country had an average annual rice consumption of 123 kg per person[1]—among the highest in the world. Filipinos spend more on rice than any other food, according to the Bureau of Agricultural Statistics (BAS).[2] The BAS survey showed, Filipinos, especially those from low-income households, are depending solely on rice more than ever for their daily dietary energy supply and dietary protein because it remains the most affordable food in the country.

[1] 2009 World Rice Statistics.
[2] Agricultural Indicators System (AIS) Report: Food Consumption and Nutrition. 2011. Bureau of Agricultural Statistics, Department of Agriculture.

However, Dr. Eufemio Rasco, executive director of the Philippine Rice Research Institute (PhilRice), points out that the increasing consumption of rice coupled with the decreasing intake of other foods can contribute to an unhealthy diet.

Not by rice alone

Rice mainly contains carbohydrates, which are an excellent source of energy, but it does not provide all the nutrients required for a healthy diet when it is eaten alone. This could lead to deficiencies in micronutrients such as iron, zinc, and vitamin A.

Micronutrient deficiency can occur when rice makes up most of the daily diet. It significantly affects the lives and health of around 2 billion people worldwide, with 26% of all children under the age of five being stunted and 31% suffering from vitamin A deficiency, according to the Food and Agriculture Office.[3] And the Philippines is not exempt. Approximately 1.7 million Filipino children (6 months to 5 years old) are vitamin A deficient.

Balancing rice

Supplementing a rice-based diet with a diversity of other nutrient-rich foods is an effective way of ensuring a nutritious diet.

"A healthy nutrition tip for a rice-based diet is to consume rice with lean meat, poultry, fish, or shellfish, legumes, and vegetables," says Dr. Maria-Bernardita Flores, executive director at the National Nutrition Council of the Philippine Health Department. "Eat a variety of foods every day."

However, the stark reality is that many people simply cannot afford or access a diverse and healthy diet that includes a range of nutritious foods alongside rice.

IRRI shares the Philippine commitment to addressing malnutrition and is developing rice with more iron (see "*Iron-clad" rice* on page 46 of *Rice Today* Vol. 10, No. 3), zinc, and beta carotene (a source of vitamin A) (See *Golden grains for better nutrition* on pages 14-17 of *Rice Today* Vol. 10 No. 4.) to help people get more of these important micronutrients. High-nutrient rice could be an effective way to provide many rural and impoverished households in Asia with improved nutrition because rice is already widely grown and eaten in these regions.

Old-school nutrition

The Philippine government is also promoting the consumption of brown rice.

Not a specific variety, brown rice refers to any kind of rice that still has its outer layer of bran and the germ—where most of the nutrients (such as niacin, thiamine, and phosphorus) are found. Moreover, brown rice is rich in insoluble and soluble fiber. Soluble fiber slows down digestion and can lower bad cholesterol, while insoluble fiber helps relieve constipation. The two types of fiber work together to promote a healthy digestive system.

Despite its health benefits, brown rice consumption remains low in the Philippines (and across other parts of Asia) compared to white rice. Cielito Habito, former director general of the Philippines National Economic and Development Authority, reported on brown rice consumption in his column *No Free Lunch* in the *Philippine Daily Inquirer*.[4] Dr. Habito's article explains that before rice mills were introduced to the Philippines and neighboring countries a century ago, pounding the grains was the only processing available and so people ate only unpolished or brown rice. The advent of modern mills made pounding of the grains unnecessary and eventually Filipinos shifted to eating polished or white rice. Brown rice disappeared from dining tables as more Filipinos shifted to eating white rice. It was soon seen as an inferior, 'dirty' product. While white rice was considered 'modern and sophisticated,' brown rice was associated with poverty. But in recent years, the tables have turned in favor of brown rice.


DR. CEZAR Mamaril mills his own paddy to commercially produce brown rice.

ISAGANI SERRANO

BROWN RICE is enjoying renewed popularity among health-conscious people because of its high fiber and nutritional content.

LANIE REYES

Benefits of brown rice

"Brown rice is rich in minerals, vitamins, and antioxidants, particularly the pigmented rice," says Cezar Mamaril, former IRRI scientist and currently a consultant at PhilRice.

He is also a rice farmer who sells brown rice and he says business is good as more Filipinos are realizing the product's health benefits. "My supply of brown rice does not last into the next season and we sometimes run out of stocks to sell."

Brown rice is popular among well-informed, middle-class professionals, but not the vast majority of Filipinos. However, Dr. Mamaril feels more Filipinos should eat brown rice.

"Based on testimonial evidence, people consume less rice when they eat brown rice," he says. This could lead to lower per capita consumption of rice and could help solve the country's perennial rice shortage.

He admits that some barriers exist that make consumers shy away from brown rice, but he believes these can be overcome. "Many people don't like the rough texture of cooked brown rice. This is probably due to improper cooking," Dr. Mamaril says. "People who cook it for the first time follow the usual way of cooking white rice where they add water to rice at a ratio of 1:1. It should be a 1:2 ratio of rice to water. They should also soak it in water for at least 1 hour before cooking."

Dr. Mamaril says using the right variety with the right amylose content is just as important. Amylose content is the chemical characteristic that makes cooked rice dry and flaky, or moist and sticky. Rice with high amylose content tends to be dry and less tender and it becomes hard upon cooling when cooked. Low amylose makes cooked rice soft and sticky.

"Most of the brown rice sold commercially is likely a mixture of different varieties with different amylose content giving the product an uneven texture," he explains. "But, if you use one variety with medium amylose content, you don't even have to soak it in water. You need more water and the time of cooking may be longer but the cooked brown rice will be soft."

But it is the price of brown rice that is really preventing more people


BASMATI RICE has a low to medium GI.

CHRIS QUINTANA

[3] The state of food and agriculture 2013: Food systems for better nutrition (www.fao.org).

[4] http://opinion.inquirer.net/32743/win-win-with-brown-rice.

SUPPLEMENTING a rice-based diet with a diversity of other nutrient-rich foods is an effective way of ensuring a nutritious diet.

ISAGANI SERRANO

from buying it, Dr. Mamaril says. Brown rice is more expensive because there is a smaller supply; plus it has a shorter shelf life. According to him, adding to the cost of production is that most mills in the country are not set up to process brown rice, so the cost of milling brown rice—even though it requires less processing—is higher.

White rice and diabetes: fact or fiction?

Although brown rice is the darling of many nutritionists, polished or white rice has sometimes been placed on the opposite end of the spectrum. It has been blamed by some as being one of the worst foods for diabetics.

All foods are assigned a Glycemic Index (GI) number, which measures how rapidly food can raise blood sugar after consumption. High-GI foods can increase the chances of getting diabetes, and make management of type 2 diabetes difficult, while foods with a low GI are considered healthier.

"Rice has previously been classified as a high-GI food," says Melissa Fitzgerald, former head of IRRI's grain quality research. "But this single GI classification for all rice is turning out to be ill informed."

In 2011, Dr. Fitzgerald's IRRI team and her colleagues at the Commonwealth Scientific and Industrial Research Organisation in Australia published research that showed the GIs of 235 varieties of rice from different rice-growing countries were more varied than previously thought.

"Our research showed that there was large variability in GI between the different varieties of rice—ranging from a low of 48 to a high of 92, with an average medium GI of 64," Dr. Fitzgerald says.

The identification of low-GI rice varieties makes it possible to conduct studies on the effect of low-GI rice on people with metabolic health issues. This information will be useful in developing long-term public health strategies and management plans for people with diabetes.

Eating smart

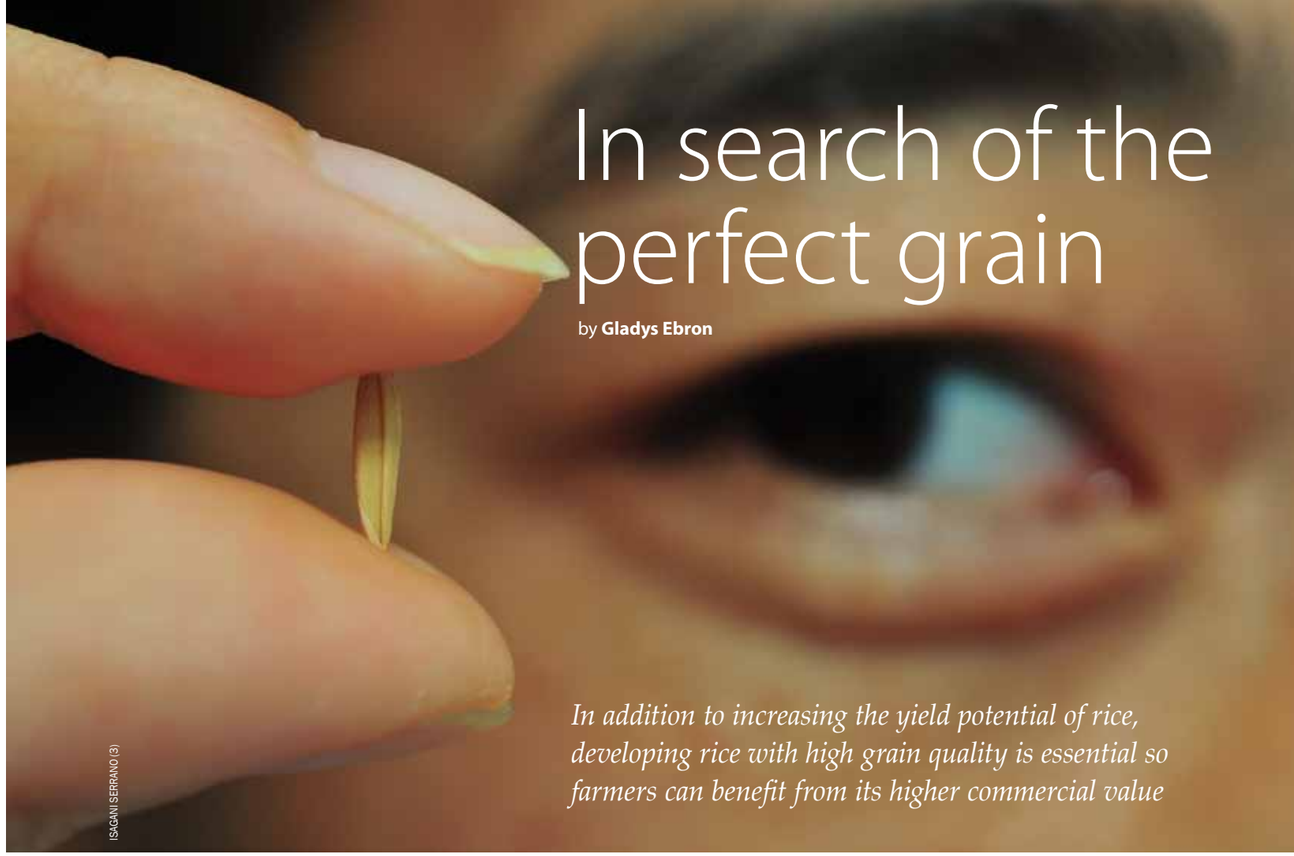
In the Philippines there is a popular saying that goes "if *you haven't* had your *rice today*, then you have not *eaten*."

The good news is that rice can be part of a healthy diet. Consumers can choose brown rice or low-GI rice for additional health benefits. Plus, rice can be combined with other healthy foods to provide complete nutrition. And, with the potential coming of high-nutrient rice – even consumers with limited choices who are likely to keep eating high quantities for rice, may be able to get a more nutritious diet.

Mr. Santiaguel is a writer at IRRI.

FILIPINOS EAT an average of 123kg of rice per person every year, for them a meal isn't a meal without rice.

IRRI



ISAGANI SERRANO (3)

In search of the perfect grain

by **Gladys Ebron**

In addition to increasing the yield potential of rice, developing rice with high grain quality is essential so farmers can benefit from its higher commercial value

Increasing the yield potential of rice has always been the priority in working to increase food security. But, in the race to feed the world, grain quality, is sometimes forgotten. Developing rice varieties without considering grain quality can leave farmers with a low-value product and consumers with rice they find unappealing to eat. So, IRRI is developing strategies to improve grain quality in rice with high yield potential.

Grain quality is not a luxury

Grain quality traits such as size, fragrance, shape, texture, color, and taste may be perceived as something of interest to only richer consumers. In fact, rice consumers across the globe look at the same indicators to define their own preferences. Since more than half of the world's population eats rice, many of whom are poor, the preferences of the poorest rice consumers matter to ensure that their rice is both nutritious and palatable.

Likewise, farmers see the value of grain quality because better quality means higher prices, and this can translate into more profit. However, some farmers continue to plant low-yielding varieties—because the grain quality of higher yielding varieties is unacceptable to local consumers. So, ensuring good or even better grain quality is one way of encouraging farmers to adopt more productive rice varieties.

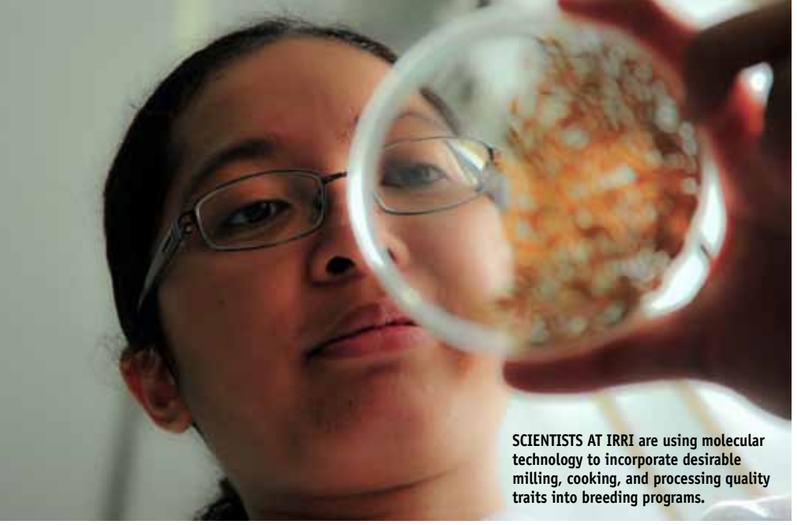
Grain quality is also an important factor during the milling process. It determines whether the grains can withstand milling without breaking. Broken grains have a lower value and can reduce the quantity of grain that reaches the consumers.

Uncompromised quality

"In the past, increasing yield somehow compromised grain quality. But unimpaired grain quality and optimum yield are something that we would like to have at the end of the day," explains Nese Sreenivasulu, head of the Grain Quality and Nutrition Center (GQNC) at the International Rice Research Institute (IRRI). "Since 2004, the GQNC team has been analyzing various grain quality traits in different types of rice to help breeders select and develop varieties with enhanced grain quality.

"Grain composition matters to the whole community because of its commercial importance. That's why we are improving grain quality by also increasing the grain's nutritional value," says Dr. Sreenivasulu.

The GQNC team evaluates physical traits (chalkiness, head rice yield, milling potential, and grain dimensions) and several biochemical traits (amylose content, gelatinization temperature, gel consistency, viscosity, grain elongation, and aroma). These traits help assess milling potential and grain composition, the two major aspects of overall grain quality.



SCIENTISTS AT IRRI are using molecular technology to incorporate desirable milling, cooking, and processing quality traits into breeding programs.

Size and shape

Dr. Sreenivasulu explains that rice has a rich diversity in grain size and shape, and consumer preferences for these traits vary among different regions. For instance, in India, people in the northwest area prefer long grains while those in the east like short grains.

"With the recent success in identifying various genes for grain size, we are in a better position to breed new rice varieties with short or long grains to suit distinct regional preferences," Dr. Sreenivasulu says.

Chalkiness

Grain appearance is judged by its opacity or chalkiness—or to the nonexperts—how translucent or how white it is. Consumers generally prefer rice with a translucent grain. Hence, chalky rice is less acceptable in the market.

Chalkiness is also undesirable because it makes rice grains weak and prone to breaking when milled. Rice with broken grains fetches a much lower price in the market. So, from a marketing perspective, high quality often means more whole grains after milling.

In 2012, in an IRRI study supported by the Australian Centre for International Agricultural Research, Melissa Fitzgerald, then head of GQNC, and her team identified important genetic information on what makes rice chalky. With this discovery, IRRI scientists are optimistic about developing higher quality chalk-free rice varieties in the future.

Aroma

Aroma is an important trait that is generally associated with high quality grains such as those of jasmine and basmati rice. IRRI and other research institutions have shown that most aromatic rice shares the same version of the aroma gene, *badh2*. Farmers have highly prized rice with this gene for thousands of years. Different rice varieties with this gene were widely adopted throughout the ancient rice-growing world.

However, what makes rice grains aromatic remains a scientific mystery today. Although 2-acetyl-1-pyrroline (2AP), the main aromatic compound responsible for the fragrance of jasmine and basmati rice varieties, has been identified, more than 150 different unknown aromatic compounds exist, says Dr. Sreenivasulu. Researchers are yet to fully understand the significance of those compounds in contributing to aroma.

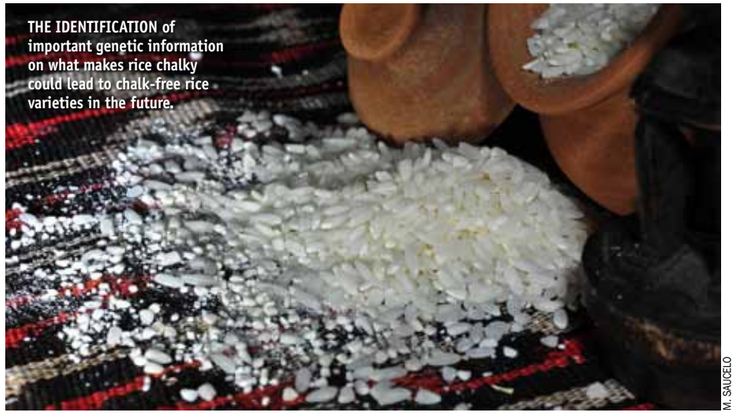
Taste

Dr. Fitzgerald and other collaborating scientists conducted research to differentiate "premium" rice from "second best" varieties from Thailand, China, the Philippines, Japan, Australia, Pakistan, India, Iran, and Brazil. Through descriptive sensory analyses with a group of trained panellists, they found that sweet taste played a major role in distinguishing the premium rice varieties among consumers in Southeast Asia.

Texture

The economic value of rice also depends on its cooking and eating qualities. In South Asia, particularly in India and Pakistan, aromatic basmati rice is highly preferred for its dry texture as the grains never stick to each other. In Southeast Asian countries such as Thailand and Lao PDR, aromatic and slightly sticky jasmine rice is highly desired.

Amylose content and gel consistency strongly influence the cooking and eating characteristics of rice. Dr. Sreenivasulu explains that rice with high amylose content is harder and nonsticky when cooked. These are the kinds that are most suited for people with type 2 diabetes. When cooked rice cools, rice with high amylose content can be either firm or soft as indicated by its gel consistency. Hard gel consistency often means the cooked rice is firmer.



THE IDENTIFICATION of important genetic information on what makes rice chalky could lead to chalk-free rice varieties in the future.

M. SAUCELO

"We are also interested in exploring grains with high protein content and combining this trait with high amylose in rice to reduce its glycemic index," Dr. Sreenivasulu says. "By manipulating amylose content among other factors, we can influence grain quality to make rice healthier."

Sensory evaluation

Understanding rice's composition and desirable traits is only the first step to improving grain quality. The next step, perhaps the most important one, is to have the value of these traits validated by consumers.

This is where Rosa Paula Cuevas, a postdoctoral fellow at GQNC, comes in. She conducts a regular sensory evaluation of rice with a group of panelists to better describe and understand the "mouthfeel" and other quality attributes of rice. She hopes that sensory evaluation can bridge what people experience when they eat rice with what scientists understand about grain components.

"Although amylose content and gel consistency can measure hardness, these do not give a complete picture of what consumers perceive," Dr. Cuevas says. "That's when sensory evaluation can be used to explore what current routine tests are missing out on. It helps ensure that rice breeding programs reflect the qualities that consumers want."

Seeds for the future

According to Dr. Sreenivasulu, environmental conditions such as drought, salinity, flooding, and high temperature adversely affect grain quality.

"Our goal at GQNC is to attain high grain quality while maintaining high yield in the face of unfavorable environments," he says. "As of now, we do not fully understand how climate change alters the grain-filling process at the molecular level. Therefore, our priority should remain with developing varieties with the best grain quality suited for the changing climate.

"Our strategy is to explore the vast genetic diversity of rice in the International Rice Genebank, harness what is already known about quality traits across different environments, and uncover potential genes conferring enhanced grain quality under abiotic stresses," he says. "This will help rice breeders select traits that are of interest for consumers and incorporate those traits into new rice varieties."

For Dr. Sreenivasulu and his team, the work has a long way to go. "IRRI further needs to complement the outcome of this holistic knowledge to optimize precision breeding in order to develop the best quality rice that is suited for changing environments," he concludes.

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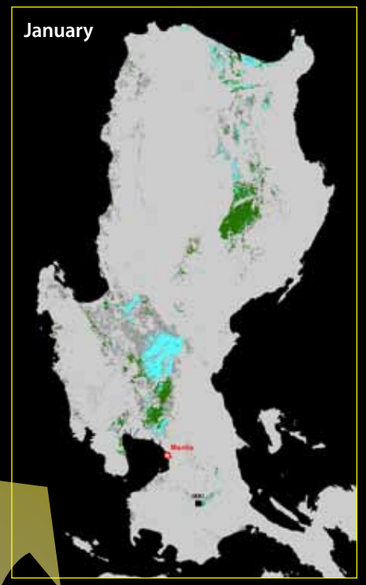
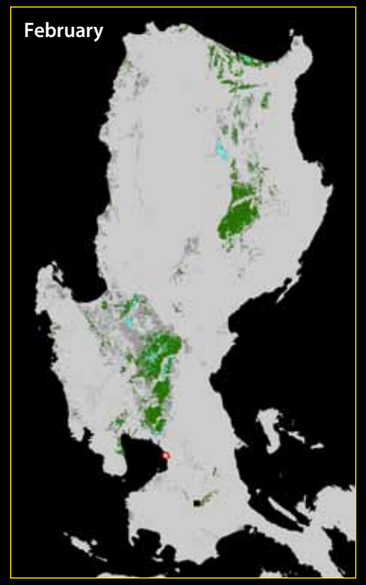
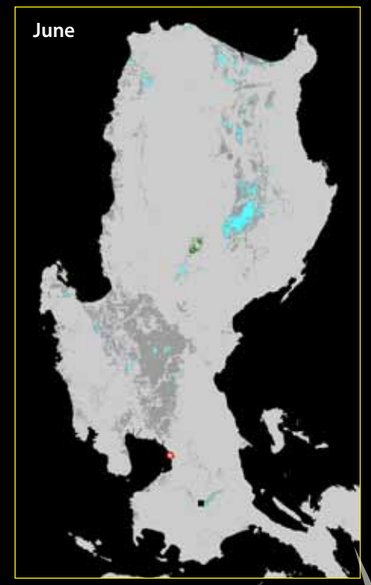
DR. NESE Sreenivasulu (*left*), head of the Grain Quality and Nutrition Center, and his team including Dr. Rosa Paula Cuevas (*far right*) aim to help deliver high-quality rice varieties.

Ms. Ebron is a public relations officer at IRRI.







A year in the life of rice

by **Cornelia Garcia and Andrew Nelson**

Where? When? How much? These are some of the most frequently asked questions about rice cultivation that we face as part of the GIS lab team at the International Rice Research Institute. In the last issue, we featured a global perspective on the rice calendar. Here, we zoom in on the details in the major rice-growing areas of Luzon, Philippines. These 12 maps—derived from satellite images—show the progression of the rice crop month by month. The areas in blue are freshly planted and the areas in green are mid- or late-season rice. The areas in light gray show the maximum extent of rice grown in Luzon.

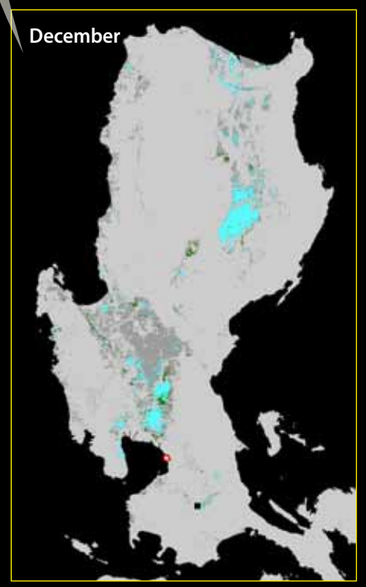
The dry-season crop is planted in December to January (blue). Most rice crops are well established (green) by March and are harvested in April or May.

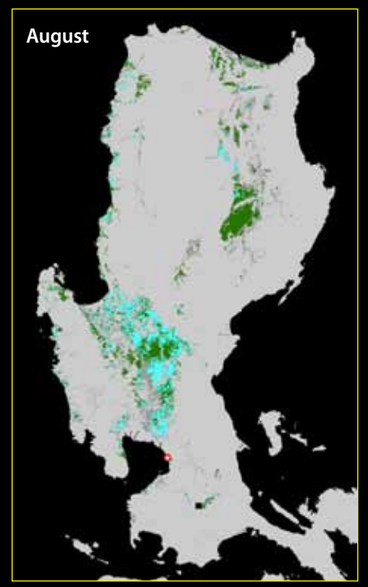
The wet-season crop is planted in June to July, is well established by September, and is harvested in October or November. The cycle starts again by December, when the following year's dry-season crop is planted.

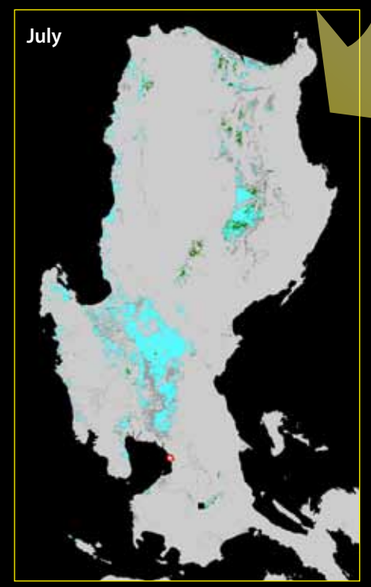
The maps show that much of Luzon has two rice cropping seasons and that the extent of the monsoon-season rice is greater than the dry-season crop. The extent of wet season rice emphasizes both its importance to productivity and its vulnerability to the impacts of typhoons and storms.

The maps also show how varied the rice calendar can be from place to place, even over small distances. This makes answering geographic questions about rice cultivation both challenging and fascinating.

Ms. Garcia is a researcher and cartographer while Dr. Nelson is a geographer and head of the GIS laboratory at IRRI.







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Rice Survivor: IRRI's own reality show

by **Bianca Paula Ferrer**

Scientists and staff at the International Rice Research Institute (IRRI) took on the challenge of personally growing rice in the field

A diverse array of 20 IRRI scientists and scholars gathered in the great outdoors of the IRRI Experiment Station in December 2012 to take up a 6-month-long farming challenge aptly called Rice Survivor. Divided into four teams, they competed to see who could produce the highest yielding rice crop most efficiently and sustainably. This unique project could be called IRRI's first reality show.

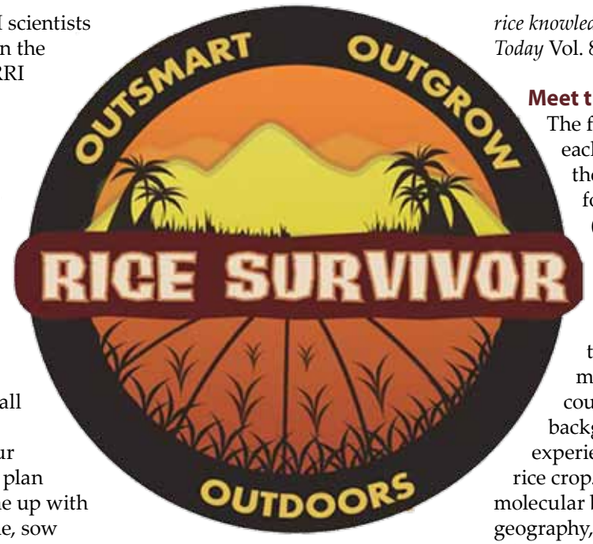
"On their relatively small patch of land (1,240–1,600 square meters each), the four Rice Survivor teams had to plan their land preparation, come up with a water management regime, sow seeds or transplant seedlings, look out for pests and diseases, hand-pull some weeds, and decide on various management approaches to use," said Nicola Wunderlich, agronomy extension specialist at IRRI's Training Center. "They then had to harvest their crop and compare results.

"They had to plan the season ahead including all the steps involved in between," she said. "Participants recorded the sources of information that they used in making their crop management decisions. We especially wanted to know how much IRRI's Rice Knowledge Bank (RKB) was helpful for them."

According to Rice Survivor co-organizer Katie Nelson who is also an agronomy extension consultant at IRRI, "In its current state, the RKB is a great source of technical information. It's just like a textbook—useful for students and researchers. "It explains 'what a technology is' but, provides less information on '*why*' or when a technology could be used.

"Our survivor teams discovered that there are gaps of practical information in the RKB and so we will focus on improving this," Ms. Nelson said. "Much of the information about managing a rice crop came from colleagues, experts, published research, among other sources. Ideally, the RKB should be the primary source of information on rice production and we are working towards this goal."

The RKB was launched in 2002 when the Training Center decided to bring together all current validated rice-farming knowledge from IRRI. The idea is for it to become a one-stop shop of online information for extension and farming communities in partner countries (see *Banking our rice knowledge* on pages 36-37 of *Rice Today* Vol. 8, No. 3).



Meet the survivors

The four teams of five persons each imaginatively named themselves: *Matatag* (Filipino for strong), *Hayahay* (Filipino for comfortable), the Double Trouble Makers, and the Future Techs.

The men and women team members were a mix of nationalities (seven countries) and scientific backgrounds, but with no experience in actually growing a rice crop. Their disciplines included molecular biology, social science, geography, education, computer science, and horticulture.

Matatag team members hailed from India, Myanmar, USA, and the Philippines. "We chose wetland preparation because it's traditional and we thought it would be a good experience for us," said Jason Beebout, a consultant at IRRI currently working with the Cereal Systems Initiative in South Asia-Bangladesh project.

Members of Team Hayahay brought a wide range of experiences to the competition. "We picked certified seed of the Philippine rice variety NSIC Rc 222 that was bred at IRRI," said Adam Sparks, a postdoctoral fellow and member of IRRI's Geographic Information Systems unit. "Our yield goal was an ambitious 7 tons per hectare," he added. "We did traditional transplanting and traditional primary dry tillage; and then, we puddled the

RICE SURVIVORS talk about their plans and strategies for the entire dry season series of Rice Survivor.

ISAGANI SERRANO (2)

field. After that, we did a secondary wet tillage and then a final smoothing before we transplanted."

"Our team decided to do a regular puddled and transplanted field," explained Sarah Beebout, a soil chemist on Team Double Trouble Makers. "We decided on this traditional cultivation because there are a lot of weeds here in this part of the research farm. And, it's very well-suited for lowland rice production.

"We also tried mechanical transplanting rather than hand transplanting of two different varieties," Dr. Beebout added. "In one half of the plot, we tried a popular cultivar, NSIC Rc 222, while in the other half, we tried traditional variety Pirurutong, which has purple grain."

Team Future Techs was the only group that tried direct seeding. "We opted for mechanized seeding using a 4-wheel tractor attached to a seeder," said Bhagirath Chauhan, a weed expert. "We think the future of rice farming is in mechanization because getting labor at critical times such as transplanting is becoming more difficult," he explained.

The diversity of approaches the teams took in how to establish and manage their rice crops and the various management methods employed reflects how farmers themselves operate and make decisions.

Let the games begin

The first real physical challenge for the teams started with transplanting the rice plants. Everyone quickly realized that this is hard work!

"It's my first experience to pull out the seedlings and sow them row by row," said Valerien Pede, an economist on Team Hayahay. "It was quite challenging. When I looked back and saw how crooked the rows were, I said to myself, 'Wow, they look terrible!'" related Dr. Pede. "I checked what the more experienced guys were doing and then realized I was not doing it right. So, I adjusted. Anyway, I enjoyed the learning process."

After transplanting, the challenges kept rolling in. There were a few surprises, which worked well for some, but not so well for others.

For example, Team Double Trouble Makers experimented with alternate wet and dry irrigation, which entailed keeping the plot dry for some time. Unfortunately, a well-meaning farm worker irrigated their plot, plus water seeped in from the adjacent plots. So, they switched back to the more traditional continuous flooding irrigation.

The curse of the snails

Golden apple snails were one of the most serious concerns for all competitors. "You can take one step, and maybe pick up 50 snails, and then take another step and do the same, said Jason Beebout. "It's overwhelming."

In the beginning, his team was looking at a good crop stand of one to two tillers per hill, but they had to re-plant after the snails had a chomping frenzy on their seedlings. "One thing that I've learned is that we should have thought about snails before the seedlings ever went into the ground," Mr. Beebout said.

More field surprises

Team Future Techs didn't have any problem with snails because they went for dry direct seeding, so they didn't irrigate their plot. But, they had to contend with their own problem when using this practice—weeds.

"We didn't get it right at the start of the season," said James Quilty, a postdoctoral fellow in IRRI's Crop and Environmental Sciences Division (CESD). "Our crop establishment was poor and as for crop protection, there wasn't any. They direct seeded their plot right before the start of the Christmas season. With the Institute closed for the holidays, by the time the team returned to its plot in January, lots of weeds were there.

"Since we did not use herbicides, we had to pull the weeds with our bare hands," said Dr. Quilty, "and it was very labor-intensive."

Like Team Future Techs, Team Hayahay also had a weed problem. "One thing that came through for us was the need for a leveled field," said Noel Magor, head of IRRI's Training Center. "The middle part of the plot was slightly higher. You can actually feel the difference when weeding. Weeding the part, which had less water, was very tough. Next time, I'd encourage laser leveling because a level field makes water and weed management much easier."

GOLDEN APPLE snails were one of the serious concerns for all competitors.

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Grains of gold

Most participants helped rival teams during the labor-intensive transplanting, weeding, and other farm activities.

"It didn't feel like several teams working for themselves in individual plots. It was more like one big team working together across several plots," said Dr. Quilty. "Rice Survivor gave us an opportunity to really know some IRRI colleagues with whom we normally wouldn't otherwise interact. Even if it's just for advice, we know now whom to ask."

Rowena Oane, a biochemist who spends most of her time in a molecular lab at the Plant Breeding, Genetics, and Biotechnology Division, learned to appreciate the management aspect of growing a rice crop. She also found that succeeding in rice farming requires three key factors: technical knowledge, time, and resources.

"Each team selected different rice-farming strategies enabling them to try different IRRI technologies and approaches," said Rowell Dikitanan, an economist with Team Double Trouble Makers. "Now that I've become familiar with different ways of growing rice, it's easier for me in my regular job when I interact with farmer-interviewees who are adopting similar technologies."

Team Hayahay's Man Marcaida, who works in water management in CESD, said, "Farming is a community undertaking. We started as competitors ready to beat the other teams, but instead we actually helped one another with various management activities, even coming up with collective decisions involving water management and controlling rats. It highlights that collaboration is very important for what we do here at IRRI."

RICE SURVIVORS get to know more about some rice diseases from rice pathology expert Nancy Castilla (*center*).

At the finish line

So how did the teams fare at the end of the challenge? Well, all "survived" with varying degrees of success.

The Double Trouble Makers harvested 7.3 tons per hectare from NSIC Rc 222—the highest from a single rice variety. They also got 6.0 tons per hectare from their other variety, Pirurutong. Team Hayahay got a combined yield of 6.8 tons per hectare from their two varieties, NSIC Rc 222 and NSIC Rc 148. Teams Matatag and Future Techs harvested 4.9 and 4.8 tons per hectare, respectively.

Team Double Trouble Makers also won in terms of overall profitability. Its profit was US$408 (PhP17,471) while Team Hayahay that gained $281 (PhP12,074) came in second. Team Matatag and Team Future Techs profited $223 (PhP9,566) and $89 (PhP3,816), respectively.

The third criterion, sustainability, had to be dropped this time around. "Judging sustainability proved too difficult as the teams couldn't measure the amount of water used and some other inputs," said Ms. Wunderlich. "But, we are working on a possible assessment scheme for sustainability in a future episode of Rice Survivor."

Beyond the fact that all the participants "survived," special recognition was given to some exemplary survivors. Ms. Annie Barreto received the Proudest Farmer award since she was a standout in caring for her field on a daily basis. Dr. Magor was named Most Obsessive Weeder. Sarah Beebout won the Best Record Keeping award while Jason Beebout was named Most Altruistic. Ms. Rowena Castillo was the Best Communicator while Dr. Quilty was the Best Team Player.

"I think each team member came out a winner," concluded Dr. Magor. "This challenge provided a rich practical experience for all participants in coming to grips with growing rice. It provided satisfaction for each person. The sense of solidarity and learning from each other and the IRRI Experiment Station staff was a plus for each of us and for IRRI."

Ms. Ferrer is a public relations specialist at IRRI.

Follow the adventures of the Rice Survivors at http://ricesurvivor.blogspot.com/. Listen to nine survivor podcasts on IRRI Radio at https://soundcloud.com/irri-radio/sets/rice-survivor.

ISAGANI SERRANO

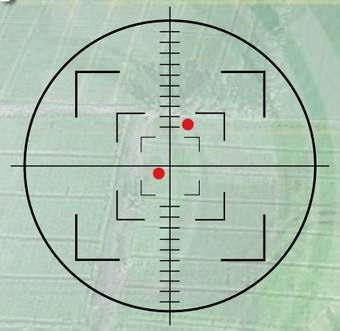
What does it really take to grow rice? IRRI staff who signed up for Rice Survivor found out for themselves the hard realities of rice production that farmers face everyday. From the backbreaking work of transplanting the seedlings, to battling pests and weeds, to just keeping the crop alive. These challenges have given them new insights about rice farming—and a deep respect for farmers.

FIELDS OF PLENTY

by **Elizabeth Finkel**

Adapted from an original article that was published in COSMOS magazine©

It's 2063. Indian farmer Prabhjit Kumar finds herself running a profitable and environmentally friendly business thanks to rice agricultural research



Prabhjit woke to the sound of the roosters crowing, just as her mother, grandmother, and countless generations of women in the state of Odisha in eastern India had always done. In the cool morning, she wrapped herself in her green and gold sari, washed her face, and braided her hair. Peering into the mirror, she daubed the vermillion bindi on her forehead and sat back cross-legged to meditate. She concluded by kneeling at the small altar to Parvati, lit an incense, and uttered a prayer for Grandmother on the anniversary of her death.

But Prabhjit's next morning ritual was different. Moving into the living room, she passed her henna-tattooed hand over an image of her daughter. Apoorva dissolved and eight grids sprouted onto the digital screen, decorated by colors every bit as vivid as Prabhjit's sari. Her practiced eye homed in on the scarlet dots. The in-field sensors, sitting among the crops like tiny one-eyed metal scarecrows, alerted her to two patches in the northwest corner in distress. Then she zoomed out to take in satellite data from the entire area. Some farms had already started the harvest. Prabhjit began ruminating about the implications. But the sound of an alarm clock pushed them to the back of her mind. Time to get 15-year-old Apoorva ready for school.

It's 8 a.m. The house is quiet again after the morning bustle. Prabhjit sits in front of her data screen and calls the foreman, telling him to increase the flow rate in the drippers for fields NW1 and NW2. She arranges to meet him for an onsite visit at 11 a.m.

There's a knock at her door. It's the twice-a-month visit from Anil, her "ag-service" provider. She puts on a pot of chai and asks about Anil's family before they move on to local gossip. Then she steers the conversation to rice. Who's planting what and what's his take on the market? Anil confirms that some farmers have started to harvest a bumper crop. But hers needs another week to reach its peak. With so much rice, will she still get a good price in a week's time? Or should she store it? Prabhjit weighs Anil's opinions, and decides to silo her harvest and wait for the price to rise.

It's 10:30 and time to drive to her meeting with the foreman. As she cruises down the road, her memory projects an unbidden image onto the green fields. Shin deep in a muddy paddy, Grandmother and Mother (then just a tiny 12-year-old) are bent over, shuffling backwards. They are in the Punjab, far from home, laborers on a team of women who day after day poke rice seedlings into the mud, heading home weeks later, exhausted.

Another image replaces this one. Grandmother and Mother are transplanting rice again but this time in their own paddy. It is a special crop that will change their future.

Grandmother may not have been able to read words but she could read the winds of change. Grandfather had gone to work in the city years before, leaving her to run the farm. They could not make ends meet on the tiny payment the government broker gave them for their harvest. Yet, the government was urging farmers here to plant more rice because the wells of the Punjab, as everyone knew, were running dry. Although Odisha was usually blessed with ample rain, there could be drought. Or floods. Both had struck the year before.

When Grandmother and Mother transplanted each seedling, they held each one tenderly, as if it were a leaf of gold. Grandmother had been given the seeds at a village meeting. She had been impressed by the educated government woman in her fine blue silk sari who explained that the seeds, developed in the Philippines, were very strong. If the floods came, the seedlings would lie dormant and then burst into growth when the waters lowered. The waterproof seeds went by the nickname of "Scuba rice"!

Their efforts paid off. That first year, floodwaters covered their crop for 2 weeks. But, their crop had not drowned! Unlike many in Odisha, they made a nice profit. Three years later, Grandmother attended another meeting. This time the lady in the fine sari introduced her to two new types of rice—she said they were the daughters of Scuba. But these daughters were smarter than their mother. Super Scuba 1 could survive flood and resist drought. Super Scuba 2 could also extract phosphate from the soil so Grandmother would not have to spend so much on fertilizer. The profit rose steadily each year. She decided that, like Super Scuba 1 and 2, her daughter would be smarter than her. She used the money, not on a dowry, but to send her daughter to an agricultural college—her daughter, the first of her family ever to finish high school, was now being sent to college!

THE EXPERIMENTAL plot at IRRI where plant breeders first successfully tested flood-tolerant scuba rice (in full plots).

IRRI (2)

In Prabhjit's teens, the winds of fortune brought more changes. One was land reform. A new law allowed the formation of small farming corporations, up to 40 hectares. Prabhjit's father took his two hectares and joined up with Grandmother's two and they began to rent more blocks. By the time she graduated from college, it was done and Father proudly left the running of the farm to her. She took a microcredit loan to build up the farm to 24 hectares—and took the wheel.

The other revolution was genetically modified (GM) crops. Nitrogen-fixing rice was more miracle than revolution. Like Super Scuba, this was a very, very clever seed. It had taken nearly 50 years to develop in a worldwide project funded by the Bill & Melinda Gates Foundation (BMGF). The rice plants had been genetically engineered to carry the powerful photosynthetic engine of a corn (maize) plant, as well as the nitrogen-fixing genes of a legume, producing yields that were double the size with half the fertilizer.

Vegetable seeds improved, too, but best of all, farmers could throw away the most toxic pesticides because these seeds produced their own, borrowed from a harmless bacterium *Bacillus thuringiensis*, or BT for short. These vegetables earned the name "Ganesh" after the elephant-headed son of Shiva who was also the god of good fortune. Mother said they could have had Ganesh seeds years before but their release had been delayed. BT cotton had already saved millions of farmers from poisoning and BT pest control spray was so safe, organic farmers sprayed the bacterium directly on their plants.

"When I proposed the flood- and drought-tolerant rice project 20 years ago, I was laughed off the stage. The tools we have now for genetically tweaking plants are vastly superior."

Grandmother passed away, aged 57, when Prabhjit was 20. She had withered from backbreaking work and the pesticides—spraying them from two tin cans yoked across her neck, barefoot! She would come back from the spraying, sick with headaches and shakes. In her final years, lying on the cot, she told Prabhjit her story, and the ending was always the same. Even now Prabhjit could clearly hear Grandmother's voice: "You will be like the rice grains that grow smarter with each generation."

The dream

You might say Prabhjit's story is a dream. And you'd be right. It is the dream of Robert Zeigler, director general of the International Rice Research Institute (IRRI), and one that he has spent the best part of his working career trying to turn into a reality. Prabhjit's farming tools are either in the development pipeline or have already emerged.

Scuba, the flood-tolerant rice formally known as Swarna-Sub1, has already been released by IRRI. (See *Scuba rice* on pages 26-31, Vol. 8, No. 2 of *Rice Today.)* A variety that is both drought and flood tolerant, referred to as "Super Scuba 1" in Prabhjit's story, is being developed by breeders and is undergoing testing. And, the variety referred to as "Super Scuba 2" that can mine its own phosphate from the soil is due for release in the next few years. It carries a gene called *PSTOL1*, which stands for phosphorus **s**tarvation tolerance. IRRI breeders extracted this gene from a traditional Indian rice variety called Kasalath that performs well in soils with low phosphate. These new rice varieties were developed through a 20-year process of shuffling genes from semiwild or traditional varieties into modern high-yielding ones by conventional breeding.

The next developments will take longer. Engineering rice that is equipped with a corn plant's photosynthetic engine is a tough task. (Corn has a so-called C_4 engine that is about twice as efficient as the photosynthetic engine of rice.) It means retrofitting a whole assembly line of corn genes and redesigning the infrastructure of the rice plant to accept it. BMGF and IRRI provided US$11 million funding for the first 3 years, and, in 2012, the progress was judged promising enough to merit a second round of $14 million. This time, the UK government, the European Union, and CGIAR pitched in.

RELEASED IN 2009, the flood-tolerant, high-yielding Swarna Sub1 has been adopted by farmers in millions of hectares of flood-prone areas in India.

An equally tough task is to ferry the genes of a legume into a cereal grass like rice, allowing the crop to supply its own nitrogen. This would truly usher in the next Green Revolution, or rather the "Evergreen Revolution." It could double yields with half the fertilizer. In 2012, BMGF also announced it would provide $9.8 million to the UK's John Innes Centre to try to entice nitrogen-fixing bacteria, normally attracted only to legumes, into cohabiting with cereal crops.

But what's the chance of success? "Undoubted," says Dr. Zeigler. "When I proposed the flood- and drought-tolerant rice project 20 years ago, I was laughed off the stage. The tools we have now for genetically tweaking plants are vastly superior."

MODERN BREEDING tools allow scientists to tweak rice genes and make it possible to develop high-yielding, stress-tolerant and disease-resistant varieties.

ISAGANI SERRANO

By the time Prabhjit takes the reigns of her father's farm, GM crops will have been revolutionized agriculture. With overwhelming evidence that GM crops are as safe as conventional breeding (established by the European Commission in 2010 after reviewing 25 years of research from 500 independent research groups), farmers and consumers will reap the benefits. Not only will these crops raise yields, and require fewer pesticides and less fertilizer, they will also deliver life-saving vitamins and micronutrients. According to the World Health Organization, globally, 250 million preschoolers are vitamin A deficient and up to 500,000 go blind.[1] Golden Rice, genetically modified to produce beta carotene, could make a huge dent in this problem. Golden Rice is in the final stages of being tested for its safety and effectiveness.

Prabhjit also relies on the latest in rocket science. The satellite from which she downloads data traces its origin to the European Space Agency Sentinel satellites, the first of which is scheduled for launch in 2013. And, its microwave beams penetrate clouds, meaning they can work throughout the monsoon season. IRRI is also developing the software to allow farmers like Prabhjit to benefit. And it's not just helpful to farmers. Data like these could help prevent global panic and food price spikes, says Dr. Zeigler. "With time to adjust to a shortage, they can import ahead of time to avoid a panic."

Prabhjit's drippers—tiny holes in tubing delivering water and fertilizer at a slow rate—are not rocket science, but literally a "grass-roots" technology developed by the practical Israelis. They more than halve water requirements and increase yields. Israeli inventor Daniel Hillel won the 2012 World Food Prize for developing them. Besides Israel, the fastest adopters have been China and India.

In 2063, Prabhjit's world is a happy place. The Malthusian spectre that haunted the planet 50 years before—that the population would outgrow its food supply—has failed to materialize. Let's hope that this dream comes true.

For a nightmare scenario, read a side bar, The dark side, *in Elizabeth Finkel's full article in* COSMOS *magazine (see www.cosmosmagazine.com/features/fields-of-plenty/).*

Ms. Finkel is associate editor of COSMOS *magazine.*

[1] www.who.int/nutrition/topics/vad/en/.

Catching up in southwestern Bangladesh

by **Sophie Clayton**

A combination of water, fish, rice, and upland crop management research is underway to help millions of the poorest farming families in Bangladesh living in the coastal zone, the region most vulnerable to the impacts of climate change

IRRI (2)

"Rice is our national occupation," says rice farmer Altaf Boyati. "My father and grandfather cultivated rice. As a farmer, I am also cultivating rice."

Mr. Boyati lives in the southwestern coastal zone of Bangladesh, where farmland has more than its fair share of water and salinity challenges and where poverty remains a chronic problem. But now, Mr. Boyati and other local farmers are getting help to catch up with the rest of the country, where agricultural gains have contributed to declining poverty. As part of the Ganges Basin Development Challenge of the CGIAR Challenge Program on Water and Food (CPWF), fresh approaches to improving water management and the use of high-yielding rice varieties, combined with aquaculture, will give farmers more effective options to increase food production and profitability.

Steps out of poverty

Bangladesh is one of the most densely populated and poorest countries in the world. According to the World Bank, about one in three Bangladeshis is poor—slightly more in rural areas.

The good news is that, over the last decade, the percentage of people living in poverty has declined. Three agricultural factors have contributed to this. First, the adoption of high-yielding rice varieties for both the rainy and dry seasons; second, private investment in groundwater pumping to irrigate rice during the dry season; and third, greater use of inputs, especially fertilizer.

With higher yield potential from new rice varieties and the ability to grow irrigated rice during the dry season (*boro* rice), farmers can more consistently—and with lower risk—produce more rice. More rice means more to eat, more to sell, and thus more income for rice farmers. And, with more rice on sale in markets, rice prices are more likely to stay affordable for even the poorest consumers.

Unfortunately, farmers in the southwestern coastal zone have missed out on the benefits these agricultural changes have delivered. A recent survey of 1,200 rural households across the coastal zone found that about 80% of the people were living below the poverty line of US$1.25/day, compared with the national average of 40%.

Here, farmers grow traditional, tall, low-yielding rice varieties during the rainy season, followed by a non-irrigated, low-yielding legume or fallow during the dry season. In most of the coastal zone, high-yielding varieties are not grown because the water is often too deep during the rainy season due to poor water management.

Water woes

Water—whether too much, too little, or too salty—is a major constraint to improved agricultural production in the southwestern zone.

Bangladesh is one of the most water-abundant countries in the world. It has an annual rainfall of 1,500 to 3,000 mm yet it has several water challenges, according to Aditi Mukherji, a water expert formerly with the International Water Management Institute.

"For one, much of coastal Bangladesh is a part of an active delta and highly influenced by tidal surges and salinity intrusion," she said. "So, in nonrainy months, availability of fresh water is scarce and management of brackish water is a critical issue. Second, relatively flat terrain, clayey soils, and high rainfall lead to severe waterlogging, inundation, and siltation of internal drainage channels."

Preventing floods and salt-water intrusion

In the 1960s and 1970s, in order to help reduce the devastating impact of tidal floods and saline water intrusion on the people of the southwestern coastal zone, embankments were built around the lands between the large rivers in the region to create "polders"—or inland islands protected by embankment walls.

Polders have proven their worth in buffering farmers against the onslaught of tidal floods and salinity. The World Bank stated in its 2010 report, *Economics of Adaptation to Climate Change—Bangladesh*, that, over the last 50 years, polders have contributed to "significantly reduced damage and losses from extreme climatic events over time, especially in terms of deaths and injuries." The report also attributes higher agricultural production, including rice, to the improved water management polders can deliver.

However, the reality of their effectiveness is much more complicated. Out of 123 polders in southwestern Bangladesh, many need to be repaired and upgraded to cope with the situation, let alone the predicted worsening conditions brought about by climate change. Internal canals, which are important for both drainage and storage of water in the wet and dry seasons, are often silted up. And, the sluice gates connecting the canals to the surrounding rivers are often leaky, badly damaged, or missing. Where the infrastructure is still functional, competing demands for water also mean control over what water goes into and out of the polder is more than a simple technical matter.

BANGLADESH FARMERS are working with research agencies to improve the productivity of their rice farms. Photo shows Dr. Liz Humphreys (*seated far left*), Dr. Manoranjan Mondal (*seated with gray shirt*), and Mr. Altaf Boyati (*squatting wearing brown shirt*).

"With many different farmers on a polder, it is inevitable that they will want to use their patch of land for different purposes," explains Liz Humphreys, senior scientist at the International Rice Research Institute (IRRI) and leader of one of the five projects in the Ganges Basin Development Challenge. "One farmer may want to grow shrimp during the dry season, which requires salty water, while another may want to grow crops such as maize or rice, which require fresh water.

"Or, it could be as simple as one farmer wanting to drain his field because his rainy-season rice crop is almost ready for harvest, and so that he can establish a dry-season crop such as wheat or maize at the optimum time, while another farmer needs the water around for his standing crop," she added.

Upgrading water management

To realize the full potential of new diversified and intensified cropping systems, the roles of polders have to be revised. In addition to salinity control and tidal flood protection, the polders and their water management infrastructure have to satisfy other needs of the new cropping systems, including drainage, intake of fresh and saline water, and freshwater storage.

Water flows into, or out of, the polders via human-operated sluice gates and flushing pipes. During the rainy season, there is often extensive flooding in the polders due to heavy rainfall, with the flooding worst (in excess of a half-meter deep and longer lasting) in lower lying lands.

Yet, at low tide (which occurs twice a day), the water level in the surrounding rivers is often lower than the land, creating a chance for drainage. A systematic approach to drainage management would enable the growing of high-yielding varieties of rice in large areas.

In some polders, community water management groups manage the sluice gates. However, the operation of the gates is often influenced by the more powerful and affluent whose interests may be at odds with the majority, that is, the poorest people whose livelihoods and food security depend on the productivity of the lands, which they often lease.

For example, when the lands need to be drained for rice, some may desire to bring yet more water into the polder because it also brings seed for their fish ponds, or because the highest lands need more water.

Manoranjan Mondal, a water scientist at IRRI, adds that 40% of the land owners are relatively wealthy absentee land owners. Typically, they are more willing to take risks as to what they do on their land in hope for higher returns. This can mean brackish-water shrimp farming; although risky, it can be more profitable than rice.

The International Water Management Institute is looking for ways to improve water governance and community-based water management on the polders. For Dr. Mukherji, tackling these water management challenges is critical for the region to reach its agricultural potential.

"We aim to show that, with investment in improved water management in polders, productivity can be greatly increased," says Dr. Humphreys. "With our collaborators, we are developing, evaluating, and demonstrating new options that help farmers increase the productivity and profitability of their rice, other crops, and fish."

Better rice options

Until recently, the evaluation and demonstration of high-yielding rice varieties have been neglected in the coastal zone. Thus, few farmers grow modern varieties, so their rice farms remain locked in the past with low productivity. A major constraint has been that most high-yielding varieties are not tall enough to cope with "water stagnation" (prolonged periods of water with a depth of 0.3–0.5m).

"Farmers here tend to grow tall traditional rice varieties that protrude well above flood waters," says Dr. Humphreys. "They transplant them when they are already quite tall and old, which is not optimal for high productivity.

"Plus, these traditional varieties mature late and they have less than half the yield potential of the modern varieties—limiting the amount of grain a farmer can produce," she added.

"We aim to show that, with investment in improved water management in polders, productivity can be greatly increased," says Dr. Humphreys.

Mr. Boyati has confirmed this by saying that he normally gets less than 2.5 tons per hectare of rice—just over half the national average of 4 tons a hectare and less than half the yield of the best high-yielding rice varieties grown in trials on his farm.

Dr. Humphreys and her collaborators from the Bangladesh Rice Research Institute (BRRI) and BRAC, the largest NGO in the world, are testing new rice varieties and upland crops with higher yields that are better suited to the local conditions—including floods and salinity—and that mature faster to allow multiple crops to be grown in one year.

Combining smart water management, that is, drainage at critical times, with shorter-duration, high-yielding rice varieties allows farmers to grow two to three crops per year and double or triple their food production.

IRRI

THE GANGES Basin Development Challenge of the CPWF is conducting a trial on growing rice and freshwater fish simultaneously.

Successful demonstration

On Polder 30, Dr. Mondal and a group of farmers showed how it could be done. They isolated about 6 hectares farmed by 37 farmers within the polder by building a small embankment and associated ditch so they could drain the fields when they wanted to. A small bund also bisects the area to separate the high land from the lower land, thus preventing excessively deep water in the lower land.

The 2012 *aman* (rainy) season saw two rainfall events of around 250 mm, each within a very short period. The farmers systematically operated the sluice gate to drain at each low tide. In short, the excess water was drained within two days and no damage was done to the rice.

It's a unique situation according to Dr. Humphreys, as the land inside the polders is not subdivided to facilitate localized water management. She is an advocate for subdividing areas because this requires little investment, separates lower and higher lands, and enables affordable drainage—provided that the sluice gates are also managed systematically to enable drainage. However, for this to be carried out successfully, farmers need to have a synchronized planting and harvesting.

Also, improved drainage management would only be feasible with greater government support to improve the whole water management infrastructure of the polders. Dr. Humphreys hopes that this will come later once it is demonstrated that creating miniwatersheds can really boost food and economic productivity.

Fish and rice together

In some of the more saline parts of the coastal zone, brackish-water shrimp are produced during the dry season. After the shrimp are harvested, the soil is left salty.

"These areas represent some of the most challenging environments for wet-season rice; but, with good water management, it is possible to grow rice in rotation with shrimp," says Dr. Humphreys. "This also requires good drainage management because the brackish water must be drained before the monsoon season so that the rain can leach the salt from the topsoil before the rice is planted."

The World Fish Center and the Bangladesh Fisheries Research Institute in collaboration with BRRI and IRRI have established a trial to optimize management of rice and shrimp production systems.

"The theory is that growing rice, instead of leaving the ground fallow between shrimp harvests, may break virus cycles that can otherwise obliterate the shrimp," says Dr. Mondal. "Also, the shrimp can help build nutrients for the next rice crop—but it's all yet to be proven; hence, the trial."

The trial also includes growing rice and freshwater fish simultaneously. Tradeoffs exist between the needs of the rice plants and the fish, but there could also be synergistic benefits that increase overall production.

"It's important we complete the trial before we make any recommendations," says Dr. Mondal. "Aquaculture requires a huge investment to establish and we don't know for sure yet if combining it with rice can help. The farmers believe it, but we need to observe and measure it first."

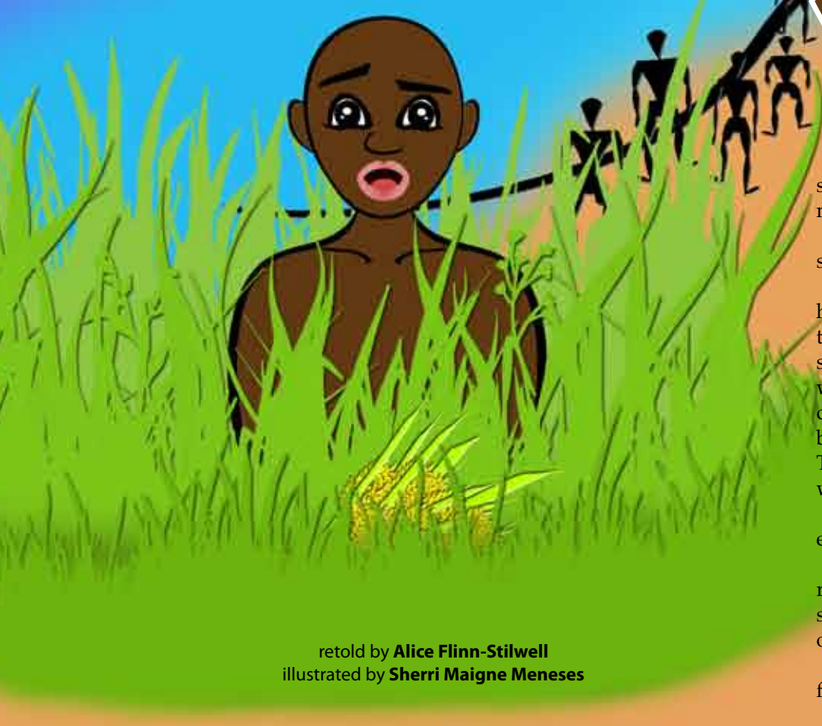
"What we do know for this region is that farmers who want to grow rice to build their personal food security will have the capacity to do it with varieties that can cope well with salinity—but again, it always has to be combined with good community water management," Dr. Mondal concluded.

CPWF Ganges Basin Development Challenge partners are also:

- Assessing the likely impacts of anticipated external drivers of change (such as changes in climate, river flows from India, population) on water resources of the coastal zone.
- Mapping where improved cropping system options (agriculture and aquaculture) could be adopted now, under current conditions, and under future scenarios.

Thanks to Liz Humphreys, Manoranjan Mondal, Phuc Tuong, Andy Nelson, and Aditi Mukherji for their assistance in compiling this article and to all project partners, including World Fish Center, International Water Management Institute, Institute of Water Modelling, Bangladesh Water Development Board, Soil Resources Development Institute, Bangladesh Rice Research Institute, Bangladesh Fisheries Research Institute, BRAC, Central Soil Salinity Research Institute, Central Institute of Brackish Water Aquaculture, and the CGIAR Challenge Program on Water and Food.

Ms. Clayton is the Rice Today *publisher and public relations manager at IRRI.*



Give me some more

retold by **Alice Flinn-Stilwell**
illustrated by **Sherri Maigne Meneses**

This fable explains how rice saved the Vai people who traveled from Mali to Liberia and how *kolo*, their word for rice, came to be

Rice has often received credit for health-giving properties. Boiled rice, which is easily digested by people recovering from illness, is sometimes eaten to treat stomach problems. People with food allergies can usually enjoy rice. This story, from the Vai people of Liberia, probably dates back to the 17th century and attests to rice's healing properties.

The Vai tribe was traveling along the West African coast. Its people had left the dry plains of their Mali homeland many moons before. Then, they reached a great ocean and turned south. Again, they walked for many moons and were nearing the region now called Liberia. To their right, the great Atlantic Ocean stretched blue and gray beyond the horizon. To their left, the dark tangled jungle formed a thick green barrier.

Their long trek had not been easy. It had been difficult for the whole tribe, but especially for the older members who had struggled to keep going. However, they had been lucky. Food and water had been plentiful, and no one had been seriously ill. Any sickness or pain had been brief and easily cured.

Khamah, the tribe's chief, strong and hearty in his younger days, was aging. Though less able physically, he was kind and his wisdom was still revered by young and old. One morning, he woke feeling ill.

"My people, I am unwell," he said weakly. "Let us not travel today."

The elders were concerned. This had never happened before. The tribe rested for a day or so. When he seemed stronger, they went on their way. They walked slowly so their chief would not tire. Yet, he collapsed by afternoon so the tribe made camp. The next day, Khamah could not walk.

"What to do?" the elders asked each other.

"We need to keep trekking to reach our destination before the hot season dries up the water holes," said one.

"And, soon food will be harder to find," said another.

They would never leave a sick person behind, certainly not their well-loved chief. The younger men bound saplings together to make a bed, and laid their chief gently on it. Their trek continued, albeit slowly. They avoided bumps and any sudden movements to keep their chief comfortable.

Whenever the tribe stopped, its members offered him the best and most succulent portions of their food. But, as the days went by, he grew weaker and weaker. They tried potions. They also tried *ju-ju* or magic spells, but even this had no effect. One day, he ate nothing at all. He was very frail indeed. Everyone feared he would die.

The elders told the tribe to halt. They camped under a tree waiting for this sad event. No one had the heart to continue the journey. No one felt much like eating either. Even the children, usually pleased for a respite from the long walks, played half-heartedly.

Young Wututu was usually very active. He climbed trees higher than any other boy and threw stones as far as any man. But, on that day, he simply wandered among the grass poking aimlessly with a stick. With a jolt, the stick hit something hard and firm. He bent down to look and found a small bundle tied tightly with a thin vine.

"Ooh … ooh," he thought, "no man come this way for long time … perhaps I be dreaming."

He poked it again.

"Maybe Ananse left it; maybe this is not good," he wondered.

Ananse was a bad spirit who took the form of a spider. Frightened to open the bundle alone, Wututu carefully carried the bundle on the end of his stick. Back in the clearing, under the tree where the tribe was waiting, he gave it to Khanuhwele.

Khanuhwele was a wise old woman whose face was deeply lined by the passage of time. She untied the vine and carefully opened the small bundle. Strange grains spilled out. She instinctively moved back. She had never seen grains like these before. She called the others. They all stood around and peered at these strange things, unsure what to do.

"What are these things for?" whispered a wizened old crone bending down to look closely.

"Gope, the spirits; they sent them," fearfully croaked another with her mouth agape.

"Maybe Nysoa sent them," suggested yet another, on a more positive note.

They knew that if bad spirits had sent the grains, they should quickly throw them away or, better still, burn them. But, if one of the gods, such as Nysoa, had sent the grains, then rejecting this gift would be foolish indeed.

Khanuhwele's age made her well respected by the tribe. They looked to her for guidance. She leaned heavily on her stick that was almost as gnarled as her weather-worn face.

"They look clean," she said quietly. "We should cook them."

Soon the grain was bubbling in a pot over a fire. When it seemed ready, everyone tasted it, and they liked its soft texture and flavor.

"This may tempt Khamah to eat," said an elder.

They fed Khamah some of the cooked grains. His eyes remained closed, but he swallowed this new *chop* or food.

"*Kolo*," he said feebly.

So, they fed him more. Again, he said, "*Kolo*," and again they gave him more. When he had eaten enough, he motioned for them to stop. The pot was nearly empty.

Amazingly, Khamah's strength returned. He kept asking for more of the small white grain that tasted so good and had led to his remarkable recovery. So did the rest of the tribe.

Even to this day, the Vai people call rice *kolo*, which means "give me some more."

Ms. Flinn-Stilwell is a writer based in Hobart, Australia. This story is part of her forthcoming book, Rice—a grain with many stories, *a collection of 28 legends about rice and the many customs associated with this amazing grain.*

What's cooking?

Risotto alla Milanese

by **Luigi Concetti**

ISAGANI SERRANO (5)

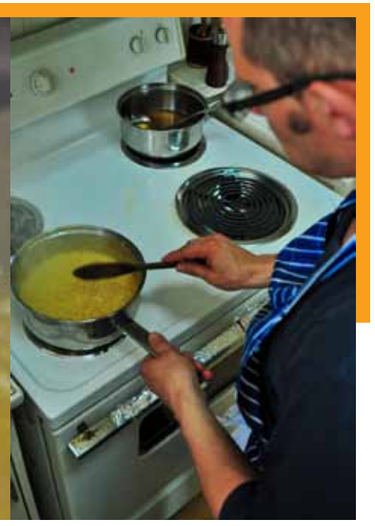
Risotto is one of the most important and beloved traditional Italian dishes, particularly in Milan. It is served immediately and eaten warm, which is why it is mainly a winter dish. It is a *primo,* or served on its own before the main course.

Risotto is a method of cooking rice varieties that are grown in Italy such as Carnaroli, Arborio, and Vialone Nano. Rice first arrived in Italy in the 13th century when it was brought by the Moors, Saracens, and priests traveling from Asia. It was initially cultivated in Sicily and around Naples. Later, rice cultivation moved to the Po Valley in northern Italy after pasta became the preferred staple of the southern population.

As with most great Italian dishes, the original risotto recipe has changed over time. The version of risotto that we know today was described by Antonio Nebbia in his 1779 cookbook, *Il Cuoco Maceratese,* in which he writes about the technique that allows rice to cook slowly and absorb the broth, ladle by ladle, after it has been toasted with *soffritto* (sautéed onion).

This is a simple recipe to prepare but all is not so easy. Patience and a little bit of practice are important in cooking a perfect risotto. It requires precise methods of cooking known as *tostatura* and *mantecatura*. *Tostatura* means toasting the rice with the *soffritto* on low heat for 4–6 minutes. The onions for the *soffritto* should be chopped to the size of the rice grains so that the onion cannot be distinguished from the rice in the finished dish. *Mantecatura* is the process of adding the parmesan cheese and cold butter into the risotto, off the heat, and mixing vigorously.

To make *Risotto alla Milanese*, it is important to use fresh ingredients for the stock or broth. The stock has to be very tasty and enriched with vegetables, fresh herbs, cloves, cinnamon, nutmeg, and grated orange peel.



Risotto alla Milanese (serves 4)

Ingredients

Stock:

4.5 liters water
300–400 g or one whole hen
250 g beef
2 large onions
2 stalks celery
2 cinnamon sticks
1 carrot
1 large potato
1 zucchini (courgette)
1 tsp white pepper (whole pepper corns)
1 tsp cloves
1 tablespoon rock salt
Peel from ½ orange
A small bunch of parsley, rosemary, thyme, and bay leaves

Directions

Place all the ingredients in a large saucepan and boil for about 2 hours, skimming the broth when necessary. Filter when done.

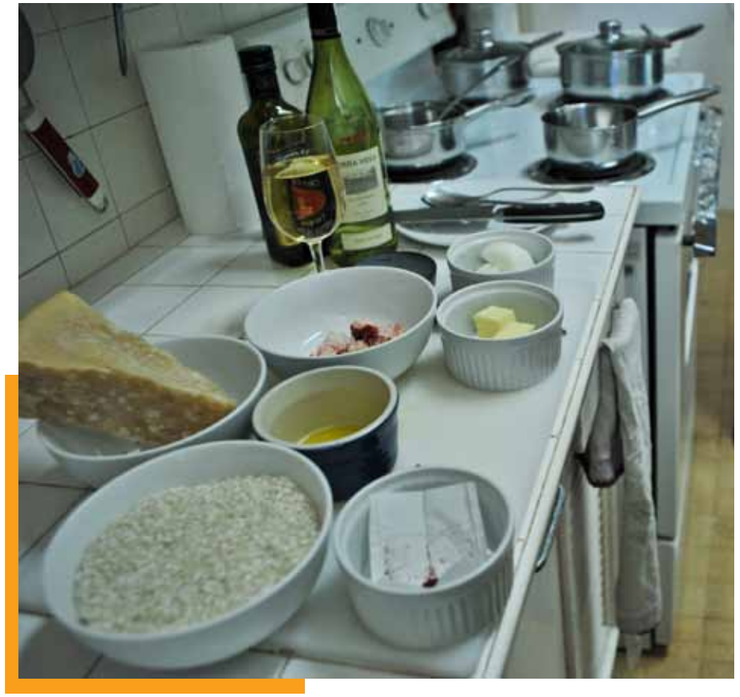
Risotto:

2.5 liters stock
320 g Carnaroli rice
60 g grated parmesan cheese
40 g unsalted butter
2 tsp extra-virgin olive oil
2 large spoons bone marrow (optional)
1 tsp saffron threads
1 packet saffron powder (preferably from Abbruzzo, Italy)
1 small yellow onion, chopped to the size of rice grains
1 glass dry white wine
Salt and pepper to taste

Directions

Put two ladles of stock with the saffron in a separate pan, and keep hot.

In another pan, boil the dry white wine for 2 minutes until the alcohol evaporates. Keep hot.



In a large pan, put in the olive oil, one teaspoon of butter (keep the remaining butter at cold temperature), and chopped onions. Cook over medium heat and stir for 6–8 minutes until the onion becomes soft. Add the rice and stir for 2 minutes until it becomes slightly translucent. Then add the white wine. Mix until the wine is absorbed by the rice. From this moment, the rice will take 15–16 minutes to cook "*al dente*."

Add a ladle of stock and cook, gently stirring from the center to the side; turn up the heat a little if necessary. Continue adding the stock, ladle by ladle, while stirring, allowing the rice to cook and the stock to be absorbed each time.

Add the saffron stock and continue to stir until the rice absorbs the stock. The risotto should have a creamy texture; as Italians say, "*all' onda*" (wavy)—which is caused by the starch coming out of the rice. Keep it creamy by stirring gently. Add the bone marrow and powdered saffron, and stir.

Taste the dish. If it is not cooked, add more broth, and continue cooking until it becomes *al dente* or when there is a slight crunchiness in the middle of the rice. Check the seasoning with care.

When ready, remove the pan from the heat and start the *mantecatura*. Add the parmesan cheese and the rest of the butter. Stir well for about 2 minutes. Now the risotto becomes very creamy.

Garnish with some grated parmesan. Serve immediately.

Luigi Concetti is a chef by training and currently consultant with Food and Housing Services at IRRI. He arrived in Los Baños in 2009 with his wife, Fiona Hay, genetic resources expert at IRRI. He has had experience setting up a number of restaurants in his home country of Italy. Living in the Philippines, he has enjoyed trying the local cuisine as well as that of other countries that he has visited since coming to Asia—including different varieties of rice.

Buon appetito!

Watch Luigi demonstrate how to prepare this delicious dish in a 6-minute video on Youtube at http://sn.im/risotto2.

COUNTRY HIGHLIGHT:

GERMANY AND IRRI

by **Bianca Paula Ferrer**

Germany's government and scientists have supported the International Rice Research Institute's (IRRI) rice research for more than 40 years. The country does not grow rice but it recognizes the importance of supporting rice research to meet global development goals.

German government funding to IRRI began in 1974. Currently, most of IRRI's funding is received through the Federal Ministry of Economic Cooperation (BMZ), both as unrestricted funding to CGIAR, which flows to the Global Rice Science Partnership (the CGIAR Research Program on Rice), and in the form of collaborative projects through the German Agency for International Cooperation (GIZ).

IRRI-Germany partnership

The first IRRI-Germany scientific cooperation began in 1966 when a research fellow came to IRRI to work on bacterial leaf streak in rice. In the years that followed, German experts continued to shape IRRI's research strategy and ensure the quality of its scientific output.

Under Dr. Klaus Lampe, who served as director general from 1988 to 1995, IRRI identified a new strategy for the 21st century and drew up a new organizational structure. Since then, all of the Institute's research became program-oriented and several new frontier activities started under his leadership.

Overall authority for IRRI's mandate and mission is vested in a Board of Trustees (BOT) composed of 15 members who are selected based on eminence in their respective fields, be it science, finance, or management. German nationals who served on IRRI's BOT were Dr. H.W. Scharpenseel of the Institute of Soil Science at the University of Hamburg (1978 to 1983); Dr. D.F.R. Bommer of the German Council for Tropical and Subtropical Agricultural Research (1988 to 1993); and Dr. Kay Beese of the European Commission for Health and Consumer Protection (2002 to 2005).

In 1982, Dr. H.U. Neue joined IRRI as a soil chemist. From 1987 to 1996, he was head of the then Soil and Water Sciences Division. Several collaborative research projects at that time brought many young German scientists to IRRI, mainly working on crop physiology, pest management, soil science, microbiology, nutrient management, agricultural engineering, and economics.

IRRI's Deputy Director General for Research Achim Dobermann, who is also a soil nutrient specialist, first joined IRRI in 1992 to lead several regional activities in Asia on developing more efficient nutrient management technologies. Dr. M. Becker and his team worked on green manure for rice systems while Dr. Reiner Wassmann, seconded from the Fraunhofer Institute, led IRRI's research activities on methane emissions from rice in the 1990s and is now IRRI's climate change coordinator.

German senior and junior experts work at IRRI through the Center for Migration and Development (CIM). In total, 32 Germans have worked at IRRI, and the Institute currently employs four German nationals.

CIM also provides training support for IRRI's postdoctoral program and is an avenue for exchanging expertise. As of 2012, 58 German scholars and 17 trainees had come to IRRI. Thirteen German scholars earned MS degrees, 19 PhDs, 2 completed their BS degrees, 11 were on-the-job trainees, and 13 were interns. IRRI currently supports five German scholars.

GERMAN STUDENTS get involved in taking measurements of greenhouse gas emissions from rice.

ISKGANI SERRANO

IRRI also received support for specific activities from the Konrad Adenauer Foundation, the German Academic Exchange Service (DAAD), the Volkswagen Foundation, the von Eiselen Foundation, and the German Research Foundation (DFG). In recent years, IRRI has also received support from or entered into research collaboration with German companies such as Bayer CropScience and Yara GmbH.

IRRI is also supported by the European Union (EU), of which Germany is a member.

Current rice research activities

With its strong technical expertise and resources, Germany continues to be an invaluable partner in IRRI's mission of creating and delivering innovative rice science worldwide. Germany's core funding to CGIAR underpins all IRRI's work and is essential to its ongoing core activities. The following projects are currently supported by Germany:

Breeding better rice varieties

One of the programs supported by Germany through BMZ aims to develop new rice varieties that are tolerant of flooding during germination in direct-seeded systems. In another BMZ-supported project, IRRI collaborates with the Leibniz Institute of Plant Genetics and Crop Plant Research to develop drought-tolerant varieties that are also flood-proof. These will be field tested in several Asian and African countries.

Germany does not grow rice but it recognizes the importance of supporting rice research to meet global development goals.

A joint scientific know-how and exchange program with Bayer CropScience aims to strengthen IRRI's rice breeding efforts by improving the use of rice genetic diversity, disease management in rice, and capacity building in rice breeding, biotechnology, and physiology.

Germany also supports IRRI and other partner institutions in the Hybrid Rice Development Consortium in improving genetic materials and related research on hybrid rice.

Supercharging rice

IRRI collaborates with the Heinrich Heine University-Düsseldorf in the C_4 rice project. This project aims to develop C_4 rice with 50% higher yield while using less water and nitrogen by identifying the mechanisms underlying C_4 photosynthesis.

Reducing postharvest losses

BMZ supports IRRI in developing a highly efficient solar greenhouse rice dryer. The dryer aims to reduce postharvest losses and aflatoxin or mycotoxin contamination in rice caused by improper drying. IRRI works in partnership with Hohenheim University in this project.

Tackling climate change

IRRI and other German research institutions are studying the different impacts on carbon, nitrogen, and water of flooded and nonflooded rice. With BMZ support, IRRI is also investigating greenhouse gas emissions from rice where farmers use water-saving technologies. And, to safeguard rice from a rapidly warming climate, IRRI works with the Max Planck Institute of Molecular Plant Physiology to develop heat-tolerant rice varieties in another BMZ-supported initiative.

Developing future rice production systems

Partly supported by Bayer CropScience, IRRI is exploring mechanized systems in maximizing the use of natural resources (such as land and rainwater) and external inputs (such as nutrients and labor). The Helmholtz Centre for Environmental Research also supports IRRI in developing ways to improve the ecological diversity of rice farms to combat pests.

With the help of the Max Planck Institute of Molecular Plant Physiology, IRRI's initiative in South Asia aims to boost the development and deployment of new varieties, enhance the adoption of sustainable crop and resource management technologies, and become a catalyst for sound policies to drive economic growth.

Ms. Ferrer is a public relations specialist at IRRI.

MS. AFOLABI Oluwatoyin Oluwakemi (*far right*), research assistant at AfricaRice Center, is training young researchers how to detect bacteria that cause diseases in rice.

P. RAMAN, AFRICARICE (2)

DECODING PATTERNS OF CLIMATE CHANGE AND RICE DISEASES

by **Savitri Mohapatra**

A study in East Africa seeks to quantify yield losses that are caused by rice diseases under various climate conditions

International and national rice pathologists, who gathered recently for a training workshop in Burundi, were surprised to find symptoms of an important rice disease called bacterial leaf streak during their field visit. "The presence of bacterial leaf streak of rice was never reported before in this East African country," said Drissa Silué, senior pathologist at the Africa Rice Center (AfricaRice).

His team has also recently detected the symptoms of bacterial sheath rot of rice for the first time in Senegal in West Africa. "Farmers in northern Senegal were desperate as their rice crop was being devastated by this 'mysterious' disease and asked us for help," said Ms. Afolabi Oluwatoyin Oluwakemi, research assistant in the AfricaRice Plant Pathology Unit, who visited the farmers' fields to examine the problem and collect samples.

"These are seedborne diseases," remarked Dr. Silué. "Although we cannot rule out climate change as one of the factors. We are testing them further to identify disease-resistant rice varieties and management practices, which can be recommended to farmers."

Plant diseases and pests are strongly influenced by changing weather patterns in the same way that many infectious diseases of humans and animals are climate-sensitive. The relationship between weather and diseases has long been recognized, but the reality of climate change has now added a new complexity. Researchers are seeking to better understand the relationship between climate and disease occurence and patterns to forecast disease outbreaks and develop control strategies.

With warming occurring in some regions, experts think that changes in temperature, rainfall patterns, and extreme events could exacerbate the spread of crop diseases and alter the pest-plant relationship. For example, symptoms of brown spot and narrow brown leaf spot are now increasingly seen in farmers' fields in West and East Africa. Dr. Silué wonders if climate change is responsible for this.

Unknown and unexpected crop disease occurrences, such as the ones mentioned above, are projected to increase and some minor diseases may become major problems in areas where they were previously insignificant. A case in point is sheath blight of rice, which had been a minor disease in Asia, but is now a serious problem.

Such changes have potentially serious implications for food security. The negative impacts of climate change are also aggravated by poverty and population explosions still occurring in developing countries.

Helping rice farmers in East Africa

"To date, little research has been done focusing on Africa regarding the potential consequences of global warming on agriculture," said Dr. Paul Kiepe, AfricaRice regional representative for Eastern and Southern Africa and focal point for the CGIAR Research Program on Climate Change, Agriculture, and Food Security (CCAFS).

"New climate-resilient varieties and crop- and resource-management technologies may help smallholder farmers adapt to the rapidly changing environments," he added. "Mitigation opportunities are also very important."

To help these farmers, AfricaRice is carrying out a 3-year project, *Mitigating the impact of climate change on rice disease resistance in East Africa*. This is being done in collaboration with the University of Göttingen and Erfurt University of Applied Sciences of Germany, International Rice Research Institute, National Agricultural Research Organization and National Crops Resources Research Institute of Uganda, Rwanda Agriculture Board, and Uyole Agricultural Research Institute of Tanzania.

The project is supported by the German Federal Ministry for Economic Cooperation and Development and German International Cooperation. Complementary funds from CCAFS are used to support climate change related activities.

It covers three countries in the Great Lakes region: Uganda, Rwanda, and Tanzania. According to the Intergovernmental Panel on Climate Change, this is one of the regions in Africa that are most vulnerable to climate change.

"Focusing on East Africa is necessary because information on rice diseases here is very scarce," said Dr. Yacouba Séré, former AfricaRice plant pathologist, who has designed and partly managed the project. "The effect of climate change on rice disease propagation and severity is not well known. This project will hopefully close the knowledge gap through strategic and applied research."

Project researchers are mapping and quantifying the impact of climate change on rice yield loss due to two important rice diseases prevalent in the region—bacterial leaf blight and blast. They are also investigating rice-pathogen interactions under different climate scenarios and identifying resistance genes. Researchers are also exploiting farmers' indigenous knowledge of local rice diseases and any climate change experiences farmers may have already observed.

Project results will allow plant pathologists and breeders to determine what these pathogen strains are, where and when they occur, and if climate change has any effects on their severity. Eventually, this will lead to the development of regional varieties resistant to these strains of blast and bacterial leaf blight and concomitant management practices with climate change in mind.

Once the team identifies effective genes with resistance to these diseases, they will be transferred through marker-assisted selection into high-yielding mega varieties currently grown by the farmers.

Building capacity

The project team is also strengthening the capacity of national partners in disease monitoring, bacterial disease diagnosis, pathogen analysis, simulation modeling, and matching of pathogens with resistance genes. For farmers, the team has organized training to show them how to assess injuries caused by diseases, animal pests, and weeds.

Six MSc and three PhD students, who are actively involved in the project's activities, will be contributing scientific papers on the effects of climate change on the pathogenicity of these two diseases and on the region's rice production.

SCIENTISTS IN Africa are working toward developing rice varieties with resistance to diseases such as blast.

Initial results

The project team has assessed the extent of bacterial leaf blight and blast disease problems in the three countries and has obtained some basic information on pathogen distribution and diversity. Initial results indicate that the *Pi9* gene is effective against blast populations tested so far.

The researchers have checked rice disease-inflicted yield losses under various climate conditions using a combination of simulation models (RICEPEST and EPIRICE) and climatic data in Tanzania, Uganda, and Rwanda. Preliminary results show that, in Tanzania, yield losses caused by bacterial leaf blight significantly increased under all climate scenarios studied. Blast, on the other hand, is predicted to have an insignificant effect on yield under the same scenarios. The simulation for Rwanda and Uganda is ongoing.

These results are being validated using field data and will be available through a public-accessible Web-based mapping application.

According to Dr. Kiepe, these efforts to study climate-change impacts on rice and the resulting adaptation and mitigation strategies will create a range of solutions to help build climate-resilient food systems that will significantly increase Africa's food security.

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

Rice Today & Uruguay's president

by **Neil Palmer**

You may remember reading an article in the July-September 2012 issue of *Rice Today*, documenting Uruguay's rice sector and the impressive gains in productivity it has seen in recent years.

I wrote the piece after accompanying a delegation from the Global Rice Science Partnership (GRiSP) to the town of Treinta y Tres, in the heart of the country's rice-growing region. With increases in yields of up to 25% in just a few years, the GRiSP scientists wanted to know the secret of the country's success with rice, and so did I.

We learned about a unique system of trust, transparency, and vertical integration in Uruguay's rice industry that has enabled the crop to flourish. A three-hour flight in a small plane over the spectacular paddy fields in the east of the country was the perfect way to end the trip.

But that wasn't the end.

The Spanish-language *BBC Mundo* used the article as the basis for an in-depth feature published in advance of international coverage of the Global Conference on Agricultural Research, which by coincidence was taking place in Uruguay in October. Happy that Uruguay was receiving attention for its success with rice, we thought that was that.

What we didn't realize was that the country's Rice Growers Association—making efficient use of *Rice Today*'s Creative Commons policy—had translated the article into Spanish and republished it in their quarterly magazine *Rice*, distributing it to their 500 members, and many other people and organizations. They were rightly proud that GRiSP—the world's largest coalition of rice experts—had singled the country out for praise, and wanted to share the good news.

AGÊNCIA BRASIL

URUGUAY PRESIDENT José Mujica, read on live radio a Spamish translation of a *Rice Today* article about his country's impressive gains in rice production.

But, in the Uruguayan media, a much bigger story was playing out at the same time. The country's flag carrier airline PLUNA—government-owned, and a great source of pride—had been on the brink of bankruptcy, and its seven planes were up for auction for US$137 million. When a deal with a private-sector buyer unexpectedly fell through, PLUNA collapsed.

Eager to hear what the president would say about the scandal, even more Uruguayans than usual tuned in to President José "Pepé" Mujica's popular weekly national radio address that week.

President Mujica is renowned for not being a "typical" president: a former guerrilla in the 1960s and '70s, he gives away most of his salary to charity, lives on a modest farm outside the capital Montevideo, and drives a 1987 Volkswagen Beetle. Perhaps his audience should have expected an unconventional broadcast.

But probably no one expected him to come on-air and read, from start to finish, an article he had recently seen that gave him and his country a reason to be proud—the Rice Growers Association's translation of the *Rice Today* article.

Gonzalo Zorrilla, former executive director of the Latin American Fund for Irrigated Rice (FLAR), which is coordinated by the International Center for Tropical Agriculture (CIAT), and now head of Uruguay's rice research program, found the sudden focus of attention on his country both surprising and well-deserved.

"It's very difficult for such a small country on the other side of the world from the rice 'big leagues' to be recognized for its achievements," Mr. Zorrilla said. "But the GRiSP meeting in Treinta y Tres, the article in *Rice Today*, the GCARD coverage, and the 'cherry on the cake' placed by the president, gave Uruguay's rice sector exceptional exposure.

"I've been in a good position to observe its remarkable evolution after more than 20 years as a rice researcher at INIA, Uruguay's national agricultural research program, and the last 7 years working in the whole region with FLAR and CIAT," he added. "So, I can say that the events of last year were an unexpected but very fitting tribute to the hard work and commitment of many, many people.

"Hopefully, the exposure given to Uruguay's rice sector will be useful for rice farmers around the world, for improving their own production."

Mr. Palmer is a communications officer at CIAT.

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PRESIDENT JOSÉ Mujica, known for his modest lifestyle, drives a 1987 Volkswagon Beetle.

NEIL PALMER (2)

"URUGUAY SERVES as an example and source of lessons for developing successful rice sector," says Gonzalo Zorrilla, head of Uruguay's rice research program.

URUGUAY'S HIGHLY successful model for rice production has attracted the attention of the world. In 2012, GRiSP brought representatives from about 20 countries to Uruguay to take a closer look at its successful agricultural strategies.

Game changers in the global rice market

by **Samarendu Mohanty**

India and China are new forces to reckon with in the global rice market

For the past four decades, the global rice market has been dominated by a few exporters, namely, Thailand, Vietnam, the United States, and Pakistan, accounting for 60–70% of the total exports. During this period, Thailand has remained the top rice exporter in the world. Unlike the export side, the import side looks quite fragmented, with many countries each importing a small amount of rice. The top six importers account for only 20–30% of the market share.

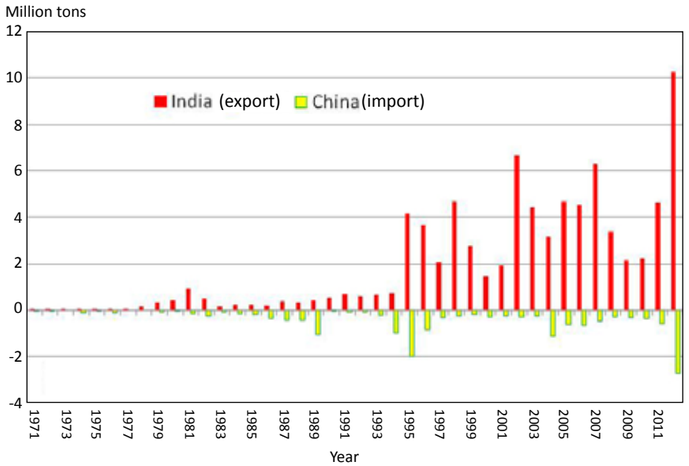

Fig. 1. The rise of India and China in global rice trade.
Source: PSD online database, USDA.

New roles for China and India

Through the years, both China and India, the top two rice producers and consumers in the world, have played a minor role globally with occasional exports and imports. Despite India's rise as an exporter since the mid-1990s, both these countries, which account for half of global rice production, have largely focused on domestic food security. Trade is an afterthought for these two giants and it is mostly used to manage occasional surpluses and deficits.

But, with India's meteoric rise to the top of the export chart and China's unexpected rise to near the top of the import chart in 2012 (Fig. 1), this might be a thing of the past. In 2012, India displaced Thailand from the top spot by exporting 10.4 million tons of rice vis-à-vis 6.9 million tons for Thailand. India's removal of its export ban on the nonbasmati market in late 2011 after a gap of 4 years, burgeoning domestic stocks, and a weak rupee definitely increased India's export prospects in 2012. But, Thailand's mortgage scheme should get most of the credit for India's rise to the top by making India's broken and parboiled rice fly off the shelves like hotcakes.

Like India, nobody expected China to come close to displacing Nigeria as the top importer in 2012, with 2.9 million tons of imports compared with 3.4 million tons by Nigeria. A majority of these imports have come from Vietnam and Pakistan. Apart from rice, China also imported large amounts of wheat and corn (maize) in 2012. Altogether, Chinese grain (wheat, rice, and corn) imports increased from 2.5 million tons in 2011 to 11 million tons in 2012 (Fig. 2). Tight corn supplies and greater demand for wheat from the feed sector increased their imports. But, it is still intriguing to many why China is importing so much rice because domestic production has no apparent shortfall in the past few years, and the carryover stocks (according to FAO and USDA) suggest that these stocks have been steadily rising since 2007. A plausible explanation, shared by many, could be that the large price spread between domestic and international rice prices is making it attractive for Chinese traders to import cheap foreign rice. Another reason could be that Chinese consumers are increasingly diversifying their food consumption, thus creating demand for different types of rice such as sticky rice from Vietnam, Jasmine rice from Thailand, and long-grain rice from Pakistan.

This raises another important question: Will China go back to its traditional insignificant role in the global rice market (low imports and exports) and India go back to its familiar territory of mainly exporting basmati rice and will self-sufficiency remain their primary motto? Or will they continue with the recent trend and evolve as dominant players in the global rice market in the coming years?

Both India and China have maintained their respective positions as dominant exporters and importers in the global rice market in the first quarter of 2013. From January to March 2013, China imported 692,200 tons of rice (according to oryza.com)

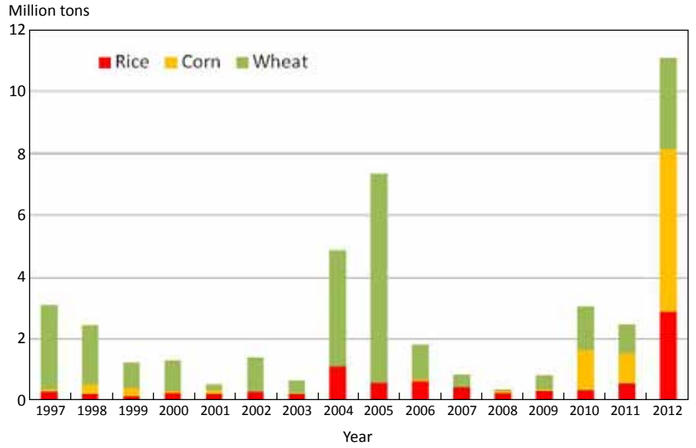

Fig. 2. Chinese grain imports (rice, corn, and wheat).
Source: PSD online database, USDA.

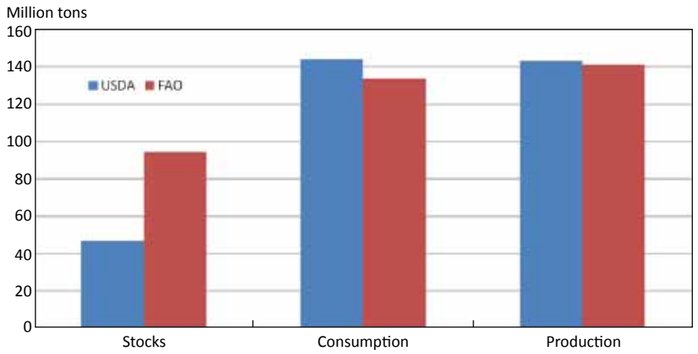

Fig. 3. Rice supply and use in China (2012-13).
Source: PSD online database (USDA) and FAOSTAT.

whereas India exported nearly 2 million tons of rice (data compiled from different sources). If this trend continues, they are likely to grab the top importer and exporter spots respectively by the end of 2013.

Some indications suggest that China and India are here to stay for the "long haul." In India's case, the government wants to move nonbasmati rice area from the northwestern states of Punjab and Haryana, which are plagued by water shortages and pest and disease problems, to eastern India. Several programs such as the National Food Security Mission, National Rural Livelihood Mission, and Bringing Green Revolution to Eastern India have been rolled out by the government to expand rice production in the eastern states, and the impact is already evident from the rapid rise in production in the last few years.

The Chinese government is also trying to expand rice production to keep up with the demand, but the rapidly rising costs of production and pressure on rice area from other competing crops are likely to keep imported rice a lot cheaper than producing rice domestically. Unless the Chinese government is strongly determined to achieve rice self-sufficiency through trade measures, it is reasonable to assume that Chinese imports will continue in the near term to mid-term.

Some implications

On the positive side, the greater participation of China and India in the rice market is likely to increase the volume of trade, thus making the market more stable. Ideally, the global rice market should account for 15–20% of total production compared with 6–8% now. On the other hand, both countries will bring greater uncertainty to the market as their politicians will continue to fiddle with domestic and trade policies to support farmers and achieve greater domestic price stability, and in the process bring volatility to the international market. India's export ban in 2007 on nonbasmati rice and its repercussions on the global market is a good example of how these countries can adversely influence the market. Similarly, Thailand has held the global market hostage through its rice pledging scheme, for which nobody knows how and when the mortgage stocks will rock the market.

In addition, the disparity in the estimates of Chinese supply and use data by two major sources (USDA and FAO) is likely to create problems in the functioning of the market if China remains in the global rice market as a dominant player for the long haul. For example, FAO projects Chinese rice stocks to be more than 50% greater than those of USDA in 2012-13 (94.2 million tons vs 46.2 million tons). In the past 3 years, the FAO estimates indicate more than a 20-million-ton rise in Chinese stocks compared with only 6 million tons in the case of USDA. The difference in domestic consumption between USDA and FAO estimates for China is more than 10 million tons.

All these disparities in supply and use data did not really matter as long as China was mostly self-sufficient and didn't trade much. But, accuracy and timely availability of this information will be essential for proper functioning of the market once China becomes a dominant player in the global rice market.

Dr. Mohanty is the head of the Social Sciences Division at the International Rice Research Institute.

Rice, health, and toxic metals

by Sarah Beebout

Arsenic, cadmium, mercury, and lead are four ubiquitous trace elements known to have a harmful effect on human health. These elements are naturally present at very low concentrations in the environment, and human bodies are able to detoxify them in limited amounts.

Most of what we know about toxicity of these elements comes from case studies of people who were exposed to the toxins through unrecognized pollution sources. In these cases, the people were exposed to the toxin through many ways such as air, water, and food simultaneously. So far, no evidence shows clearly that rice consumption, by itself, has had toxic effects on humans.

But, since the effects of long-term chronic exposure are not well known, people are concerned that rice consumption *might* expose them to these elements and endanger their health. This concern has led to interesting scientific investigation and discussion in the 7 years since I last wrote on this topic (see *Are we at risk from metal contamination in rice*? on page 38, Vol. 5, No. 3 of *Rice Today*).

Arsenic

Of these four elements, arsenic remains the biggest concern. Arsenic can move from the soil into rice grain, and rice produced in high-arsenic soil has higher arsenic than average. The arsenic in soil or irrigation water is sometimes high enough to inhibit plant growth, resulting in low yield. Scientists have already identified rice varieties that grow well in high-arsenic conditions and can minimize arsenic accumulation in the grain. So, plant breeding programs can potentially develop even safer varieties. Also, rice plants in more flooded soil (anaerobic conditions) take up more arsenic. So, an effective way to lessen arsenic uptake is to use moderately dryer growing methods through irrigation management. The relative toxicity of different chemical forms of arsenic is still debated. But, the science for differentiating among these forms is progressing rapidly. I hope that we will soon know which forms of arsenic are safer and which forms accumulate in rice grains under different conditions.

Cadmium

Cadmium is second as a public concern about toxins in rice. We know that rice plants can take up cadmium from polluted soil and produce grains with elevated cadmium concentration. However, very few reports have shown cadmium concentrations higher than the "allowable limit" for rice grains, even when they are grown in moderately polluted soil. But, not everyone agrees on what this allowable limit should be. Cadmium is known to be more likely taken up by rice plants when the soil is aerobic (the opposite of arsenic). So, one way to minimize cadmium uptake would be continuous flooding.

Studies to understand and identify the genes that control the movement of cadmium from rice roots into the grains are in progress including the identification of genes that essentially prevent cadmium from reaching rice grains. These genes can be helpful in plant breeding programs to ensure that all new rice varieties have a very low cadmium risk.

Mercury

The mercury content of rice has not received much public attention because of other more important food sources of mercury (most notably, fish). Mercury in rice is reportedly lower than "allowable limits"—with the same caveat that these "limits" are still under discussion.

A potential problem is that, although mercury in rice is lower than in fish, a large amount of rice consumed from some contaminated areas may be enough to raise the overall consumption of mercury to a worrisome level. Since moderate mercury contamination is widespread from coal-burning exhaust, some scientists have been investigating how mercury contamination affects rice. One of the more toxic forms, methylmercury, is formed in flooded or intermittently flooded soils and is sometimes present in rice grains. Some rice varieties are better than others at excluding mercury from the grains, but we don't know yet *how* they do this so we cannot recommend which varieties are the safest.

Lead

Lead, on the other hand, received the least public interest until last month, when an unpublished study indicating high lead in rice was presented at a scientific meeting, causing a publicity stir. However, these anomalously "high concentrations" have not been published scientifically, and the preponderance of published evidence so far indicates that very little lead accumulates in rice grains, even in areas with moderately polluted soil.

Conclusion

Consumers need not change their rice-eating habits based on any known risks from toxic elements. Scientists can now detect very low amounts of these elements in rice grains. Some studies are being done on how these elements move within soil and rice plants. We hope that these will enable us to develop even safer rice varieties and rice production techniques.

Dr. Beebout is a soil chemist at IRRI.

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Contact persons:
Eero Nissilä, email: e.nissila@irri.org
Elma Nicolas, email: e.nicolas@irri.org

Co-organizer and RG7 secretariat:
Kenes MP Asia Pte. Ltd.
Contact persons:
Marcel Ewals, email: m.ewals@kenes.com
Sharon Mascarinas, email: smascarinas@kenes.com

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