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International Rice Research Institute
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Rice genetics gets personal

Debunking Golden Rice myths
The revolution underground
Mapping the crop of the future
Cameroon: Central Africa's potential rice granary

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IRRI 2014 Wall Calendar

Feathers in the fields: The birds of IRRI

Feathers in the Fields:
THE BIRDS OF IRRI

20 IRRI 14

The 2014 wall calendar features a bevy of birds species living among the rice plots of IRRI's experiment station captured by the cameras of noted bird photographers Tirso Paris, Jr. and Segfredo Serrano. The stunning images represent a portion of their portfolios that Dr. Paris describes as their "addiction."

The photos are enriched with the commentary of Paul Bourdin and Richard Smedley. Mr. Bourdin has been bird-watching since childhood--and has lived and birded in many countries in Africa, Europe, and Asia. For the last 7 years, Mr. Smedley has been studying birds in the UK, his home country, South Africa, and the Philippines.

Price: US$ 10.00 plus shipping

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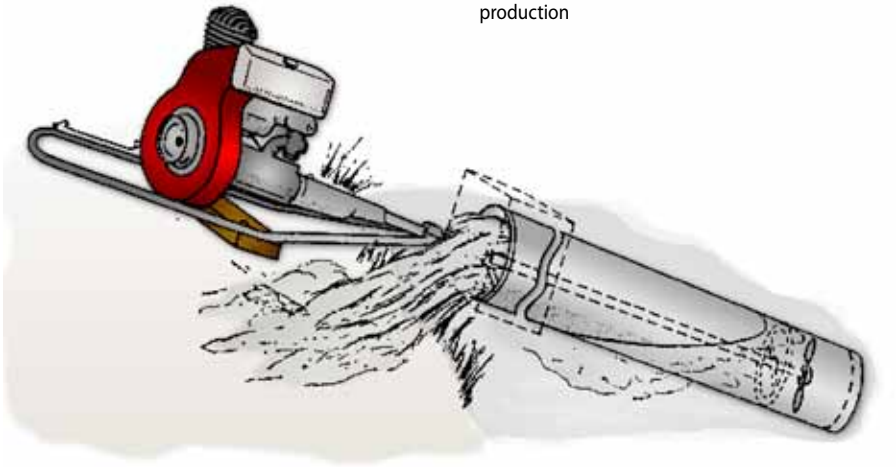

About the cover. By 2035, when the planet's human population is expected to surpass 8.5 billion, the world will require more than 100 million tons of additional rice. With a tighter race against time, rice scientists are turning to advancements in genetics to eradicate extreme poverty, hunger, and undernourishment, and sustain food security without irreversibly damaging the world's natural resources. (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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A legion of heroes

World Food Prize laureates Hank Beachell, Gurdev Khush, Yuan Long Ping, and Monty Jones have made their marks in staving off hunger by increasing rice productivity worldwide. But, even with their milestone achievements of developing high-yielding semidwarf rice varieties and hybrid rice, the challenge of defeating hunger continues. Only now, it is an even tighter race against time to increase rice production.

By 2035, when the planet's human population is expected to surpass 8.5 billion, the world will require more than 100 million tons of additional rice. It takes around 10 years to breed a new rice variety, meaning that 2035 is just two conventional breeding cycles away—not much time from a breeder's perspective.

With such a daunting challenge, we cannot count on just a few heroic rice scientists to save the day; we need what I would call a legion of heroic scientists—all working together like the IRRI staff members in the photo below!

In November, the 7th International Rice Genetics Symposium in Manila, Philippines, will gather many of the world's best rice researchers, experts, and representatives from the public and private sector to share their knowledge and experience on advancements in rice genetics, a cadre of current and future heroes!

So, *Rice Today* is focusing on rice genetics and how it is helping fast-track the development of improved varieties (see *Rice genetics gets personal*).

Thanks to modern breeding using our understanding of genetics, Golden Rice has been developed. It contains a source of vitamin A and has the potential to help reduce the devastating effects of vitamin A deficiency, especially among poor rice consumers. To help clear up misconceptions about Golden Rice, Dr. Michael Purugganan, an authority on plant evolutionary and ecological genomics, confronts some misconceptions in *Debunking Golden Rice myths: a geneticist's perspective.*

We also focus on what some of our modern-day rice heroes are working on. A team of plant breeders and pathologists continues to work together to improve resistance against bacterial blight disease (see *Beating blight).* Green Super Rice, a type of rice that thrives under less than perfect conditions, is now making its way to farmers' fields. This has been made possible because of new breeding tools and the excellent collaboration of IRRI scientists and their partners (see *Breeding for tough times ahead*).

Elsewhere, in Africa, the Cameroon government has deployed strategies and policy measures to increase its rice production and make it more competitive in the market. See *Cameroon: Central Africa's potential rice granary.*

Want to know some more about farm mechanization and its progress? A feature on the *Not-so-silent revolution* has a historical perspective on small machines in postwar Vietnam while *Laser-guided dreams* is a story about how laser-leveling is changing lives in Vietnam today.

We also get up close and personal with two scientists, worlds apart but with a common passion, who ended up being more than laboratory partners in *For the love of rice.*

In *Breaking the barriers: from housewives to breadwinners,* IRRI economist Sam Mohanty tells the tales of three Indian women who have risen above cultural stereotypes and are helping other village women improve their economic conditions.

Will rice production in India or throughout South Asia see a brighter scenario in 2035-40? *Mapping the crop of the future* offers a glimpse into the yield gains of C_4 rice in the region through simulation models.

I hope you enjoy these and other features and appreciate the efforts and contributions of the "heroes" who have been working toward finding solutions to the challenges of feeding the world.

Lanie Reyes
Rice Today managing editor

Improved rice brings mixed results in Uganda

T BERHE, ATA, ETHIOPIA

WHILE WOMEN benefit from the equal partnership and higher production that NERICA varieties bring, they also take on more burdensome work.

The introduction of improved upland NERICA rice varieties has not only improved rice production in Uganda but has also provided many women farmers with more bargaining power with their husbands, says an article in the *Journal of Eastern African Studies.*

In Uganda, men traditionally produce high-value cash crops and women produce low-value food crops. Since rice is a high-value food crop produced by both sexes, women are treated as partners in its production—and not just as free family labor.

But, a gender analysis offered a more complicated picture as women and children take on the most burdensome tasks related to rice cultivation. Thus, women are exhausted and unable to perform other tasks, while their children have to miss school.

Source: www.cigar.com

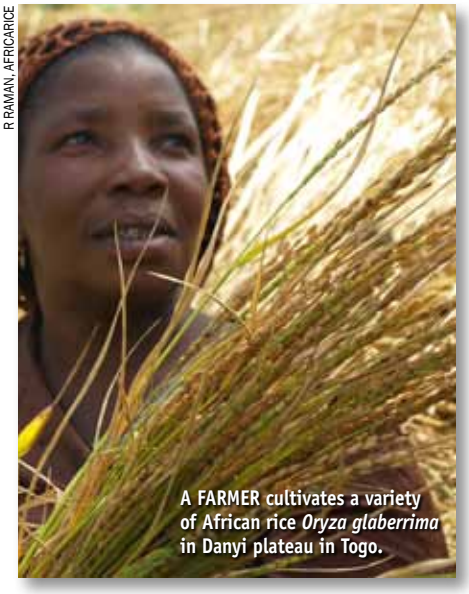
New project to boost rice yield in African countries

Researchers from the Support for Agricultural Research and Development of Strategic Crops (SARD-SC) project attended the 6th African Agricultural Science Week in Accra, Ghana. The event aimed to draw more support from partners for SARD-SC to raise agricultural productivity in 20 African countries.

Project coordinator Dr. Chrysantus Akem of the International Institute of Tropical Agriculture said that narrowing the yield gap is key to helping millions of African farmers compete globally and feed themselves. The project aims to reduce food importation and offer farmers better access to markets, to improve livelihoods, and to tackle poverty through empowered beneficiaries.

With funding of US$63 million from the African Development Bank, SARD-SC will work with farmers in Benin, Côte d'Ivoire, DR Congo, Eritrea, Ethiopia, Ghana, Kenya, Lesotho, Madagascar, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, Sudan, Tanzania, Uganda, Zambia, and Zimbabwe.

Source: http://reliefweb.int



R RAMAN, AFRICARICE

A FARMER cultivates a variety of African rice *Oryza glaberrima* in Danyi plateau in Togo.

Endangered African rice showcased at 2013 Africa Agriculture Science Week

The CGIAR booth at the 6th Africa Agriculture Science Week featured samples of the African rice *Oryza glaberrima* from the AfricaRice genebank. This African rice, which is threatened with extinction, is a rich reservoir of genes for coping with local stresses in adapting to climate change that could potentially strengthen food security. The booth also showcased seeds of five recently released ARICAs, upland and lowland NERICAs, and the Sahel series developed by AfricaRice and its partners.

The science event held in Ghana was attended by more than a thousand delegates from across Africa and scientists and experts from various CGIAR centers and research programs. This year's theme was Africa feeding Africa through Science and Innovation.

Source: http://africarice.blogspot.com

Work on Golden Rice greatly supported

On 8 August 2013, 300 militants stormed the Department of Agriculture Experiment Station in Bicol, Philippines, and vandalized a field trial site of Golden Rice. The damaged trial site was less than 1,000 square meters and nearly all the plants were uprooted. As a result, the trial, which was being conducted by the Philippine Rice Research Institute and the International Rice Research Institute (IRRI), had to be terminated.

The trials were approved by the Department of Agriculture Bureau of Plant Industry, the national regulatory authority in the Philippines for crop biotechnology research and development, after establishing that the trials would pose no significant risks to human health and the environment.

PHILIPPINE DEPARTMENT OF AGRICULTURE REGIONAL FIELD UNIT V

A FIELD trial site of Golden Rice was vandalized in Bicol, Philippines.

Renowned scientists, writers, and the general public from all over the world denounced the act and expressed their support for the work on Golden Rice. Notably, an online petition supporting Golden Rice was launched just days after the incident. More than 6,000 people have signed the petition so far (see http://sn.im/golden-rice-petition).

IRRI and its partner organizations remain committed to helping improve health and nutrition in the Philippines, Bangladesh, and other rice-eating countries.

Golden Rice is a new type of rice that contains beta carotene, which is converted to vitamin A when eaten. The field trials are an important part of the project to determine whether Golden Rice can be a safe and effective way to reduce vitamin A deficiency in the Philippines. Vitamin A deficiency in the country affects approximately 1.7 million children aged 6 months to 5 years and one out of every ten pregnant Filipino women. Research indicates that eating a cup of Golden Rice a day could provide half of the vitamin A needs of an adult.

Despite the vandalism, the fight against malnutrition continues. IRRI and its partner organizations remain committed to helping improve health and nutrition in the Philippines, Bangladesh, and other rice-eating countries.

Source: www.irri.org/goldenrice

Climate change-ready rice for Malaysia

The Malaysian Agricultural Research and Development Institute launched a new rice variety to help boost Malaysia's rice production amid climate change. The new variety, MRIA 1, exhibits heat tolerance and requires less water. Agriculture and Agro-based Minister Datuk Seri Ismail Sabri Yaakob said the new variety would help increase the nation's rice production while adapting to climate change. MRIA 1 is highly recommended to farmers with little access to water supply. Also, it matures in 90 days, has more disease resistance, and can be planted during the off-season.

Source: www.nst.com.my

World's first high-zinc rice released in Bangladesh

BRRI dhan 62, the world's first zinc-rich rice variety has been released in Bangladesh and will be available to farmers in time for the aman season of 2014. BRRI dhan 62 has 20 to 22 parts per million (ppm) of zinc while the average zinc content of rice is 14 to 16 ppm. The variety was developed using conventional breeding methods by scientists at the Bangladesh Rice Research Institute (BRRI) with support from HarvestPlus, which leads a global effort to develop more nutritious varieties of staple food crops. HarvestPlus is a part of the CGIAR Research Program on Agriculture for Nutrition and Health. The new variety was developed from the zinc-rich rice parental germplasm produced at the International Rice Research Institute (IRRI).

ZINC-RICH rice will help improve the health of the children in Bangladesh.

ISAGANI SERRANO, IRRI

The high-zinc rice could help decrease zinc deficiency in Bangladesh.

Bangladeshi children suffer from high rates of deficiencies in micronutrients, including zinc: more than 40% of Bangladeshi children under five are stunted while 44% of the same age group is at risk for zinc deficiency. Levels of zinc inadequacy in the diet of most Bangladeshis range from 20% to more than 90%. Zinc deficiency is a major cause of stunted growth, for lack of development, and for deaths from diarrheal diseases in children. It is predicted that regular consumption of zinc-rich rice could halve these dietrary inadequacy levels.

More than 40% of Bangladeshi children under five are stunted while 44% of the same age group is at risk for zinc deficiency.

BRRI Director General Md Syedul Islam said that the zinc-rich rice variety also surpassed BINA dhan 7 and BRRI dhan 33, two of the country's best performing early-maturing varieties for aman. These two varieties mature in 110–120 days while BRRI dhan 62 can be harvested in only 100–105 days.

In addition, a field trial of a zinc-rich rice variety being developed for the boro season has been successfully completed, according to Alamgir Hossain, the main breeder behind BRRI dhan 62. Dr. Hossain, who is currently a breeder at IRRI, added that this zinc-rich rice for the boro season will be submitted for approval to the National Seed Board soon.

Through international collaboration led by IRRI, similar zinc-rich rice varieties are expected to be introduced in Cambodia, Indonesia, the Philippines, and Vietnam.

Source: www.thedailystar.net

Rice could play a role in reducing diarrhea

A team of researchers designed a new strain of genetically engineered rice, which could potentially fight rotavirus that causes severe diarrhea. MucoRice-ARP1 contains the antibody arp1, originally found in llamas, that has been clinically proven effective to protect against the deadly virus.

If proven safe for human consumption, this rice could complement vaccines and be given to children under two years old when they are most vulnerable to the viral infection. Severe diarrhea in young children and infants is fatal and accounts for 520,000 deaths each year, according to the World Health Organization.

Miren Iturriza-Gomara, a virologist at the UK-based University of Liverpool and one of the research authors, says rice is a cost-effective way for delivering the antibody because it is a widely produced staple food.

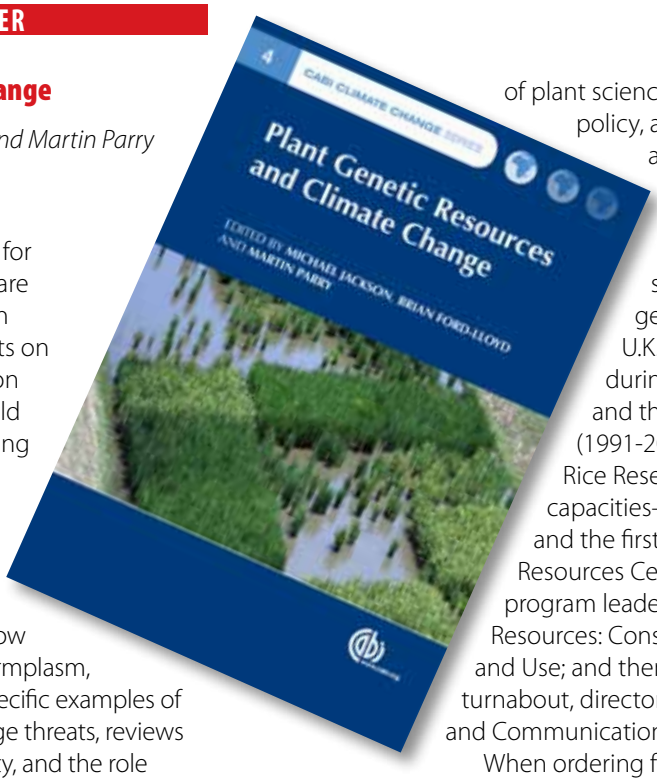
Source: www.scidev.net.

FOR RELEASE IN DECEMBER

Plant Genetic Resources and Climate Change

Edited by Michael Jackson, Brian Ford-Lloyd, and Martin Parry

Published by CABI. 288 pages.



Climate change is an enormous challenge for societies worldwide. Many plant species are temperature sensitive; predicted increases in global temperatures will have adverse effects on our environment and put increasing stress on agriculture. With so many people in the world still without access to adequate food, ensuring global food security continues to be a big challenge.

This book tackles the changes that global warming is predicted to create over the coming decades, the effects of climate change on potential food production, and how it will affect conservation and use of crop germplasm, both in and ex situ. In addition, it includes specific examples of germplasm research related to climate change threats, reviews of abiotic stresses such as drought and salinity, and the role of crop wild relatives and their untapped genetic diversity in improving modern crops.

Bringing together the latest perspectives about how plant genetic resources can contribute to achieving food security, this book is a valuable resource for researchers and students of plant sciences and agricultural policy, as well as anyone with an interest in climate change.

The lead editor, Dr. Michael T. Jackson, started his career in genetic resources in the U.K. and Latin America during the 1970s and 80s and then spent 19 years (1991-2010) at the International Rice Research Institute in various capacities—germplasm specialist and the first head of the Genetic Resources Center (created in 1991); program leader for Rice Genetic Resources: Conservation, Safe Delivery, and Use; and then, in a complete turnabout, director for Program Planning and Communications.

When ordering from CABI online (http://bit.ly/1gRykCZ), purchasers can use this code (CCPGRCC20) for a 20% discount off the retail price. The discount code is valid until 31 December 2013.

The standard prices are £85.00, US$160.00, or €110.00. The discounted prices are £68, $128, or €88. ■

TRAINING COURSES AT IRRI

Course title	Date	Venue
Scientific Writing Workshop	14-18 October	IRRI, Philippines
Rice: Postproduction to Market Training Course	28 October-8 November	IRRI, Philippines
Ecological Management of Rodents, Weeds, Insects, and Birds in Rice Agroecosystems Course	4-15 November	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.

RiceToday around the world

RICE IN the city. Singapore Science Centre staff Lee Song Choon (*far left*) and Savita Sharma (*third from right*) as well as IRRI Fund Singapore Executive Director Ian Chen Leo (*far right*) are working together to promote rice science in Singapore. Through a rice-growing competition, students and teachers from the Anglo Chinese School and Dunman Secondary School had a chance to have hands-on experience in cultivating the staple food of half the world's population.

A CLASS act. Students from the United World College of South Asia in Singapore enjoy *Rice Today* during a Geography Department's party. (*From left to right,* Debra Mcwhirter, Tim Shepherd, Paul Brogden, Kate Lewis, Dan Orr, Simon Bignell, and Nathan Hunt.) Nathan says that they also find *Rice Today* articles very useful in their geography and ecology courses.

RICE TODAY, paiting! *Paiting* is a Konglish (nonstandard abbreviations or combinations of English words invented by Koreans) term derived from fighting. It is used to encourage someone, often in sports or whenever facing a challenge. This expression is usually accompanied by a fist pump, a gesture denoting enthusiasm, exuberance, or victory—shown here by members of the Korean Women's Association in the Philippines, together with IRRI scientist Joong Hyoun Chin and his wife, Jeehyoung Shim-Chin (*second from left*), as they cheer and rally for *Rice Today*.

Debunking Golden Rice myths: a geneticist's perspective

by **Michael Purugganan**

A leading authority on plant evolutionary and ecological genomics confronts the misconceptions about Golden Rice with cold, hard facts

ISAGANI SERRANO (2)

It all started in 1984 in Los Baños, Laguna, in the Philippines. Scientists had begun to develop an exciting new approach to breeding crops—genetic engineering—and everyone wondered how it could be used to help the world.

In a house in this college town sat several breeders who were dreaming of what traits they could come up with using this exciting new technology. Increase yields? Develop crops to survive droughts? Protect rice against pests?

One breeder, who developed many of the Green Revolution crops that had saved hundreds of millions from famine, gave a startling answer: yellow rice. Why? Because, he said, vitamin A deficiency afflicts millions of people around the world.[1]

Finding answers to global malnutrition

How bad is vitamin A deficiency? In 2005, for example, the devastating effects of lacking this one vitamin affected 190 million preschool children and 19 million pregnant women in 122 countries. Each year, it is responsible for up to 2 million deaths and 500,000 cases of irreversible blindness.

Rice could substantially reduce the devastating impact of vitamin A deficiency because in many developing countries—the Philippines among them—the poorest families lack the means to buy the vegetables and fruits that contain this crucial nutrient. They can afford nothing more than plain white rice.

There is only one problem. Rice is not usually a source of vitamin A. While many fruits and vegetables have the genes to make this vitamin, neither rice nor any of its close wild relatives have these genes. Traditional breeding in rice is useless in the fight against this deadly vitamin deficiency. It would take genetic engineering to help solve the problem of making rice produce its own source of vitamin A.

Golden Rice, from dream to reality

Today, we are there. The dream of yellow rice—now dubbed Golden Rice—has gone from a rice breeder's dream to actual rice plants that can be grown in fields.

Golden rice promises to help reduce the deaths and blindness that come with not getting enough vitamin A in poor communities around the world. As we try to improve the nutrition of poor families across the country, Golden Rice can help alleviate the health scourge of vitamin A deficiency. Studies have shown that one cup of Golden Rice could provide around 50% of the recommended vitamin A that an adult needs for a day.

We are there—that is, if we are not misguided enough to turn our backs on this important technology.

Recently, activists stormed a research field in Bicol on southern Luzon island in the Philippines and destroyed one of several field trials of Golden Rice, potentially setting back the delivery of this humanitarian crop. It was a criminal act against a project whose only goal is to help elevate the health of the world's poorest people.

[1] That person was Peter Jennings, the first breeder at the International Rice Research Institute (IRRI). In an IRRI Pioneer Interview, Gary Toenniessen, a managing director of The Rockefeller Foundation and long-time IRRI collaborator, recalls this discussion among the breeders. Go to http://youtu.be/a7bGykLVm2E.

Many misconceptions exist about Golden Rice—too many to list them all here. But, as a plant scientist who works on rice, although not genetically modified rice, let me talk about three of them.

Myth 1: Golden Rice is "unnatural"

First is the notion that Golden Rice is some sort of unnatural, monster rice.

The truth is, in developing Golden Rice, geneticists have inserted only three genes into rice DNA to allow it to make beta carotene, which is a source of vitamin A. Three genes out of the more than 30,000 genes present in a rice plant. And, the genes they inserted to make the vitamin are not some weird manufactured material but are also found in squash, carrots, and melons.

So, there is nothing unnatural about the process—scientists just figured out how to take a gene from one species and add it to another's DNA. Plants do this in the wild all the time. It is called horizontal gene transfer, and plants, animals, and bacteria have been shown to acquire many genes from each other as they evolve.

Breeders actually do much more radical things to the rice genome and the rice plant by traditional breeding methods, and with much less information about what exactly they are doing to the rice plant's genes. We know a great deal more about the genes that were inserted into the Golden Rice by geneticists—what they do, how they act—than we know about thousands of genes and millions of mutations in rice.

Myth 2: GMOs are unsafe and risky

Second is the idea that genetically modified organisms (GMOs) are unsafe, cause cancer or other major health risks, or pose serious environmental problems.

Let me be clear here—the safety issue has been studied and discussed by scientists around the world, and they concluded that there is no evidence that GMOs are inherently unsafe. Let me repeat again. The most prominent scientific bodies in the world—among them, the U.S. National Academy of Sciences, the American Medical Association, the World Health Organization, and the Philippine National Academy of Science and Technology—have publicly concluded that GMOs are safe.

Now, it is true that we still have to test the safety of every new genetically modified plant variety that is developed—that is just common sense. In fact, GMOs are probably the most intensely tested and studied crop varieties in the world. Much more so than the seeds you buy from your local garden or farm store, which are released with no health or safety analysis.

But, you ask, haven't I read stories about scientists that have supposedly linked health problems—even cancer—to eating GMO foods? Well, the overwhelming majority of reputable scientists who have examined these claims have shown that such conclusions are simply wrong. These stories are based on research that was poorly designed and analyzed, and other scientists have strongly criticized these studies.

Myth 3: Golden Rice is a big business

Finally, there is the idea that Golden Rice is being developed to be sold by big biotechnology companies to profit from poor famers.

Again, let us be clear here: Golden Rice is a public project. While the company Syngenta helped develop Golden Rice, they have given it to the International Rice Research Institute (IRRI) for free—no costs, no fees, no royalties.

Golden Rice is now being bred by IRRI, in cooperation with the Philippine Rice Research Institute, and other public breeders around the world. The varieties that are developed will be turned over to government agricultural agencies in developing countries, which will then determine how to distribute them to farmers.

IRRI is not selling Golden Rice, and no big biotech company will make money out of it.

Critical juncture for the Philippines

Our country, and the world, is now at a critical point. The population of the planet will hit 9 billion people by 2050. The Philippines already has more than 100 million people. In the face of the decreasing land for farming, a growing population, and increasingly erratic climates, we need to use every tool we have, including agricultural biotechnology, to help our farmers and our people to survive and thrive.

Our scientists have helped develop Golden Rice varieties, as well as other genetically engineered crops, to increase our food security. Let us not turn our backs on this technology for the 21st century, and find ourselves once again at a technological and economic disadvantage.

Nearly 30 years ago, some of the best rice breeders in the world gathered in Los Baños and discussed harnessing biotechnology to help feed the world. What they dreamed up is now poised to become a reality that will help farmers produce more nutritious rice that can save lives.

Let us make sure that those who need it most can, for once, put gold on their plates.

Dr. Purugganan is a Dorothy Schiff Professor of Genomics and Dean of Science at New York University.

This edited version of the article is reprinted with permission from GMA News Online *and the author.*

NANCY CASTILLA, IRRI

Beating blight

by **Lanie Reyes**

With an ever-evolving pathogen and changing climate, scientists continue to improve defenses against bacterial blight

Unmindful of the heat and the humid air circulating from an industrial fan in the glasshouse, Casiana Vera Cruz, plant pathologist at the International Rice Research Institute (IRRI), met with her team to check the progress of the rice plants that exhibit resistance to bacterial blight. Several rows of plastic boxes with plants from different rice-growing countries filled the facility.

"Some varieties are from South Asia while others are from Southeast Asia," said Dr. Vera Cruz. "The plants look healthy for now but, in the next few weeks, we will see the plants that are more resistant to bacterial blight, as they have been inoculated."

A deadly disease

"Among rice diseases, bacterial blight is one of the most costly," said Dr. Vera Cruz. "It can damage as much as 60–70% of the plant and can even result in crop failure, especially when disease strikes at the seedling stage."

Once infected at the seedling stage, the leaves turn grayish green and roll up. And, as the disease spreads, the leaves turn yellow to straw-colored and then wilt. The result can be a grim nightmare for farmers as they helplessly watch their seedlings dry up and die.

This is exactly what happened to farmers in Haryana and Punjab states in India in 1980 when for the first time, the rice they were growing succumbed to a bacterial blight outbreak. It is the same disease that has been associated with major epidemics that ruined the fortunes of farmers in China, Korea, Indonesia, the Philippines, Sri Lanka, Myanmar, Laos, Taiwan, Thailand, and Vietnam. The disease also occurs in Australia and Africa.

It is no surprise that farmers are taking this disease seriously. Although there are chemicals developed to control this disease, none of them are completely effective at eliminating outbreaks.

Breeders at work

However, farmers no longer need to worry spend very much on chemicals to combat bacterial blight thanks to the scientists at IRRI and other research organizations who have been scouring the world for rice plants that have natural resistance to bacterial blight.

"Many improved rice varieties now have major genes for resistance to the disease," said Dr. Bertrand Collard, IRRI plant breeder. "Thus, the chances of farmers losing their crop to bacterial blight are lower."

As early as the 1970s and '80s, rice scientists found varieties TKM6 and DV85 that had inherent resistance to bacterial blight. Recently, researchers have identified more than 30 genes (named *Xa1* to *Xa38)* that impart blight resistance.

"Making rice resistant is not only most economical, but it is also a sustainable way of controlling bacterial blight," said Dr. Vera Cruz. "A good example is IR20, one of the elite varieties that has been promoted by IRRI since 1975. Even after more than 35 years, IR20, which carries the *Xa4* gene, is still resistant to some strains of bacterial blight."

At IRRI, more than 80% of the elite lines have the *Xa4* gene and, since 2000, released cultivars such as PSB Rc82 carry combinations of genes with resistance to the predominant population of the pathogen. Other elite lines have also been developed with different combinations of *Xa5, Xa7, Xa13,* and *Xa21,* among other genes. Some elite lines and released cultivars show broad-spectrum resistance, indicating that unknown or novel genes may be present in these lines and cultivars.

Nevertheless, bacterial blight continues to be an important concern due to the capacity of the pathogen to change and overcome the deployed resistance genes. Government agencies know well that the stakes are high. Whenever susceptible rice varieties are grown in environments that favor bacterial blight, the disease can turn green rice fields into wastelands of dry and wilting leaves, and empty grains—wiping out investments and potential profits.

Balancing genetic protection

Recently, Dr. Vera Cruz's team made a discovery that will further improve the resistance of rice to the disease. They learned that it is not just the presence of resistance genes *Xa4* and *Xa7* that is important, but that environmental factors such as temperature also play an important role in how the genes protect the plant. They found that *Xa4* is more effective as temperatures drop, while *Xa7* does its job better at higher temperatures.

"Since the two genes compensate for each other's weaknesses, this will also help farmers withstand changes in weather patterns," she said. "Climate change could radically alter temperatures during the dry and wet seasons."

Since pathogens co-evolve with the plant, growing a single resistant variety over large areas will "push" the virulent form of the pathogen to become dominant. Therefore, one key questions for breeders and plant pathologists is how to deploy the resistance genes to prevent pathogen epidemics while maintaining yield.

Diverse genetic resources

This is where the importance of genetic diversity comes into play. The good news is that IRRI has a genetic gold mine of different types of rice including wild rice accessions that is stored in its International Rice Genebank. The genebank continues to provide rare versions of genes to enrich and diversify the sources of resistance to manage bacterial blight.

Aside from finding a critical mix of genes, IRRI scientists are aiming to map the genome of the blight pathogen and understand what role genes play in the plant. With this information, they can precisely target certain genes of the pathogen that cause virulence in the plant host. According to Dr. Vera Cruz, this will radically shorten the breeding process for designing blight-resistant rice varieties.

No one can tell what challenges the future may bring. With the ever-evolving diseases and changing climate patterns, IRRI scientists are not resting on their past successes. They are constantly searching for better ways of doing things to deliver what farmers need to win the battle against this insidious disease.

Ms. Reyes is the managing editor of Rice Today.

ISAGANI SERRANO, IRRI

(*From left*) IRRI's associate scientist Rhulyx Mendoza, researcher Pauline Capistrano, plant breeder Bertrand Collard, and plant pathologist Casiana Vera Cruz are working together to develop bacterial blight-resistant rice.

Breeding for tough times ahead

by **Ma. Lizbeth Baroña-Edra**

Green Super Rice is making its way to farmers' fields

Throughout history, humanity has always struggled with the specter of hunger caused by human-made or natural disruptions in the food supply. Back in the 1960s, the goal of the Green Revolution was clear: increase crop yield to ward off widespread food shortages and famine across poor rice-eating countries.

However, new challenges appeared in the decades since the successful introduction of high-yielding rice varieties. As climate change starts to have significant impacts on the conditions affecting agricultural lands in vulnerable rice-producing regions, food security is once again a priority for rice research. But, it is not just about yield any more. It is about tolerance of and resistance to new problems. Focused and cutting-edge agricultural research will be critical in meeting this formidable and daunting challenge.

One such technology, Green Super Rice (GSR), is now on its way to farmers' fields.

From laboratories to rice fields

GSR varieties are products of mixing hundreds of rice varieties that possess traits such as drought, flood, or salinity tolerance. These varieties were developed to maximize yield under a limited supply of nutrients and water.

"This is rice that seems to do the improbable—increase yield while using fewer inputs, such as fertilizer and water," said IRRI's Jauhar Ali, who has been working on developing Green Super Rice since 1998. "Green Super Rice is not just a moniker. The fact that GSR varieties are good for the environment is why we are passionate about getting these into farmers' fields."

Earlier this year, the GSR project created a road map for GSR seeds to reach farmers across rice-producing countries during a meeting for the second phase of the project. At the event, Dr. Ali announced that two GSR varieties (BSHS6-GSR hybrid and Weed-Tolerant Rice 1) have been officially released in Indonesia and Vietnam, respectively, after national multilocation testing. "GSR has also already been nominated to the Philippines' National Seed Board. It is very close to being released in the Philippines," Dr. Ali said.

EARLIER THIS year, farmers in the province of Laguna, in the Philippines, participated in a variety selection trial of GSR.

ISAGANI SERRANO (3)

FARMER BERNARD Brosas and his family are among those who will benefit once GSR seeds are released in the Philippines.

A long road

In 1998 until 2003, under the International Rice Molecular Breeding Program at IRRI, Dr. Zhikang Li former IRRI senior scientist and still director of the Green Super Rice Project, led the initial research work pertaining to the GSR breeding strategy in 18 countries, involving 36 partners, introducing genes from 200 rice donors into their popular rice varieties.

"We screened early generations of backcross bulk populations for valuable traits such as drought, salinity, flooding, and phosphorus and zinc deficiency tolerance from a very large collection of different types of rice," said Dr. Ali. "During that time, only China, out of 18 countries, followed through with the research."

The project in China involved 14 institutions and about 200 molecular breeders under the China National Rice Molecular Breeding Network. From 2003 to 2008, when the project gained momentum, valuable genes from 500 donor varieties were introgressed into 46 elite adaptable recipient parents, which eventually gave the GSR project a substantial set of materials to work on.

Although many institutes worldwide are working on different key rice traits separately such as nitrogen use efficiency and tolerance of drought, salinity, and flooding, researchers at IRRI are working on combining many traits in one rice variety.

"This challenge feels like a dream, but breeding can change everything," said Dr. Ali. "Breeders from 50 years ago did not have the new breeding tools we enjoy now. A good example is the case of farmers in Bangladesh. Some of them require rice varieties with flood tolerance during the early to middle stages of the plant, and then they require drought tolerance in the terminal crop growth stage. The needs are complex, and they must be addressed."

Ms. Baroña-Edra is a public relations specialist at IRRI.

A farmer's dream come true

Bernard Brosas, a farmer in the province of Laguna, Philippines, tested Green Super Rice on his 2-hectare farm. GSR's performance encouraged him to become a seed supplier to his fellow farmers and nearby towns.

"At first, my fellow farmers wondered whether I'd get good rice plants from using fewer seedlings, and using fewer inputs," Mr. Brosas narrated. "After they saw how robust my rice was, and how I was able to save on input costs, and still got a good harvest with good quality, they started asking for GSR seeds from me to test on their farms."

He welcomed the news that GSR varieties are under consideration by the Philippine National Seed Board for distribution to Filipino farmers.

BERNARD BROSAS is a 51-year-old farmer who who tested GSR varieties and is now reaping the rewards.

What's cooking?

GRANT LECETA (3)

Tteokbokki: Korean rice cake in spicy sauce

by **Jeehyoung Shim-Chin**

Tteokbokki is a popular Korean snack food, especially among students. It is served in many small eateries and restaurants located near schools and universities.

Basically, it is made of *garaetteok*, a chewy, cylinder-shaped white rice cake, and is cooked in spicy *gochujang* sauce, a Korean fermented red chili pepper paste. It is available in several variations such as *tteokbokki* with noodles, *tteokbokki* with fish cakes, and *tteokbokki* with seafood, among others.

Its other ingredients, which include eggs and vegetables, make it a healthier option than regular meals and other snack foods.

Jeehyoung left her job as a preschool teacher in Korea and moved to the Philippines in 2006 to join her husband, Joong Hyoun Chin, who works as a molecular breeder at IRRI. Aside from cooking for her family and friends, she spends some of her time painting and playing string instruments with her children.

Ingredients for the *gochujang* sauce
90 g *gochujang* (Korean red chili pepper paste)
60 g Korean red chili pepper powder
50 g sugar
20 g minced garlic
50 mL rice syrup
20 mL soy sauce

Ingredients for the broth
800 mL water
2 slices radish
1 piece white or light green part of a leek, sliced
7–8 pieces dried anchovies
3 pieces fish cakes
1 piece dried kelp

Other ingredients
400 g sliced *garaetteok* (5 cm in length)
70 g sliced cabbage
50 g sliced leek (green part)
A pinch of toasted sesame seeds
Sliced boiled eggs or fried dumpling (optional)

Directions
1. Mix all ingredients for the *gochujang* sauce in a container. Set aside.
2. Put all the ingredients for the broth, except the fish cakes, into a sauce pan and allow the mixture to boil.
3. When the broth starts boiling, add the fish cakes and boil the broth until it thickens and its color becomes opaque white.
4. Remove the fish cakes and the rest of the ingredients to make a clear broth. Slice the fish cakes into 5-cm squares. Set aside.
5. Stir in the previously prepared *gochujang* sauce in the broth.
6. Add the sliced *garaetteok* and simmer until the *garaetteok* becomes soft, and the sauce becomes thick. (Stir constantly so that the rice cakes won't stick to the bottom of the pan.)
7. Add the sliced fish cakes, leeks, and cabbage and gently mix them with the sauce.
8. Remove from heat. Serve immediately and garnish by sprinkling toasted sesame seeds on top.

This dish can be served with sliced boiled eggs or fried dumplings.

Watch Jeehyoung demonstrate how to prepare this delicious Korean dish in an 8-minute video on YouTube at http://sn.im/tteokbokki.


MICHAEL THOMSON


GERALDINE MALITIC

For the love of rice

by **Alaric Francis Santiaguel**

Two scientists, worlds apart but with a common passion, end up being more than laboratory partners

At first glance, Endang Septiningsih and Michael Thomson are worlds apart. Dr. Septiningsih was born and raised in Indonesia. Dr. Thomson hails from the southwestern United States. Despite the distance of some 15 thousand kilometers between them, fate, science, and a common passion to improve rice and farmers' lives found a way to bring them together.

When Michael met Septi

Septi, as she is called by her colleagues at the International Rice Research Institute (IRRI), had a keen interest in plant breeding as an undergraduate student in Gadjah Mada University, Yogyakarta, Indonesia. She then became a researcher at the Indonesian Center for Agricultural Biotechnology and Genetic Resources Research and Development (ICABIOGRAD) in Bogor.

"Rice is a part of my life and rice cultivation in Indonesia is usually done by smallholder farmers," she said. "My dream is to help them."

Michael's love affair with rice was less direct. He became interested in plant science when he joined a high school summer program on plant biotechnology at the University of Arizona. "Even as an undergrad, I didn't have an agriculture background so I was more interested in pure science and genetics," he said.

In 1997, Michael attended Cornell University to pursue his interest in molecular genetics, where Septi happened to be working toward her PhD in plant breeding with Susan McCouch as her adviser. Dr. McCouch, a renowned rice scientist, spent 5 years at IRRI before joining the Cornell faculty. (See *A juggling act: Gender barriers and molecular maps* on pages 37-39 in *Rice Today* Vol. 9, No. 2)

"When I moved to Cornell, I spent some time working in two labs on wheat and tomatoes," Michael said. "Finally, I worked with Dr. McCouch. Rice was the one that got me most excited."

Like the protagonists in the film *When Harry Met Sally*, they started off as colleagues and friends. "We were classmates and we were part of a study group with several other people from different countries," Septi recalled. "Then we became close friends after we both studied under the same adviser." Michael and Septi got married in 1999 and they had their first two children, both boys, while at Cornell.

Following their hearts

After completing their postdoctorates at Cornell, Michael started looking

for work, but Septi felt it was time to move back to Indonesia. She wanted to give back to the Institute that allowed her to study at Cornell for her PhD. It was a decision that Michael fully supported.

"We were trying to find something that would advance both of our careers," he said. "Going back to her home institute was important to her. For me, I wanted to get that international experience."

In 2003, Septi returned to ICABIOGRAD, where she worked on varietal identification and diversity analysis of the germplasm of major Indonesian crops such as rice, soybean, and sweet potato. Michael, on the other hand, received a grant from the *National Science Foundation International Research Fellowship Program* to study the genetic diversity of traditional and improved Indonesian rice varieties, also at ICABIOGRAD, for 2 years.

After completing his fellowship, Michael then found an opportunity at IRRI, where he was accepted as a postdoctoral fellow with Dr. Abdelbagi Ismail, plant physiologist and coordinator of the Stress-Tolerant Rice for Africa and South Asia (STRASA) project, in mapping *quantitative trait loci (QTL)*—stretches of DNA containing or linked to genes responsible for important traits—and marker-assisted breeding of salt-tolerant rice. Septi was also accepted as a postdoctoral fellow to focus on the development of flood-tolerant rice with Dr. David Mackill, former head of IRRI's Plant Breeding, Genetics, and Biotechnology Division. They moved to the Philippines in 2005, with their two boys and 2-month-old daughter.

"For a professional couple in the same field of research, it's quite difficult to find a place where we can both work and do our research on rice," Michael said. "In that aspect, IRRI is the perfect place for us."

Careers in full bloom

Today, Septi leads IRRI's work to identify traits to help develop new flood-tolerant rice that can survive different types of flooding at different stages of the rice plant's development. This includes looking for genes and QTLs that help direct-seeded rice to germinate even when flooded (anaerobic germination), and protect rice plants when submergence is complete or when floods of 20–50 cm remain in the field (stagnant flooding).

A FAMILY portrait of scientists Michael and Septi, taking time off from their rice laboratories with their children Ilham, Irfan, and Atiya.

JON SCHROEDER

"We search for new QTLs and genes," she said. "Every time we have something good on the genetic side, we incorporate it in our breeding to develop new rice varieties that are particularly suited for changing climatic conditions.

"Flood-tolerant rice varieties are particularly important because more than 15–20 million hectares of land, mostly in Asia and some parts of Africa, are prone to flooding."

Michael now runs IRRI's Genotyping Services Laboratory and offers DNA marker services for research and breeding groups. Genotyping determines the genetic nature of individual rice varieties (genotype) by using DNA markers to detect differences between rice plants based on their underlying DNA sequence. DNA markers flag the location of genes of interest associated with useful traits, thus making it easier to breed the traits into new varieties. "Plant breeders are increasingly using specific DNA markers to track genes," he said. "We like to make it more efficient by using new technology."

His role includes validating new DNA markers and looking for new technologies to further improve the efficiency of the lab. "I enjoy exploring new technology that in the end can really help the breeders," he said. "Connecting the diversity and breeding applications is really exciting. The main impact I hope to offer is to make breeding faster. It can take 9 or 10 years to develop a new rice variety. If there's a way we can help breeders do that in, say, 6 years instead of 10, we can release new and improved varieties faster."

Chemistry, in and out of the lab

Science is a competitive field. Its history is fraught with intellectual feuds and rousing debates between disagreeing scientists. Does science, which brought Septi and Michael together, also work against their careers and marriage?

"Our interest is genetics but we are not competitive," said Septi. "We are complementary because our work is different. My first research area at IRRI was submergence while he worked with salinity. We support each other."

In fact, Michael said being married to a colleague has its advantages. "We get to bounce ideas off each other," he said. "If we have problems at work, sometimes we can help each other solve them after office hours."

Septi agrees. "At home, we can have work-related discussions. If I need to use his laboratory facilities and get help from his staff, we can talk about it while in the car or when we are shopping."

With both being scientists, they also understand the needs and pressures of each other's job and give each other advice.

"She reminds me to focus and not neglect the things that are important for my own career," Michael said. "I can get distracted by many activities at work. People often ask me for help about software and different things. I fall behind in writing publications of my own."

Michael also has advice for Septi. "Sometimes, I feel overwhelmed because a lot of stuff is going on at the same time since I have more responsibilities now," Septi said. "Michael tells me not to worry too much. Just take it easy.

"It can be a struggle at times," she added. "Sometimes, we have a lot of work even during the weekends. But, we make sure we spend quality time with our kids since it is also our responsibility to raise them to be successful."

They also have to coordinate their schedules, including attending scientific conferences. "At the start of the year, we discuss who goes to what conference because we try not to leave our children alone," Septi said. "Although on some occasions we do, but just for a couple of days."

Were there moments when they considered shifting jobs and having only one scientist in the family? "If she's more successful, then I can retire early," Michael joked. "But we are both committed to our careers. We can't really imagine if either one of us stops being a scientist."

Facing the future

American millionaire Dennis Tito recently announced his plans to fund the first manned mission to Mars in 2018. The voyage would take 501 days, round trip, and could include an adventurous married crew. Could Septi and Michael's professional and personal relationship survive such an ordeal?

"We could probably handle the journey but we might drive each other crazy," Michael said in jest. They would rather stay right here on Earth and hopefully see their dreams, as scientists, come true.

For Michael, that would be having all the rice genomes in IRRI's International Rice Genebank—which has more than 117,000 types of rice—sequenced and characterized to the point where scientists can just pick the desired version of the gene they need in their breeding programs.

"Having an integrated database that contains all the genetic information about all the rice in the International Rice Genebank is something I'd really like to see as a resource for breeding programs," Michael said. "There's so much potential, but, so far, we don't have the sequence and trait data to do it efficiently."

Septi shares this vision with Michael. "I want to use certain genes in my trait development program to speed up the development of new varieties."

Behind the high-end technology and the intricate science of molecular genetics and breeding, the two scientists have a singular pragmatic target. They want to help farmers all over the world by developing better rice.

"My ultimate goal as a scientist is to make rice farmers happy by helping them harvest more rice and have better incomes," Septi said. Michael, her fellow scientist and husband, couldn't have said it any better.

Mr. Santiaguel is a writer at IRRI.

Mapping the crop of the FUTURE

by **M.V.R. Murty, Tao Li, William P. Quick, Sam Mohanty, Khondoker Abdul Mottaleb,** and **Andrew Nelson**

By 2035, the world will require more than 100 million tons of additional rice when the population surpasses 8.5 billion. To meet this global demand, the International Rice Research Institute (IRRI), through the International C_4 Rice Consortium, is developing C_4 rice, a new kind of rice equipped with a more powerful "engine" for transforming carbon dioxide (CO_2) and solar energy into food.

C_4 plants such as maize and sorghum have more efficient photosynthesis than C_3 plants. The photosynthesis in C_3 plants such as rice is not as efficient because of a wasteful process called photorespiration that takes place in the mesophyll cells of leaves. In C_4 photosynthesis, CO_2 is concentrated in the bundle sheath cells where photorespiration is negligible.

Scientists are now attempting to introduce C_4 photosynthesis, including the required changes in the leaf structure, into rice. The good thing about C_4 rice is that it can thrive under high temperature caused by global warming, and with a decreasing fertilizer and water supply.

If research is successful, the C_4 rice varieties could be available to farmers in another 15 years. By 2035, farmers could adopt them in irrigated areas.

So, in the future, how much would the yield gain of C_4 rice be in South Asia, where many rice consumers live? To help answer this question, we used ORYZA2000, a rice growth simulation model, combined with the C_3 and C_4 photosynthetic modules from GECROS.

In one simulation set, we assumed that 220 kg of nitrogen was applied per hectare of rice area, and we used spatial soil data and weather from three climate scenarios between 2035 and 2040 with corresponding increases in atmospheric CO_2 level (map A in figure). The other simulation set used the current CO_2 of 400 ppm (map B in figure).

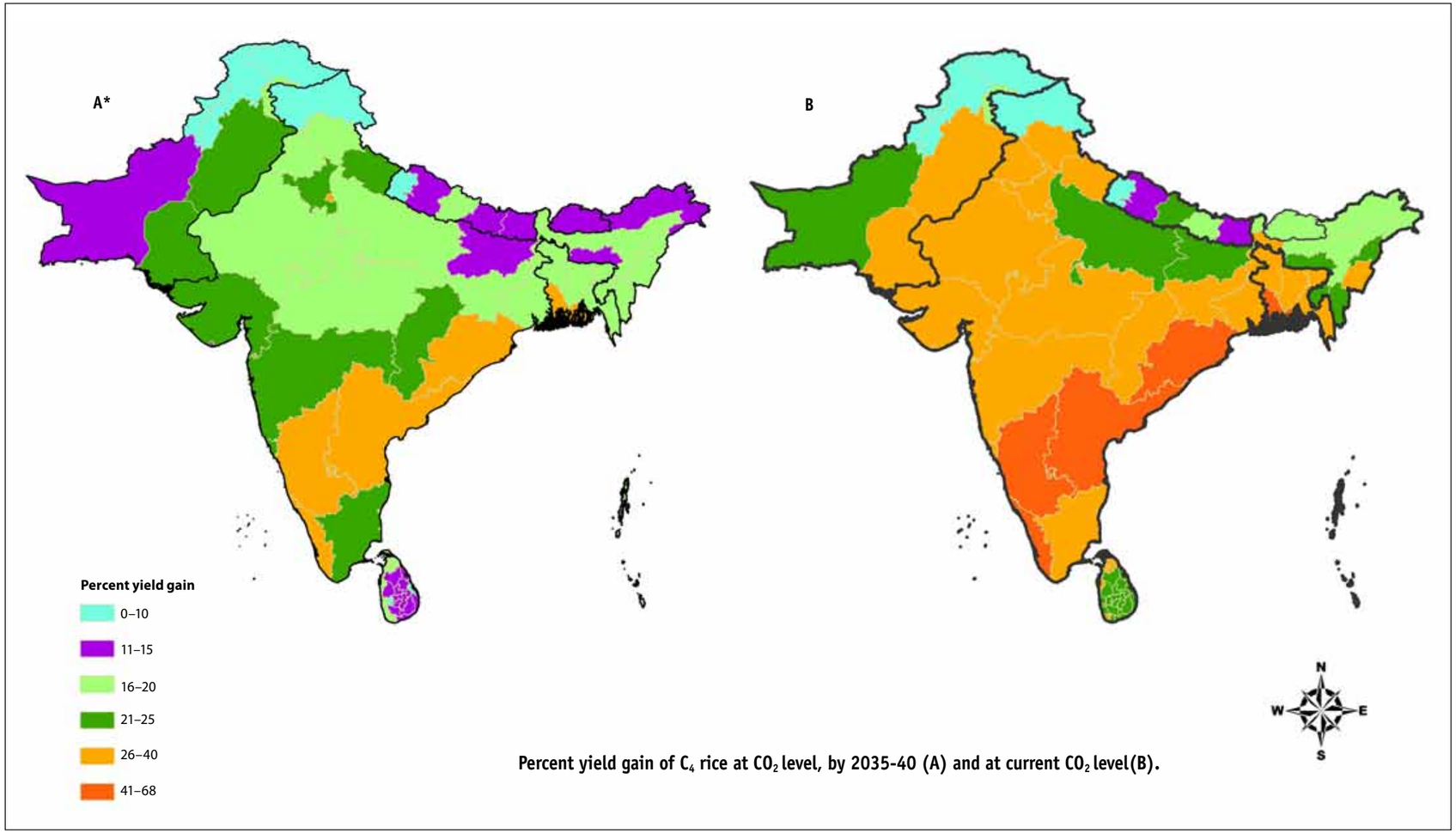
At the current CO_2, the yield gains of C_4 rice could be more than 40% in Kerala, Odisha, Andhra Pradesh, and Karnataka in India and in Khulna Province in Bangladesh. But, at a higher CO_2 level in anticipation of climate change, yield gains are lower. The reason for this is that CO_2 concentration is already high in the bundle sheath cells of C_4 rice so it won't be able to take much advantage of the increase in atmospheric CO_2 level. Even with this setback, the virtual C_4 rice could still yield an impressive additional 26–40% in Andhra Pradesh, Karnataka, Odisha, and Kerala in India, and in Barisal and Khulna provinces in Bangladesh.

Yield gains across South Asia would vary because of the interaction between soils and climate. Generally, the yield gain of C_4 rice would average 32% at current CO_2 level. At higher CO_2 level, on the other hand, the average yield gain would be 21%.

These initial results suggest that appropriate location-specific C_4 rice cultivars, fertilizer doses, and management options will further improve these yield gains. This clearly shows the importance of the development and deployment of C_4 cultivars for global rice production to keep up with increased rice demand.

Note: This work is a part of *Global Futures for Agriculture: Integrated Modeling and Scenario Assessment* funded by the Bill & Melinda Gates Foundation and the International Food Policy Research Institute.

Dr. Murty and Dr. Li are crop modelers in the Geographic Information Systems (GIS) group and Crop and Environmental Sciences Division. Dr. Quick is the head of the C_4 Project. Dr. Mohanty is the head of the Social Sciences Division (SSD). Dr. Mottaleb is a postdoctoral fellow in SSD. Dr. Nelson is the head of GIS Laboratory at IRRI.



Percent yield gain of C_4 rice at CO_2 level, by 2035-40 (A) and at current CO_2 level(B).

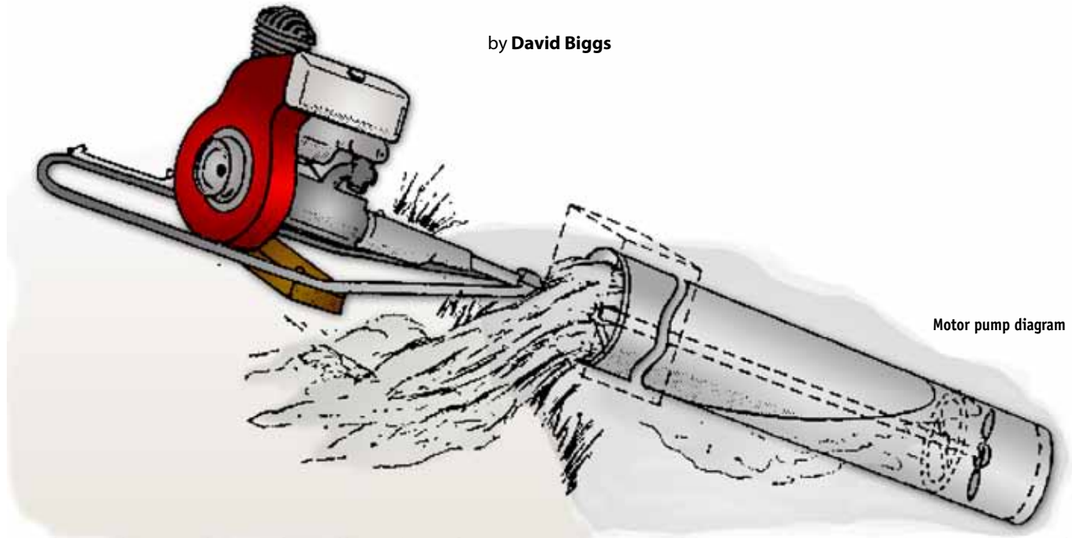
* The results are expressed as averages of three future climate scenarios and weighted averages of rice pixels in each state/province.

ISAGANI SERRANO

Beta carotene, which the human body converts into Vitamin A, is essential for eye health and the proper functioning of the immune system. It is naturally found in fruits, vegetables, and now it is in Golden Rice thanks to genetic modification.

The not-so-silent revolution

by **David Biggs**



Motor pump diagram

The widespread use of small engines for water pumps and boat motors gave rise to profound changes in the Mekong Delta

During the Vietnam War, the Mekong Delta was perhaps best known as a Cold War battleground. While the war raged, however, a technological revolution, every bit as profound, was underway as farmers began adapting small engines for water pumps and boat motors. Since the introduction of these engines in the early 1960s, almost every household managed to acquire one. Mounted on a water pump, these engines enabled farmers to irrigate crops and double their yields. Higher yields permitted other purchases from bicycles and Honda motorbikes to generators and sewing machines (see *I remember Honda rice* on pages 39-44 of *Rice Today* Vol. 5, No. 4). As the war escalated in the late 1960s and the Vietnamese government's authority deteriorated in the countryside, a sort of fragmented modernization was underway. After a relatively brief respite after 1975, imports of these engines have surged since the 1990s.

Invasion of the small engines

Across monsoon Asia, a similar small-engine revolution occurred. Powering scooters, three-wheeled trucks, boats, and water pumps, low-horsepower (hp) engines have radically altered the social and ecological fabric of rural life. Almost everyone is familiar with their sounds, if not their operation. Rarely a moment exists in the rivers or fields when one does not hear the percussive rattling of a motor. Such goods first became widely available in the 1960s. And, since the 1980s, their use has grown exponentially. The adoption of cheap internal combustion engines to power pumps allowed farmers to start growing with high-yielding rice and fertilizers that have become the norm today. These pumps have played a pivotal role in what Francois Molle and others call a silent revolution.[1]

Local ingenuity

Although American and international aid missions were usually quick to claim the credit for "winning hearts and minds" via such introductions of new machinery, American technical advisers were, for the most part, the spectators, and local farmers the inventors. Robert Sansom, a Rhodes scholar who studied the rural economy of the Mekong Delta in 1966-67, noted that an enterprising Vietnamese dredging mechanic adapted an impeller to build a "shrimp-tail pump" (*may bom duoi tom*) out of the engines available in 1963.[2] By 1967, he sold some 80,000 pumps across the delta and made a sizable fortune. It was only after Dr. Sansom related his observations to officials at the U.S. Agency for International Development (USAID) in Saigon that Robert Komer, an American ambassador and head of U.S. President Lyndon B. Johnson's nation-building operations, considered the revolutionary implications.

Farmers, working in muddy fields far removed from agricultural extension offices, experimented with engines for several years before the Americans and the Saigon government paid any attention. The ironic role reversal here was not simply a case of the tail wagging the dog, however. The Americans played a supporting role in this "takeoff" story through a Commercial Import Program that promoted the widespread importation of American technology at cut-rate prices. There were other factors, too, particularly the involvement of Asian technical advisers. In the same town where the dredge mechanic improvised the shrimp-tail pump, Taiwanese advisers successfully introduced the first high-yielding rice varieties from the International Rice Research Institute (IRRI) that could produce more rice when irrigated.

Big engines vs. small engines

To understand both the popularity of the small engines and the challenges faced by governments and people in the region today, one must consider the problems inherent with the older, state-managed forms of large water pumping stations and canals ("big engines"). Reclamation programs initiated by the French colonial government produced an agricultural landscape that depended on large inputs of labor and funding. In the Mekong Delta, this infrastructure fell into disrepair as Japanese military occupation (1940-45) gave way to almost three decades of fighting. Throughout this era, engineers, social scientists, and aspiring Vietnamese nationalists all debated the future of water management in the delta.

After the Geneva Accords were concluded in 1954, the U.S. advisory mission in Saigon immediately embarked on an ambitious scheme to use its own big machines, especially a fleet of multimillion-dollar, cutter-suction dredges manufactured in Baltimore, Maryland.

President Ngo Dinh Diem presented Americans with ambitious plans to resettle hundreds of thousands of northern Vietnamese refugees on abandoned rebel-held lands of the delta, and Americans responded by sending several dredges to clear the main canals for these grid-like projects covering thousands of hectares. With a surge in violence in 1959, communist insurgents began a concerted effort to attack the American machines. In new settlements across the delta, platoons of a new People's Liberation Armed Forces scattered settlers and then opened fire not on government troops but on the dredges. While

[1] Molle F et al. 2003. The Groundswell of Pumps: Multilevel Impacts of a Silent Revolution. Paper prepared for the ICID-Asia Meeting, Taiwan.
[2] Sansom R. 1969. The Motor Pump: A Case Study of Innovation and Development. In: Oxford Economic Papers, New Series, Volume 21, Number 1. p 109-121.

MARTIN GUMMERT, IRRI

MANY ADVANCEMENTS in Vietnam's agricultural mechanization started with small engines introduced in the early 1960s.

the insurgents deliberately shifted targets, the new socialist government in North Vietnam also favored big-engine approaches to irrigation. Insurgents appropriated small-engine technology for immediate tactical needs, but the general attitude in the north was that irrigation was the responsibility of the state, typically involving mass labor campaigns and Russian-designed pumping stations.

A not-so-silent revolution

The shift to an agricultural economy dependent on small engines began simultaneously at many sites across the region in 1963. American and Vietnamese archives suggest after the President of South Vietnam, Ngo Dinh Diem, was overthrown in 1963 the way was opened more importers to participate in American-backed programs. Four years later, in 1967, American officials first noticed the demand for this equipment, and they began promoting motorized equipment in their overall nation-building strategy. Among English-language sources, the best known account of the shrimp-tail pump's development comes from Dr. Sansom's 1967-69 research.

A severe drought in 1962 prompted farmers around the town of My Tho to start major canal projects to save their harvest. One prosperous farmer in a nearby village bought a diesel-powered centrifugal pump for roughly US$600. Another farmer witnessed how the pump effectively lifted water into that landowner's fields and quickly grasped the value of motorized irrigation. This man had worked on French dredges as a mechanic in the 1940s, so he set to devise an impeller similar to suction dredges in use after 1945. After several unsuccessful trials with a French bicycle motor and a Japanese 4-hp engine, he purchased a 4.5-hp Clinton engine, and within months turned a profit by renting out this improvised pump. In 1964, dealers improvised their own impellers and tin sleeves. Across Asia, sales of similarly made motor pumps increased steadily. In each place, locals circulated their own stories of invention.

IRRI's high-yielding rice also played an important supporting role in the small-engine revolution. Privately owned water pumps allowed farmers to more reliably irrigate fields planted with one of the early high-yielding varieties, IR8, introduced in 1966. This variety required about 30 fewer days to mature than most varieties, and it was extremely responsive to nitrogen fertilizers, but it required steady irrigation for maximum productivity.

By 1967, 80,000 shrimp-tail pumps were in use based on an American estimate citing import statistics for 4-hp engines. With Dr. Sansom's revelations to colleagues at USAID and successful IR8 trials, American aid officials were aware that a kind of agroeconomic revolution was underway. Meanwhile, war-related violence escalated and the canal infrastructure deteriorated further. By 1974, a Dutch advisory team estimated that more than a million pumps were being used across the delta for irrigation and flood control.

Inefficiency and insurgency

Although American advisers and Vietnamese officials in Saigon generally supported modernization, their reactions to the improvised pumps and shrimp-tail motors ranged from concerns about inefficiency to outright opposition. American advisers, in memos and promotional literature, favored the more efficient single-purpose centrifugal pumps while ignoring the importance of the shrimp-tail as a twin-use pump/motor. Local government representatives often refused to publicize the shrimp-tail pump because it was only 5–40% as efficient as the centrifugal pumps. In keeping with the USAID line on inefficiency, Vietnamese publications on motorized water pumps excluded the shrimp-tail from the lineup.

The South Vietnamese response ranged from obstructionist to concerns over military security. One of the biggest bottlenecks to the rapid sale of engines in the 1960s was not supply or even hard currency, but the arcane process in which only farmers lucky enough to acquire a license were permitted to buy an engine. Navigating government and insurgent checkpoints also slowed the transport of equipment from Saigon docks to the delta with bribes and taxes, thus raising the end price. Government bans also aimed to prevent the sale of boat motors to insurgent-controlled areas. By restricting the sale of engines and even rice seed in government-held areas, the end result was to spur rice production in "liberated zones."

Thus, the shrimp-tail revolution became an integral part of the Vietnamese revolution, too. An American report in 1970 noted that government bans on the sale of equipment had resulted in the rapid movement of equipment into territory held by the National Liberation Front (NLF). With rice prices at all-time highs in 1970, much of the rice was then being sold in government-controlled markets to generate cash.

Postwar epilogue

Although academics have extensively examined mechanization, the rural cash economy, and the Green Revolution in most of monsoon Asia, the role of small engines has been largely ignored.

The rapid adoption of these engines raises important questions about the state's role in managing water resources. This is an increasingly difficult task even in countries such as Vietnam that advocate a form of "state-managed capitalism."

The postwar government in 1975 first supported a model of centralized state control over irrigation with large irrigation stations and mass-labor public works campaigns. After 1986, with Vietnam's liberalization policy, imports in boat motors, motorized pumps, and other equipment surged as the state reduced its obligations. This small-engine revolution produced a kind of ecopolitical impasse in which states and their constituencies were at odds over measures to divide up increasingly scarce resources. This resulted in some notable disasters such as a 2002 forest fire that consumed much of the U Minh Forest, a freshwater area with cajuput trees that once protected a large rear base for the NLF. The pumping of groundwater on surrounding farms lowered the water table in the forest and dried out the layer of peat, which fueled the fire.

Advances in small technology since the 1960s, the not-so-silent revolution, have literally empowered millions of individuals to improve crop yields and to survive ecological challenges brought by natural and social changes. However, to the extent they contribute to groundwater depletion and other problems, they point to a present-day predicament for states trying to manage increasingly scarce water resources. The turn towards everyday technology since the 1960s has produced a middle ground on which farmers and states alike must navigate landscapes shaped both by small-engine technology and aging networks of levees, canals, and older works. States have, for the most part, been left in the dust and engine exhaust of the small-motor revolution, and it remains a challenge for experts and intellectuals to catch up and respond to this trend.

IRRI

VIETNAM'S GREEN Revolution started when farmers in the Mekong Delta adopted IR8, IRRI's first high-yielding rice.

Dr. Biggs is an associate professor of history at the University of California at Riverside. His research reflects interests in Southeast Asia, environmental issues, and agriculture. His most recent book is Quagmire: Nation-Building and Nature in the Mekong Delta *(University of Washington Press, 2011).*

This article is an edited excerpt from an essay by the same author. See Small Machines in the Garden: Everyday Technology and Revolution in the Mekong Delta on pages *47-70, Vol. 46, No. 1 of* Modern Asian Studies. *This is reprinted with permission from Cambridge University Press.*

Laser-guided dreams

Story and photos by **Trina Leah Mendoza**

Truong Thi Thanh Nhan doesn't look like a typical farmer, but she is proving to be a powerful "engine" for growth in Vietnam's farming communities

With her tiny frame, blunt-cut bangs, and trendy outfits, 28-year-old Truong Thi Thanh Nhan looks more like a school girl than a farmer. Nhan earned her degree in software programming from the University of Science in Ho Chi Minh City, Vietnam, in 2010. But, after graduation, she agreed to her parents' wishes to oversee their family farm in Dak Lak Province in Vietnam's Central Highlands.

In December 2011, Nhan started the daunting task of managing their almost 70 hectares of land. She started planting rice twice a year on 20 hectares of their farm. Once a year, Nhan also grows maize and pumpkin on 10 hectares each. Although her family's farm is located on a steep slope, bringing water into the field was easy because the field was next to a water canal. It was managing the water—making sure that higher areas were reached—that was the problem. Most of the rice plants in higher areas die because they lacked sufficient water. She had no choice but to hire many laborers to replant the field.

A flair for laser

In early 2012, Nhan chanced upon a show on a Vietnamese TV channel that featured rice farmer Nguyen Loi Duc from Tri Ton District, An Giang Province. She found herself glued to the channel as Nguyen was sharing his experiences and the benefits from laser leveling his 150-hectare field. With her interest piqued, she searched the Internet to learn more about the technology.

With laser leveling, a transmitter placed at the side of the field sends a laser beam to a receiver, which is attached to a leveling bucket drawn by a tractor. Then, a control panel mounted on a tractor interprets the signal from the receiver and opens or closes a hydraulic valve, which in turn raises or lowers the bucket. The bucket then drags and drops soil across the field to make it even.

Nhan, together with her family, visited Nong Lam University (NLU) in Ho Chi Minh City. They were briefed on the technology by NLU

staff member Tran Van Khanh, a principal lecturer on agricultural machinery, and Phung Anh Vinh Truong, a researcher who became Nhan's husband in 2013 and now helps her manage the farm.

Engr. Khanh emphasized the benefits of the technology and assured Nhan's family that the International Rice Research Institute (IRRI) also provides technical support. Nhan's family was convinced and decided to buy laser-leveling equipment and a drag bucket from a Saigon-based distributor, Ideal Farming Corporation.

Loads of benefits

They began using laser leveling in their rice-growing area. "Now that 9 hectares of our rice field have been laser-leveled, the benefits have been tremendous," Nanh says. "We save on water because we don't need to pump more water to reach the once-high areas. With even water coverage, the crops are healthy and thriving—and we don't need to hire laborers for replanting."

Laser leveling their land had other benefits too. Fertilizer is now spread evenly among the crop, saving as much as 77 kilograms per hectare. Pests, which used to hide in uneven spots, can no longer do so, resulting in less pesticide applied. Weed control is also easier. Herbicide spraying has been reduced to one, before the emergence of rice, unlike before when they sprayed herbicide twice during the season. The yield from the laser-leveled field during the dry season, from January to May 2013, was higher at 6.7 tons per hectare compared with 4.5 tons per hectare for the unleveled field.

The laser-leveling equipment, however, is subject to wear and tear. Nhan's husband, Truong, shares that the usual challenges they face with laser leveling have more to do with fixing the equipment when it breaks down. It usually takes a week to repair the system, and Truong, being an agricultural engineer by profession, does it on his own in their workshop. However, since they live in a rural area where power shortages are common, repairing broken equipment takes more time and effort.

NHAN AND her husband Khanh are changing farming practices and the image of farmers in Vietnam.

Spreading the word

But, overall, Nahn's decision to purchase the equipment is proving to be a very wise one. As the neighboring farmers witnessed the improvements on Nhan's rice farm, it wasn't long before they sought her help. She already provided laser-leveling services to one farmer's 2.7-hectare rice field in December 2012 and she has plans to do more.

"After I finish leveling our 20 hectares of rice farm and our maize farm, we plan to rent out our equipment to other farmers, not only for rice but for other crops as well," says Nhan.

Nhan is now also on a mission. An advocate of laser-leveling technology, she shares her experiences in adopting laser leveling with representatives from both the public and private sector during meetings and seminars on postharvest technologies organized by the Asian Development Bank-IRRI Postharvest Project.

A role model

Although Nhan is not a typical Vietnamese farmer, she has managed to turn their farm into a productive and efficient business. But, many people are surprised by Nanh's decision to be a farmer. They do not understand why a young lady like her, with a background in software programming from a prestigious university, would want to go back to agriculture.

For Nhan, it was no surprise. Her parents both grew up on farms, and agriculture was part of their family tradition. Going back to her roots made her happy and she is optimistic about her future. She hopes that, with a new generation of farmers like her, it will be possible to change the general perception of farming.

"Nowadays, young people think that farmers are old-fashioned, poor, and lack social standing, and that returning to the farm is a last option," says Nhan. "I am a smart, young, dynamic person, and even though I am a farmer living in an area without many comforts and I face difficulties with finances and managing people, I know that I am on the right path toward a stable income and a sustainable future.

"I am contributing to food sustainability for my region and country, which young people now rarely do. And, I have my family to thank for helping me be the farmer that I am now."

Ms. Mendoza is a senior communication specialist with the Irrigated Rice Research Consortium at IRRI.

YUSAKU UGA, NIAS (2)

The revolution underground

by **Neil Palmer**

Crop scientists have discovered a gene in rice that promotes a deeper root system, which could significantly improve the crop's resistance to drought

An international team led by the National Institute of Agrobiological Sciences (NIAS) in Japan, which includes scientists from the International Center for Tropical Agriculture (CIAT), has discovered the *DEEPER ROOTING 1* (*DRO1*) gene that makes the roots of rice plants grow downward instead of outward. This allows the plants to reach water held deeper in the soil. Plants with *DRO1* can continue to grow and produce grain even under extreme water stress.

The researchers also found that the *DRO1* gene appears to change only the angle of root growth and slightly increase the length of the root tips, rather than the overall root density, meaning that energy is not diverted away from the production of grain.

An exciting discovery

"It's a very exciting discovery," said CIAT's Manabu Ishitani, who was part of the research team. "We've known for some time that deeper roots can buy farmers extra time during drought, but, until now, we haven't known which gene in rice is responsible for root architecture, or how to control it."

Dr. Masa Iwanaga, president of the Japan International Research Center for Agricultural Sciences, welcomed the findings. "The Green Revolution in the 1960s and '70s was made possible by the introduction of

THE YIELD of rice with the *DRO1* gene (page 30) is twice as much as compared with varieties with shallow roots (*above*).

short-stature, shallow-rooted cereals capable of producing high yields," he said.

"The *DRO1* gene confers deeper root system architecture to crops, which will surely mark the start of an 'underground revolution' in crop improvement, which will be essential for meeting the increasing worldwide demand for food," he added.

Rice feeds around half of the world and production needs to increase by around 40% in order to meet the demand of more than 9 billion people by 2050. But, each year, drought affects some 23 million hectares of rainfed rice in South and Southeast Asia alone. In parts of India, water scarcity can cut rice yields by more than a third, equal to losses of US$800 million annually. Water scarcity is also expected to increase because of climate change and increased demand for water for industrial and urban use.

"Water availability will soon become the most limiting factor in rice production around the world," Dr. Ishitani said. "Improving the water-use efficiency of rice is essential if the crop is going to continue to be relied upon as a staple food for half of the world."

He hopes that deeper roots might also be able to gain access to additional nutrients deep in the soil, meaning farmers could use fertilizer more efficiently.

Improving a popular variety

Since its release in 1985, IR64 has been widely grown in South and Southeast Asia. Its positive traits such as high yield potential, good grain quality, wide adaptability, and good disease resistance have made IR64 very popular among farmers. But, this commercial variety has short roots and is drought-prone. Although IR64 already has the *DRO1* gene, the plant cannot produce the necessary proteins that enable the gene to function effectively.

The scientists crossbred the high-yielding IR64 with Kinandang Patong, a deep-rooting upland rice variety from the Philippines. Through conventional breeding techniques, the scientists combined the high yield of IR64 with the fully functional *DRO1* gene in Kinandang Patong. NIAS evaluated the resulting plants grown in rainfed lowland trial fields with scientists at the International Rice Research Institute in the Philippines.

The roots of the resulting plants were able to reach more than twice as deep as those of IR64. When tested under simulated conditions of moderate drought, IR64 yields decreased by almost 60%, while the crossbreeds suffered only a 10% yield loss. Under extreme drought, IR64 failed completely, but the new rice plants continued to produce grain—about 30% of the yield of unstressed rice plants growing under normal conditions.

"The discovery of the *DRO1* gene is a significant breakthrough in research to adapt food crops to water stress, especially as farmers around the world begin to feel the pressure of climate change on water availability," said Joe Tohme, director of CIAT's Agrobiodiversity Research Area. "Technologies like this can help boost production of one of the world's most important crops."

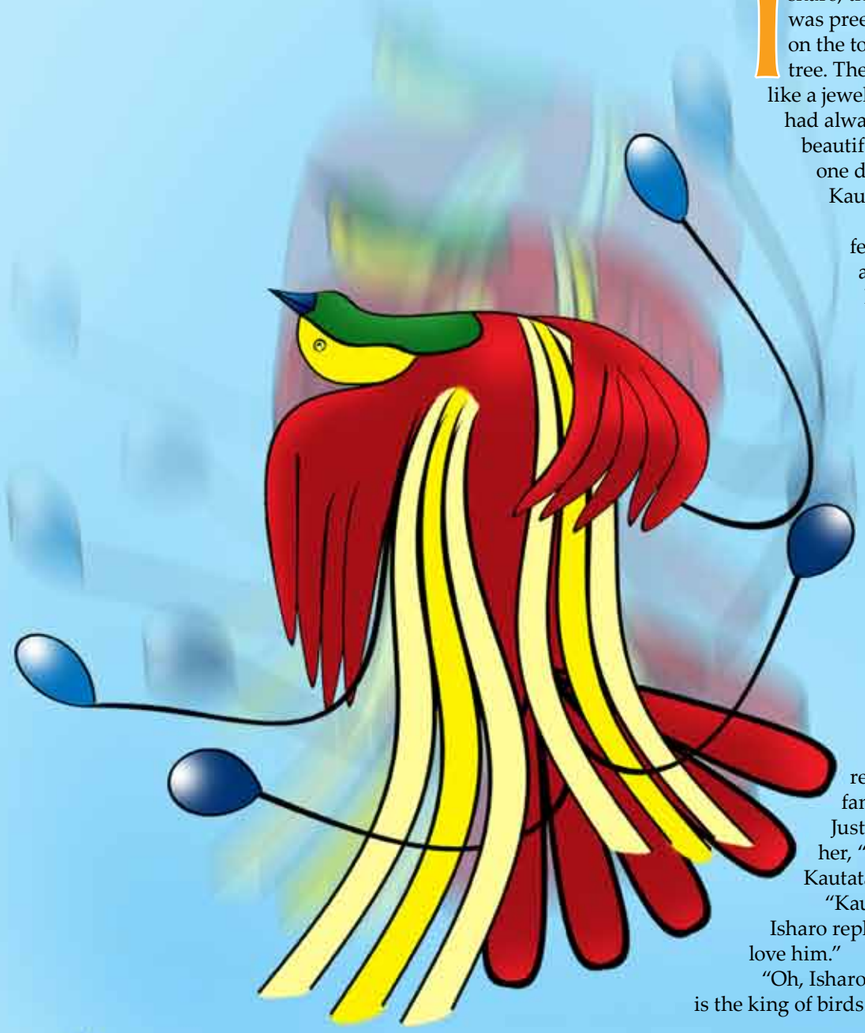
Neil Palmer was formerly the public awareness coordinator at CIAT.

DROUGHT STRESS due to water scarcity is also expected to increase because of climate change.

IRRI

How rice came to the Torajas

Retold by **Anupa Roy**
Illustrated by **Sherri Maigne Meneses**



Isharo, the beautiful bird of paradise, was preening her multicolored feathers on the topmost branch of a forest tree. The morning sun made her look like a jewel among green leaves. Isharo had always thought she was the most beautiful creature in the forest, until one day she glanced up and saw Kautatali.

Kautatali, the splendid bird feared and worshipped by all, swooped down from the heavens to rest on a large mountain tree. His feathers were the colors of the sun and his beautiful human-like body shone in the morning sun. His sharp golden beak and eyes missed nothing in the forest beneath. He glanced down and saw Isharo—just when Isharo glanced up.

Isharo had never seen such a big and beautiful bird and instantly fell in love with Kautatali. But Kautatali ignored her. He spread his wings and rose slowly in the air.

Isharo flapped her yellow-red wings and spread her fan-shaped tail to follow him. Just then, a man called up to her, "Isharo, Isharo, do not follow Kautatali."

"Kautatali, what a beautiful name," Isharo replied. "But I must follow for I love him."

"Oh, Isharo!" the man said. "Kautatali is the king of birds. He flies the highest and the fastest among all winged creatures. He will never love you, for lovely though you are, you can never match him in flight."

Ignoring the warning, Isharo spread her beautiful wings and rose above the forest canopy.

Kautatali was already high up, heading towards the sun. Isharo flew higher until she was above the mountains. In the cold air, her breath came fast and her little heart started beating faster. She had never flown so high.

Kautatali looked down at Isharo. "Go back, beautiful bird. You can never fly as high and as fast as me," he said as he glided on an air current. "And I will marry none other." Kautatali rose even higher.

"Oh, Kautatali, if you only knew how much I love you," cried Isharo. And she flapped her wings even harder to reach him.

But, Kautatali circled the mountain and flew on.

Isharo was exhausted. She looked down at the forest way beneath. Then she set her eyes skywards and flew after Kautatali.

Alas, the bird of paradise was a delicate creature made for the forests. Isharo began to fall from the sky.

Isharo tumbled down, down back into the forest—through the trees and into a forest clearing. Her little body was broken.

The man who had followed her flight sighed at the sight of the dying Isharo.

"I have failed to fly to Kautatali." Isharo whispered with her last breath. "But I will not die in vain. Plant my eyes and you will never lack food."

Indeed, Isharo's death was not in vain. From her multicolored wings sprung the leaves of sago palm and fruit trees; from her tail grew the coconut tree. But the most important gift was from her golden eyes. Isharo's eyes turned into beautiful rice grain.

And since then, people have had fruits and sago and coconut to eat. But most of all, they have rice to grow and never lacked food again.

The Torajas live in the highlands of South Sulawesi, Indonesia, and have cultivated rice from a very early time. They have detailed rituals for sowing and cultivating rice.

Ms. Roy is a consultant at an international school in India. She devotes most of her time to writing and studying stories for children and teens.

Rice in the eyes of a child

Budding photographers from Hong Kong's primary schools submitted their images to the Rice is life photography contest, which aimed to raise awareness of the importance of rice. Children aged 12 and under were encouraged to illustrate the role of rice in their daily life. Here are the winning shots. (The short descriptions of the photos by the kids are translated from Chinese to English by Zhongqiu Wang and Lee Huiwen.)

ZHONG ZHIXUAN, Grade 6, Saint Joseph English Primary School
Step by step, a farmer toils under the hot sun in order to harvest rice.

CAI ZIJIAN, Grade 5, Saint Joseph English Primary School
The warmth of cooked rice.

GAO JINGXI, Grade 5, Saint Joseph English Primary School
The joy of watching Papa enjoy his lunch.

ZENG ZIQING,
Grade 6, Y.C.H. Chan Iu Seng Primary School
No gourmet or fast food can beat the delicious and nutritious meals prepared by our mothers.

JACKIE MA, Grade 5, Pui Ching Primary School
The Chinese character 米 refers to rice. The character resembles a field. We can see rice everywhere and it is important to us. Beside the character is a bowl of cooked rice—the fruit of our daily struggles for a decent meal.

YE HUIYING, Grade 4, Leung Kui Kau Lutheran Primary School
Rice is cooked this way.

LI YINGXI, Grade 5, Bishop Walsh Primary School
Every day Papa works hard just to provide for the family while Mama happily cooks each meal so that we can all grow up healthy. No matter how tired Papa is or how busy Mama is, the whole family will put aside all troubles of the day to have dinner together. Each bowl and mouthful of rice we eat together represent every minute and second of our happiness and bliss. My wish is for everyone to be able to treasure every grain of rice filled with family warmth.

CAMILLE BASTINE, Grade 2, French School
Brown rice is healthier than white rice.

ZHAO KANGZHENG, Grade 4, Saint Joseph English Primary School
Please do not waste rice as it would sadden the hearts of farmers.

NICOLE LE, Grade 6, St. Margaret's Co-Educational English Secondary and Primary school
What is rice? Rice is an energy-giving food, which has made the world go round for hundreds of years. It is a valuable source of nutrients and carbohydrates. It is also inexpensive and has long storage life, which is very practical.

What is rice to me? To me, rice is the "pearl of the farm" because farmers have to work long hours to grow rice for us. Even some poor children have to work, which explains my photo.

Cameroon: Central Africa's potential rice granary

by **Savitri Mohapatra**

Cameroon may soon gain fame as a rising star in rice production

EXCLUSIVE SHOWROOM for rice of the Upper Nun Valley Development Authority (UNVDA) in Ndop, Cameroon.

Ndop Rice Value Chain Cooperative Quality Processing and Training Center, Ndop, Cameroon.

R.RAMAN, AFRICARICE (2)

The Republic of Cameroon is often described as "Africa in miniature" because of its rich diversity of climate, ecology, landscape, and culture. Few are aware that the country has huge potential to not only achieve rice self-sufficiency but also become the rice granary of Central Africa.

The country is endowed with large areas of arable land, abundant water resources, and favorable agroclimatic conditions that are conducive to rice production. Recognizing its agribusiness potential, and in response to the food crisis that severely affected Cameroon in 2008, the government is taking measures to revitalize the rice sector.

These government efforts to improve the country's food security are supported by the World Bank, the International Fund for Agricultural Development, the Japan International Cooperation Agency (JICA), the African Development Bank (AfDB), and the Food and Agriculture Organization of the United Nations (FAO).

Reviving the rice sector

Rice is still a relatively new crop in certain areas of Cameroon although the Far North, Northwest, and West provinces have a long tradition of rice cultivation.

Moreover, rice is increasingly becoming an important commodity fueled by shifts in consumer preferences and rapid urbanization. In Tonga, for example, homage is paid yearly to the farmer who introduced rice in the region. Here, local rice is preferred over imported varieties; when quality concerns are met, consumers are prepared to pay a premium for local varieties.

With renewed interest in the rice sector in recent years, the government is strengthening the country's rural infrastructure such as irrigation, milling and processing facilities, and farm-to-market roads.

Government-owned corporations, such as the Company for the Expansion and Modernization of Rice in Yagoua in Far North province and the Upper Nun Valley Development Authority (UNVDA) in the Northwest province, are being revamped to support rice farmers.

UNVDA, for example, supports about 13,000 rice farmers, facilitating their access to improved seeds, fertilizer, herbicide, information, and training as well as equipment rental services for farm operations.

The company also provides a market for farmers by buying rice from them. "Thanks to the UNVDA support, I have been able to pay school fees for my children and medical bills from the sale of my rice harvest," remarked Mr. Ako Thea Francis, a rice farmer from Ndop.

Connecting researchers and farmers

The Institute of Agricultural Research for Development (IRAD) is a public institution that has been collaborating with international partners to develop improved rice varieties and technologies to increase rice productivity in the region. Technology packages developed by IRAD are shared to farmers for faster adoption.

"We multiply the foundation seed of improved rice varieties received from IRAD and provide seeds to farmers at subsidized rates," said Ms. Lilian Yacoumbo, UNVDA chief officer.

Highlighting the vital role of research in the revival of the rice sector, IRAD Director General Noé Woin said, "The government recognizes the need to support a strong research and development program to develop improved technologies for smallholder farmers to help them raise their output and income."

Serious constraints

But, despite all these efforts, some constraints hinder the country from expanding and intensifying its rice production. These challenges include a lack of good-quality seed and adequate equipment for labor-intensive tasks, and a lack of postharvest technologies to make local rice competitive in the market.

The country's rice production has not yet been able to keep pace with the increasing demand. Over the last few years, its rice self-sufficiency ratio has been less than 20%, according to the United States Department of Agriculture and FAO. In 2012, Cameroon produced 102,000 tons of paddy rice and had to import up to 375,000 tons of rice to meet its demand.

Overcoming challenges

Another constraint is the long distance between the major rice production facilities and the main cities, which are filled with imported rice rather than "Cameroon-made" rice.

"Thus, JICA has launched a program to support mainly the production of upland rice in the Center, South, and East provinces of Cameroon, so that people living in these areas can eat their own rice," said Dr. Yoshimi Sokei, a JICA advisor based in Yaoundé.

The National Rice Development Strategy, drafted in 2009 within the framework of the Coalition for African Rice Development, has an ambitious aim to raise domestic production to 627,250 tons by 2018. To achieve this vision, the Cameroon government has deployed the following strategies.

Building rural enterprises

Some challenges are being tackled through collaborative research such as the innovative Common Fund for Commodities (CFC)-funded project on "Improving the competitiveness of local rice in Central Africa." Carried out by AfricaRice and its national partners from Cameroon, the Central African Republic, and Chad, it aims to build rural enterprises through co-sharing mechanisms.

Upland and lowland NERICA varieties selected through participatory varietal selection were introduced along with improved crop management practices to boost rice productivity. After that, the project established a "rapid-impact" seed program, postharvest technologies, processing activities, and links with input dealers and microfinance institutions.

"To ensure competitiveness, 'one-stop shop' quality-processing centers, were established to enhance quality along the whole value chain from seed through milling, sorting, and packaging to marketing," said Ms. Dorothy Malaa, IRAD national project coordinator.

The quality-processing center in Ndop, which was inaugurated in 2013 by Cameroon's minister of scientific research and innovation, testifies to the success of this model.

Quality rice as well as rice bran and other by-products are sold to both wholesalers and retailers. The production and marketing of rice flour have opened up new opportunities for women farmers who can process and sell rice-based products.

Focus on postharvest technologies

Cameroon is one of eight pilot countries that are partnering in a pioneering Canada-funded project to enhance the quality and marketability of locally produced rice through improved harvest and postharvest technologies.

The project, which is carried out by AfricaRice with its partners, aims to develop and evaluate suitable harvest and postharvest technologies that help produce quality rice products that respond to market demand.

The project gives households opportunities to raise their income by promoting the development of new rice-based products and rice by-products. Now, it is exploring the use of rice for producing fortified food items.

"Strengthening the capacity of rice stakeholders throughout the value chain, from farmers through millers and parboilers to marketers, is a major part of the project," said Dr. Jean Moreira, AfricaRice project coordinator.

Looking forward

The Cameroon rice sector is increasingly benefiting from collaborative research for development activities carried out by AfricaRice and its partners with support from several donors, including the AfDB, CFC, Canada, the European Union, Japan, the Arab Bank for Economic Development in Africa, the Bill & Melinda Gates Foundation, and the Global Rice Science Partnership, the CGIAR Research Program on Rice.

IRAD is involved in all the Africa-wide Rice Task Forces covering breeding, agronomy, processing and value addition, mechanization, policy, and gender. It has welcomed an approach, rice sector development hubs, for greater coherence and impact and has identified three hubs representing the main rice ecosystems in the country.

With all these measures in place, Cameroon is well on its way to realize its vision for a high-quality rice sector serving the entire region.

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

by **Samarendu Mohanty, Bidhan Kumar Mohapatra, Swati Nayak, Arindam Samaddar,** and **Sampriti Baruah**

Three women in India are taking up new challenges beyond their traditional roles

SAM MOHANTY, IRRI (3)

SUKANTI SWAIN, *the leader,* (*left*) is updating the account books of a women's self-help group.

SANJUKTA NAIK, *the machine,* shows how she packs vermilion, one among her many money-making activities aside from rice farming.

RABI PRADHAN, *the fighter,* has put up a betel leaf plantation from the money she borrowed from a local self-help group.

Breaking the barriers: from housewives to breadwinners

The leader, the machine, and the fighter are nicknames of three women farmers from Khanijipur, a village on the bank of the Prachi River, in the eastern Indian state of Odisha, located 40 kilometers from the state capital.

Married to farmers with less than half a hectare of land, they play a traditional role of women in their society: housewives. But now, they are also successful farmers, entrepreneurs, leaders, and motivators. They have a confidence that is rare.

Sukanti Swain, the leader

Sukanti lives in an extended family unit with her husband and three children, her mother-in-law, and her brother-in-law and his family. She is a high-school dropout.

Despite her lack of higher education, Sukanti manages a 2.3-hectare farm. (Only 0.3 ha of the land is owned by her family while the rest is under sharecropping.[1]) During the paddy-growing season, she spends most of her time in the field supervising all farm operations.

But, there is so much more to Sukanti than that. She also owns a small village grocery store and helps her husband with his *pakhundi* business (making of fence using bamboo sticks and coconut leaves, on which betel plants grow). She is the secretary of a women's self-help group she founded a decade ago, and also serves as a community resource person for 10 other self-help groups in neighboring areas.

Her achievements are even more remarkable considering the difficulties she faced—a culture that is restrictive for women. She still vividly remembers trying to convince her own family and the villagers to form a self-help group 12 years ago. "In the past, women were not allowed to go outside the house to attend meetings," Sukanti says. The villagers put pressure on her husband to dissuade her from forming a self-help group. They even questioned her character. "But, things are different now."

Today, she even organizes gatherings of many government-sponsored programs involving male farmers of her community. Her demeanor and professionalism are unparalleled.

Sukanti admits she couldn't have done all these things without the help of her family. Her husband gives her a hand in farm operations, her mother-in-law and children assist in managing her small grocery store, while her sister-in-law helps her in cooking meals and other household chores. Nevertheless, Sukanti, the leader, exhibited great courage and determination in changing the traditional image of an ideal Indian woman.

Sanjukta Naik, the machine

Unlike a large proportion of poor women in India who cannot read or write, Sanjukta is literate—in fact, she is a high-school graduate. She has two children in college, a son studying to be a police officer and a daughter who wants to be a teacher. Her youngest daughter dropped out of high school and helps her with the household work.

Unlike Sukanti, she has little support from her family as her husband works in a private company in a nearby district. Her husband sends about US$80 every month and comes home to visit a few times a year. However, not having her husband around has made her resourceful and independent.

Sanjukta grows paddy twice a year on 0.20 hectare of her own land and another 1.2 hectares through sharecropping. She also raises two cows and six goats. Apart from farming, she is involved in other money-making activities. She makes garlands, cuts betel nuts, bottles *alata*, which is a flower-based dye used to paint the feet of brides, and packs *sindoor* that Indian women apply on their forehead as dots or on hair parting. She makes nearly US$300 a year from these activities. Even with her busy schedule, she manages to serve as the president of the local self-help group.

All in all, her family's annual income from selling paddy, milk, and goat and other nonfarming products; remittances from her husband; and an honorarium as an officer of their local group adds up to more than $3,400 per year. With this income, they can afford to pay for higher education—something many in her village could only dream of for their children. Sanjukta spends 15% of their total income on her children's college education.

Her tireless efforts and seemingly inexhaustible energy have earned Sanjukta the nickname "the machine" as she works up to 20 hours a day, from 4 a.m. until midnight. For her, every minute of work is worth it because it means a better future for herself, her family, and the other women in her village who look up to her as their role model.

Rabi Pradhan, the fighter

Rabi's story could have easily been a tragedy. After 25 years of marriage, her husband left her with their three children. Making matters worse, Rabi is illiterate—a handicap that can prevent women from improving their economic status. But, Rabi has one quality that sets her apart from other women in similar circumstances. She has an unbreakable spirit.

Since her husband abandoned them, she has rebuilt her life with the support of friends and family. Although landless, Rabi grows rice during the wet season and, come the dry season, she plants rice and mung bean on 0.80 hectare of land on a sharecropping basis. Without enough money for hired labor, Rabi does most of the field work by herself.

Recently, she borrowed money from the local women's self-help group to start a betel leaf plantation on a small patch of land near her home. She also sells milk from her two cows. Altogether, she makes $1,800 annually selling paddy, betel leaves, and milk.

Rabi could have decided early on that her life situation was too hard without her husband, and that she and her children had no discernible future. But, the stakes were too high for Rabi, the fighter. Like Sukanti and Sanjukta, she turned to farming and other ancillary activities to improve the living standard of her family. With financial and emotional support from the women's self-help group and its members, Rabi was able to rise above her limitations.

Contagious success

The success stories of Sukanti, Sanjukta, and Rabi have been contagious in the sense that other women in Khanijipur have been encouraged to take up farming and other activities to supplement their family income. It is a wave of change, created by women for women. Hopefully, this will sweep through other villages as well.

Dr. Mohanty is the head of IRRI's Social Sciences Division (SSD). Mr. Mohapatra and Ms. Nayak are assistant scientists, Dr. Samaddar is a collaborative research scientist, and Ms. Baruah is a scientist in SSD, IRRI-India office.

[1] Sharecropping is a farming system in which a landowner allows a tenant to use the land in return for a share of the crops produced on the land.

SMARTER, CLEANER HEAT

by **Rona Niña Mae Rojas-Azucena**

ISAGANI SERRANO, IRRI (4)

A new design of a rice hull furnace has not only improved grain quality, but has also made drying cleaner and easier

If the searing heat wasn't enough, the thick, dark smoke that engulfed the area surrounding the furnace made the workers want to give up. The smoke wasn't confined only to the immediate vicinity, but it affected neighboring areas as well. This "smoke machine" was the inclined-grate design of a rice hull furnace used to provide heat to a flatbed dryer that is used to dry rice.

"The workers couldn't stay long near the furnace because it was too hot," says Jose Gagelonia, a flatbed dryer operator in the province of Nueva Ecija, Philippines, about the old furnace of his dryer. "The smoke and ash coming from it irritated our neighbors, who said that they ended up smelling like smoked fish."

The furnace, a key component in flatbed dryers, greatly affects the quality of the seeds and grains dried in it. Rice farmers and seed producers who came to Mr. Gagelonia to have their produce dried often ended up with grains that were unevenly dried and reeked of smoke. Because of this, they opted to have their grains sun dried.

Cleaner heat

Now, thanks to the new semi-automated downdraft rice furnace (dRHF) designed by experts at the International Rice Research Institute (IRRI), farmers and seed producers have a better choice.

In the old updraft furnaces, ashes were sucked from the top of the burning husk, especially when the grill bed was stirred or fed with rice hull. The new dRHF allows hot air to go down into the chamber and blower ("downdraft") instead of being blown upward and outward. This produces clean hot air because the burning husk on the combustion grill filters the ashes.

The dRHF has an automatic feeding mechanism that controls the amount and frequency of the rice hulls fed into the combustion grill using a programmable electronic timer connected to a motor. This produces a clean and steady combustion, resulting in a constant drying air temperature.

The cleaner combustion greatly reduces machine operators' exposure to heat and smoke because they need to check on the new furnace only every half hour (instead of the old practice of every 5 minutes) during an 8-hour operation.

Perseverance and perfection

The dRHF was first developed through collaboration between IRRI and Hohenheim University in Germany, in the 1990s. It was intended to be used for drying systems with small energy requirements. However, the concept was not successfully introduced to its target market in Southeast Asia, setting back the testing of the furnace's design.

Fortunately, Nong Lam University in Ho Chi Minh City, Vietnam, an IRRI collaborator, continued working on the design of the dRHF. Its improved design


Dr. Pat Borlagdan

was tested for commercial use in three 4-ton-capacity flatbed dryers in Vietnam before IRRI adapted it for further testing at Philippine pilot sites.

Although the development of the dRHF was partly supported by the Irrigated Rice Research Consortium—through the IRRI Postharvest Unit—a lack of funds and ideal test sites for adaptive research in the Philippines proved to be a challenge. The solution arrived in 2010 when Generoso Bautista, an agricultural engineer by education and a commercial airline pilot by profession who had just acquired a rice farm in the province of Batangas, became interested in flatbed dryers.

"I wanted to build a more efficient flatbed dryer for my own rice farm," explains Capt. Bautista. "Then I came across an online *Rice Today* article, *Machines of progress,* which featured IRRI's postharvest technology package and its impact on the lives of farmers (see pages 38-41, Vol. 9, No. 3 of *Rice Today*). He contacted Martin Gummert, head of IRRI's Postharvest Unit, who referred him to Pat Borlagdan, the engineer in charge of the testing of the dRHF in the Philippines.

On his farm in Batangas, Capt. Bautista and Engr. Borlagdan spent hours going over the design and discussing the parts that needed tweaking. "I financed the construction of the furnace, while Pat provided technical assistance," says Capt. Bautista.

After 2 years of hard work, Capt. Bautista is now the proud owner of a rice hull furnace with aerodynamic fan blades.

"We could safely work around the new furnace without worrying about the heat and smoke," says farm manager Luis Soliban, Jr.

Other beneficiaries

In Kidapawan, North Cotabato, the National Food Authority, one of the first recipients of the dRHF, suffered from high costs of drying and grain quality losses until the new furnace was installed in its warehouse.

In Peñablanca, Cagayan Valley, Don Lister, an entrepreneur, wanted to learn more about rice postharvest losses. While searching the Internet, he read a story about mechanical dryers using rice husk furnaces. He wasted no time in contacting Engr. Borlagdan, who sent him diagrams of the flatbed dryer, blower, and dRHF. After months of coordination, the 6-ton-capacity flatbed dryer with the dRHF was finally launched in March 2012.

"If the family can harvest rice, that's good," says Mr. Lister. "But, if we can help other farmers save their harvest, that's even better."

Interest in the furnace has continued to spread. Early technology adopters believe that the dRHF is a simple technology that the government should support and disseminate.

Marketable technology

Mr. Gagelonia runs a semi-automated dRHF and he manufactures made-to-order furnaces after he and 19 others attended training provided by IRRI on rice husk furnace manufacturing.

All materials used for fabrication are sourced locally, making them more affordable. He has already sold 12 rice hull furnaces to farmer groups and seed growers from all over the Philippines. He has also made smaller furnaces to fit dryers with lower capacity.

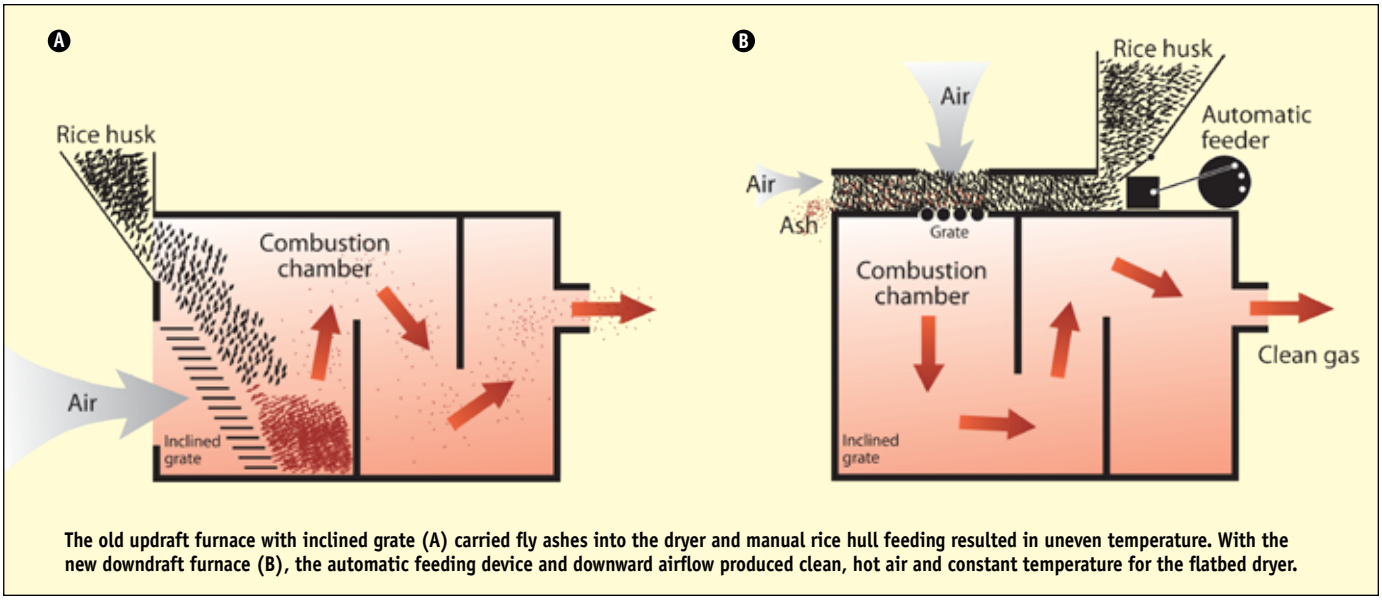
Capt. Bautista, on the other hand, still wants to continue improving the machine and he is now in the process of developing another type of furnace. In fact, an all-steel furnace sits in a shed on his farm, waiting to be taken to another farm for further testing.

Other training participants have also started making and marketing their own machines. Mr. Eugene Manalo from Laguna and Mr. Antonio Caspillo from North Cotabato have manufactured and sold the dRHF in their respective provinces.

Partnership forged in heat

Engr. Borlagdan, though no longer with IRRI, still provides technical assistance and shares his experiences to help improve the operation and maintenance of the furnace. He credits the public-private

JOSE GAGELONIA is an early adopter and manufacturer of the downdraft rice hull furnace.



The old updraft furnace with inclined grate (A) carried fly ashes into the dryer and manual rice hull feeding resulted in uneven temperature. With the new downdraft furnace (B), the automatic feeding device and downward airflow produced clean, hot air and constant temperature for the flatbed dryer.

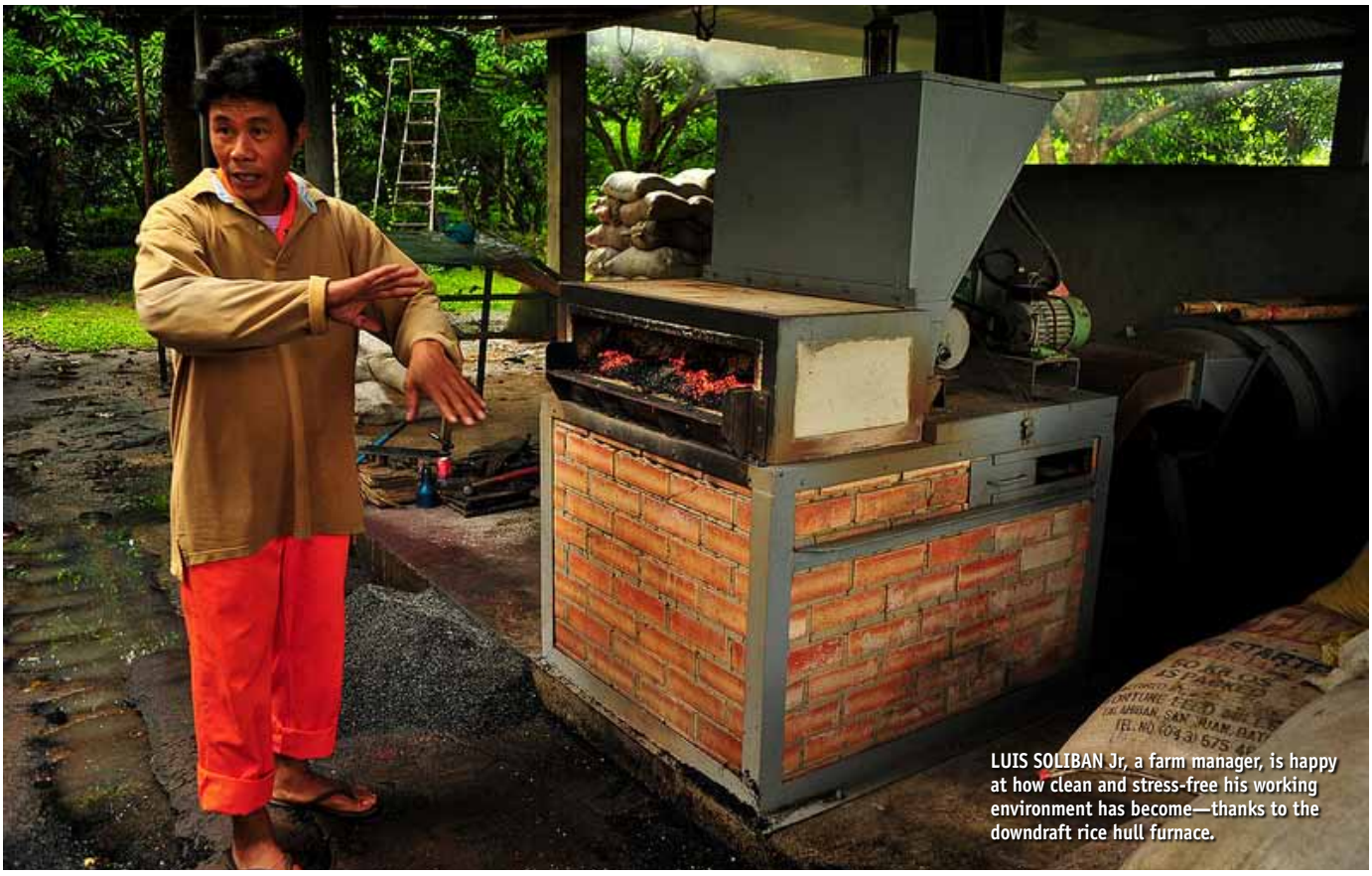
partnerships that had been formed for the successful adoption of the dRHF technology.

"Partnering with the private sector during the early testing stages became a valuable reference point when technological trials by government agencies failed," Engr. Borlagdan explains. "It was easier to show that the dRHF works, and is actually being used by the private sector."

The IRRI postharvest team, in collaboration with the Asian Development Bank, has now taken steps to transfer the dRHF technology to other countries such as Cambodia and Indonesia.

"Farmers should be aware that the technology is available to them," adds Capt. Bautista. "With support from both the private and public sector, technologies such as the dRHF could go a long way in improving the quality of rice—and life—of farmers."

Ms. Rojas-Azucena is a public relations specialist at IRRI.



LUIS SOLIBAN Jr, a farm manager, is happy at how clean and stress-free his working environment has become—thanks to the downdraft rice hull furnace.

Rice genetics gets personal

by Michael J. Thomson

In 2000, *Science* journal's "Breakthrough of the Year" was full-genome sequencing—highlighting the accomplishment of decoding a working draft of the three billion base pairs of the human genome at a cost of US$3 billion. At the time, E. Pennisi wrote that "*Science* marks the production of this torrent of genome data as the breakthrough of 2000; it might well be the breakthrough of the decade, perhaps even the century, for all its potential to alter our view of the world we live in."

Come 2007, another breakthrough followed—this time focusing on the remarkable amount of human genetic variation identified through the first human HapMap project using three million single-nucleotide polymorphism (or SNP; pronounced as "snip") markers, which are basically changes in the DNA code that differ between individuals.

Subsequent advances have led scientists to pinpoint SNPs linked to specific traits that help define who we are—ranging from markers associated with eye color and bitter taste perception to the predisposition for diabetes and Alzheimer's disease.

These achievements have now ushered in the age of personal genomics—giving each individual access to knowing about his/her own genome—and the predictions it contains. These can be done through, for example, the genetic testing company 23AndMe, which uses a "SNP chip" with more than 900,000 SNPs simply by sending a saliva sample through the mail, and Illumina's "Individual Genome Sequencing," which has brought the cost of the personal genome down to less than $10,000.

As with many advances in biology, cutting-edge research developed through a large influx of funding in the biomedical sciences often trickles down to agricultural research as well—a cascading effect that has started to revolutionize rice genetics. For much of the last century, rice breeders have been taking advantage of the heredity of rice varieties without the benefit of knowing the specific genes that control traits such as high grain yield or disease resistance. This is quickly changing because of breakthroughs in molecular genetics across the globe and the characterization of the wealth of genetic diversity in rice genebanks. At the same time, new technology has provided rapid, low-cost DNA marker genotyping that enables alleles at important genes to be tracked and transferred into new improved rice varieties efficiently.

"IRRI has been a key player in the genomics revolution in rice—making key investments to leverage new knowledge and technology to accelerate progress in research and breeding."

The International Rice Research Institute (IRRI) has been a key player in the genomics revolution in rice—making key investments to leverage new knowledge and technology to accelerate progress in research and breeding. Trait development teams at IRRI, in collaboration with advanced universities such as University of California-Davis, have successfully identified high-impact genes for breeding. One good example is the *SUB1* gene that confers tolerance of submergence in popular rice varieties. At the same time, the T.T. Chang Genetic Resources Center has worked to characterize valuable rice accessions with high-density SNP chips and next-generation sequencing. Its ultimate goal is to sequence the entire genebank. IRRI has recently upgraded its laboratory infrastructure by investing in cutting-edge equipment for genetic testing of DNA samples.

In line with this direction, we have recently established the Genotyping Services Laboratory (GSL) within the Plant Breeding, Genetics, and Biotechnology Division at IRRI. The lab aims to efficiently provide high-quality, cost-effective DNA extraction and SNP marker genotyping services to research and breeding programs within IRRI and the Global Rice Science Partnership, the CGIAR Research Program on Rice, across Asia and Africa. Current facilities provide genome-wide molecular markers for genetic mapping, diversity analysis, and DNA fingerprinting as well as trait-specific markers for breeding programs to select specific traits of interest.

Another exciting development is the founding of the Genomic Institute of Asia (GINA), a nonprofit startup located on the IRRI campus initiated by the managing director of PHILAB Industries. Using the Ion Torrent system, GINA is bringing rapid next-generation sequencing to fast-track genetic discovery and genotyping activities at IRRI and for its partners. Just as the human genome sequence and personal genomics are now transforming medical research, similar advances in rice genetics promise to accelerate discoveries and supercharge efforts toward developing improved rice varieties that can meet future challenges. Although the rice plants may not appreciate the power of personal genomics, the rice breeder who needs to select the best individual rice plant in a field of 10,000 will certainly be thankful.

Dr. Thomson is a molecular genetics and marker applications specialist at IRRI.

Listen to a podcast on IRRI radio about the GSL at: http://sn.im/irri-gsl

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