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Rice Today

International Rice Research Institute
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MAP SPECIAL
Rice around the world

RATS!
The damage they do

The delicious world of quality rice

Rice and climate change
What will happen, and what's to be done?

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Outlook on AGRICULTURE

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RiceToday
Vol. 6, No. 3

On the cover: Traditional rice varieties from Laos, like this one, are usually highly glutinous, resulting in their characteristic stickiness. See the story on pages 16-17.

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Rice Today is published by the International Rice Research Institute (IRRI), the world's leading international rice research and training center. Based in the Philippines and with offices in 13 other 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. IRRI is one of 15 centers funded through the Consultative Group on International Agricultural Research (CGIAR), an association of public and private donor agencies. For more information, visit the CGIAR Web site (www.cgiar.org).

Sacred ceremonies and political will

On 10 May 2007, two oxen were hitched to a wooden plow, with which they plowed a small plot of soil at the Sanam Luang Royal Grounds in front of Bangkok's Grand Palace. Watched by a crowd of VIP guests, a man then planted rice seeds in the recently furrowed soil.

Presided over by His Royal Highness Crown Prince Maha Vajiralongkorn, this was Thailand's ancient, annual royal plowing ceremony. First performed during the Sukhothai era (1238 to 1438), the ceremony, which marks the traditional beginning of the rice-growing season, was discontinued in the 1930s. The Thai Monarch, His Majesty King Bhumibol Adulyadej revived the ceremony in 1960.

For their efforts, the oxen are offered a choice of rice, corn, beans, sesame, grass, water, and rice whisky. What they choose to eat is used to predict the coming season—certain combinations mean a bountiful harvest, while others spell more difficult times ahead.

The sacred rite is yet another symbol of the huge importance of rice in Asia. The hard truth of the matter, though, is that, no matter how good the season predicted by the oxen, there remain millions of poor rice farmers and consumers throughout Asia and beyond. However, increasingly—and encouragingly—there are more and more signs that such rituals will be backed up by political support.

Immediately following the plowing ceremony, Thailand held an international rice convention on 11-15 May. Attended by around 300 participants from rice-trading countries, the convention highlighted the importance of rice to Thailand and celebrated the beloved Thai king, who has long worked to bring a better quality of life to Thai farmers (see The rice king on pages 11-15 of Rice Today Vol. 6, No. 1). At his keynote address, the Thai prime minister, His Excellency General Surayud Chulanont, drew upon this theme:

> "Guided by the fundamental principle that knowledge and technology should be simple, inexpensive, and easily applicable to farmers, the royally initiated projects involve research on, and experimentation with, new plant varieties that give a higher yield and produce healthy seedlings. To this end, His Majesty has allocated parts of the Chitralada Palace compound to be stations for conducting research and experiments in all fields of agriculture."

Noting that new varieties from His Majesty's experimental rice paddies were in fact used for the plowing ceremony, as well as distributed to rice farmers, General Surayad went on to discuss the Thai rice situation in the context of the current global state of affairs:

> "As the world's number-one rice exporter, we have a strong interest in safeguarding the rice trade and global food security. A number of major challenges threaten global rice production and trade. First, the future of global rice production is clouded by diminishing land and water resources, which are in turn constrained by increasing pressures from industrialization and urbanization. Secondly, factors such as climate change and uncertainties over international trade practices have also greatly influenced the world's rice situation."

The prime minister finished by assuring the audience that Thailand continues to strive for greater efficiency and productivity in agriculture through the adoption of new technologies and modern farming techniques, and by making the best use of traditional knowledge.

It was a speech that symbolized a growing and heightened awareness among leaders in rice-producing countries that rice research and development have a key role to play in the state of nations.

Adam Barclay
Editor

A new generation, a new revolution

An exciting new program just launched in Asia is encouraging some of the world's brightest young scientists to consider careers helping developing nations, instead of taking jobs focused on the developed world.

Many recent scientific advances—such as the sequencing of the rice genome in 2004—have already begun to help poor farmers overcome such age-old problems as drought, flooding, and high levels of salinity. Much of this progress was achieved in advanced research institutes in developed nations by researchers far removed from the problems poor farmers face in the field. The 3-week *Rice: research to production* course, launched last month at the International Rice Research Institute (IRRI) in the Philippines, is one of the first attempts to deal with this issue.

"Many young scientists working in developed nations are increasingly isolated from the very people in poorer nations who could really benefit from their work," Susan McCouch, one of the leaders of the new course and a professor in the Department of Plant Breeding and Genetics at Cornell University, said. "We want to change this, and encourage good young scientists, wherever they are, to think of themselves as a new generation of revolutionaries—taking the latest scientific knowledge and using it to improve the lives of the world's poor."

In the 1960s, young scientists from all over the world traveled to Asia to help launch the Green Revolution via the development of new agricultural technologies for Asian rice production. Since then, fewer and fewer young people have chosen careers in agricultural research in the developing world, sparking concerns of slowing progress and stagnation.

Sponsored by the National Science Foundation in the United States, the United Kingdom's Gatsby Foundation, and IRRI, the new course attracted 26 participants from 12 nations, with half coming from the U.S. and European Union and half coming from rice-growing countries in Asia and Africa. The program also seeks to reverse the one-way traffic of recent decades that has seen thousands of young scientists from the developing world taking jobs in the developed world.

Participants learned the basics of rice production, were shown the latest in rice research, and given hands-on experience in such areas as rice breeding and fertilizer management.

Megan O'Rourke, a 27-year-old mother of three doing her Ph.D. in ecology and evolutionary biology at Cornell University in the U.S., said it was the first time she had worked in a developing nation and seen the economic conditions first-hand. "It has reminded me that I began studying agriculture because of its essential place in supporting lives and societies," she said.

IRRI plans to run the same course next year.

Agreement to boost rice production in Indonesia

Indonesian efforts to avoid food shortages by increasing rice production have been boosted by the signing of a new agreement to help the nation's millions of poor rice farmers with new technologies.

Senior officials and scientists of the Indonesian Agency for Agricultural Research and Development, and other agencies of the Indonesian Ministry of Agriculture, signed the 3-year agreement with IRRI on 23 March 2007 in Jakarta.

Indonesia, the world's fifth most populous nation, has been struggling for several years to increase its rice production. Shortages could trigger price rises and cause severe hardship for the nation's poor.

The Indonesian government wants to see an additional 2 million tons of rice produced in 2007, followed by 5% growth in national rice production each year after that.

"With world rice production growing at less than 2% annually, it's increasingly difficult for countries to boost production beyond 2–3%," IRRI's Deputy Director General for Research Ren Wang explained.

But with global rice prices at a 10-year high after doubling in the past 2 years and world rice reserves at a 30-year low, there is pressure on rice-importing countries such as Indonesia to achieve self-sufficiency. The new agreement between Indonesia and IRRI focuses on three key areas: support for the Indonesian government's Rice Production Increase Program, collaborative research, and human resource development.

Support efforts will include the development of improved varieties with high yield potential, grain quality, and resistance to pests; a national strategy and framework for hybrid rice; and improved rice varieties that can tolerate submergence, drought, and low-temperature damage in high-elevation areas.

Collaborative research will include the strengthening of research capacity for the development and safe use of transgenic rice in Indonesia, improving grain quality and the nutritional value of rice, and special emphasis on drought, disease resistance, and poor soils.

Capacity building will focus on postgraduate degree training, on-the-job training, scientist exchange, short courses, and in-country training.

Rice Camp 2007


ARIEL JAVELLANA

Twenty high school students from Thailand and the Philippines attended IRRI's second annual Rice Camp on 23-28 April 2007. The camp is a fun training course that teaches participants about the basics of agriculture and rice research. First held in April 2006 (see *A rice future for Asia* in *Rice Today* Vol. 5, No. 3), Rice Camp exposes participants to current trends in rice science and rice farming, offers hands-on experience in field and laboratory work, creates awareness of the importance of rice research, and promotes rice science as a future career. It is also a chance for the students to share cultural differences and similarities. Participants drove a tractor, planted rice, collected and identified insects, tasted different varieties of rice, and more. Rice Camp 2007 was supported by IRRI, the Thai Rice Foundation under Royal Patronage, and the Philippine Rice Research Institute.

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4th International Meeting on Rice

The Rice Research Institute (IIArroz) and the Agro-industrial Group of Cattle and Rice, under the auspices of the Agriculture Ministry of Cuba, have announced the 4th International Meeting on Rice, to be held on 2-6 June 2008 at the Havana International Conference Center. The meeting will run concurrently with the 1st International Workshop of Millers and a rice expo. The meeting's objectives include discussions on the transfer of sustainable technologies and updates and evaluations of rice knowledge, especially relating to rice production in Latin America and the Caribbean. Key themes will include plant breeding and phytogenetic resources, technologies for managing rice cultivation, crop protection, physiology and nutrition of the rice plant, and harvest and industrial grain processing. Look for more details in future issues of Rice Today.

Pakistan price rise

Despite rapidly rising rice prices, the Pakistani government has no plans to impose a ban on rice exports. Sikandar Bosan, federal minister for food, agriculture, and livestock, told the Pakistani Daily Times in May 2007 that a combination of rice shortages in other South Asian countries and a rise in Pakistani production has led to a boost in exports, which rose from 267,000 tons in March to 284,000 tons in April. The higher prices are prompting Pakistani traders to export rice that would otherwise have been sold on the local market, leading to increased domestic prices. According to Rice Exporters Association of Pakistan Chairman Aziz Mania, rice smuggling is also affecting local prices.

Indian plan to boost grains

In May 2007, Indian Prime Minister Manmohan Singh announced a new scheme to increase food grain production. This 25 billion rupee (US$614 million) investment aims to increase food grain production by 20 million tons by the end of 2009, and thereby avoid spiraling imports. Rice production will be boosted in two key areas—through an additional 5 million hectares of land to be brought under irrigation, and by increasing the area planted to high-yielding hybrid rice varieties to 10 million hectares, from the current 1 million, by 2012.

Ag ministers' Mekong meeting

Agriculture ministers of the Greater Mekong Subregion (GMS) met on 9-11 April 2007 in Beijing to review progress in the region's cooperation in agriculture, endorse the Strategic Framework for Subregional Cooperation in Agriculture and Core Agriculture Support Program (CASP), and discuss the implications for the GMS of new trends in agriculture. IRRI coordinator for the GMS Gary Jahn, representing the Consultative Group on International Agricultural Research (CGIAR), noted that CGIAR centers are able to contribute to the five key components of CASP—facilitating cross-border agricultural trade and investment, promoting public-private partnerships for sharing agricultural information, enhancing capacity in agricultural science and technology, establishing emergency response mechanisms for agricultural and natural resource crises, and strengthening institutional linkages and mechanisms for cooperation.

New rice DNA map

Researchers at the University of Delaware and Ohio State University, USA, have used new technology to construct a comprehensive "expression atlas" of the rice genome. As well as identifying individual genes, the new map indicates regions of nongene DNA that are "expressed"—that is, transcribed into RNA—and may therefore play a regulatory role in the cell (genes are transcribed into RNA, which is then translated by the cell into proteins; some RNA is not translated but instead plays a role in the regulation of cellular processes). The study, discussed by Antoni Rafalski in the April 2007 issue of *Nature Biotechnology* (*Tagging the rice transcriptome*), increases researchers' knowledge about the functionally active regions of DNA between genes and will thus help crop biotechnologists develop improved rice varieties.

Gates Foundation looks at rice in China

ZHI-KANG LI (*left*) shows Bill Gates (*center*) and Prof. Shumin Wang, deputy director general, Institute of Crop Sciences Research, CAAS, around the CAAS-IRRI Joint Lab.

CAAS

A delegation from the Bill and Melinda Gates Foundation led by Bill Gates, cofounder of the Foundation and chairman of Microsoft Corp., and Raj Shah, director of the Agricultural Development Program of the Foundation, visited the Chinese Academy of Agricultural Sciences (CAAS)-IRRI Joint Lab on Rice Molecular Breeding and Genetics headed by IRRI molecular geneticist Zhi-Kang Li on 18 April 2007.

The delegation met with Dr. Li and his team at CAAS, where Dr. Li gave presentations on *Rice breeding in China—current status and prospects*, the concept of "Super Green Rice," and progress in the China National Molecular Breeding Network, a new breeding strategy to combine gene discovery with variety development initiated at IRRI in 1998 and coordinated by Dr. Li.

Mr. Gates showed great interest and discussed several topics, including molecular markers, the rice genome sequence, gene expression, and rice breeding, with Dr. Li. The group also visited the National Key Facility for Crop Gene Resources and Genetic Improvement and the China National Crop Genebank.

Temperate Rice Research Consortium launched

The Temperate Rice Research Consortium (TRRC) was launched during an international planning workshop on temperate rice on 2-4 May 2007 in Suwon, Republic of Korea. More than 90 scientists from 12 temperate rice-growing countries in Asia, Europe, and North America attended the workshop, which was coordinated by IRRI with financial support from the National Institute of Crop Science, Rural Development Administration (RDA), Korea.

The TRRC aims to strengthen national agricultural research and extension system (NARES) partnerships for technology development, validation, and dissemination for improvement of rice production and productivity in temperate environments; strengthen capacity building among TRRC partners; develop and share improved germplasm and technologies for problem solving and sustainable temperate rice production; and improve grain quality, nutritional value, and postharvest technology.

In a welcome address, RDA Administrator Kim In-Sik emphasized the importance of temperate rice in world food production and the need for improvements in production, stress resistance, grain quality, and nutritional value to feed a rising population. IRRI Deputy Director General for Research Ren Wang spoke on the need to reduce the big gap in the yield potential of temperate rice between developed and developing countries.

Participants focused on major issues of temperate rice and identified research priorities and strategies for four major working groups: yield potential and grain quality, biotic stress (blast), abiotic stress (cold), and resource-use efficiency (water and nutrients).

ADAM BARCLAY

Reader's Letter

Dear *Rice Today*,

I write with hat in hand in admiration of the Aussies. Skimming through the April–June issue of *Rice Today*, I find on page 7 (*Australian rice doldrums*) the extraordinary report of the national rice production for last year of 1,048 *million* tons (roughly twice the output of the remainder of the world). While it has declined some 80% for this year, 126 *million* is nothing to sneeze at. I remain humbled by this achievement and depressed to consider that I labored decades in the Americas to raise production by a few measly million tons.

PETER JENNINGS
LATIN AMERICAN FUND FOR IRRIGATED RICE

Rice Today *apologizes for the error, which was in no way caused by parochialism on the part of the Australian editor. The correct figures are 1.05 million tons in 2006-07, with 0.126 million tons predicted for 2007-08.*

Rice market at a glance

The Food and Agriculture Organization of the United Nations (FAO) reported in the March 2007 issue of the *FAO Rice Market Monitor* that estimates of world paddy (unmilled rice) production in 2006 have been downgraded to 629 million tons, a cut of 2 million tons. This figure is 4 million tons lower than the record high of 2005. The decrease is thought to be largely due to smaller crops in Asia, which were damaged by insects and irregular monsoon rains. Production also fell in Latin America and the Caribbean, but rose in Africa for the fifth consecutive year. As expected, estimates of world rice stockpiles at the end of the 2007 season have been downgraded 2 million tons to 103 million tons, due to the lower 2006 outlook.

Initial global forecasts for 2007 predict a rise in production back to 2005 levels. This assumes a return to average growing conditions, positive price expectations, and rejuvenated institutional support.

FAO's forecast of world trade in 2007 was raised to 29.8 million tons, nearly 1 million tons more than previously anticipated, and almost matching the 2005 trade record. The expected increase in trade largely reflects greater supply needs by importing countries facing production shortfalls.

As anticipated, rice export prices have continued to climb. According to the June 2007 *FAO Rice Price Update*, the All Rice Price Index (set at 100 for 1998-2000 prices) reached 121 in May 2007, up from 115 in December 2006. Experts predict this trend is expected to continue for at least this year.

IRRI Filipino staff recognized

The winners in the 2006 Awards Program for IRRI Filipino staff were recognized during the Institute's Board of Trustees meeting on 18 April 2007. Plant physiologist Evangelina Salcedo-Ella (pictured, *left*), Crop and Environmental Sciences Division (CESD), won the Award for Outstanding Scientific Achievement, and CESD research technician Edgar Amoloza (pictured, *right*, receiving his award from Board Chair Keijiro Otsuka and Director General Robert Zeigler) won the Award for Outstanding Research Support. The Award for Outstanding Administrative Support was shared by staff members of the Plant Breeding, Genetics, and Biotechnology Division for their work in organizing the Fifth International Rice Genetics Symposium (Manila, 19-23 November 2005) and the IRRI-India Office staff for their work in helping to organize and run the 2nd International Rice Congress (New Delhi, 9-13 October 2006). Ms. Salcedo-Ella was chosen for her work on flood tolerance in rice and Mr. Amoloza was recognized for his research project on increasing Analytical Services Laboratory sample throughput and helping improve the lab's operations.

JOSE RAYMOND PANALIGAN (2)

Scientific infrastructure vital for helping the poor

World-class scientific facilities play an increasingly important role in helping poor nations overcome poverty, food insecurity, and new challenges such as the impact of climate change.

The need for such infrastructure was highlighted at the annual meeting of the IRRI Board of Trustees (BOT) in the Philippines on 16-18 April 2007. IRRI has spent several million dollars over the past 5 years upgrading its main laboratories to keep them up to world scientific standards.

"While advanced scientific research institutes in developed nations have a vital role to play in helping to solve some of the developing world's most intractable problems, it's essential that we also build, and continue to upgrade, scientific infrastructure in poorer nations," BOT Chairman Keijiro Otsuka said. "And, it's vital that institutes such as IRRI have the resources to continually upgrade and renovate their own labs and facilities; otherwise, they will quickly become irrelevant."

As a result of the upgrading, the Institute has re-opened three labs at its Philippine headquarters:

A microarray laboratory: first set up in 2001, this lab became fully operational in 2002 after an investment of US$895,000 on new equipment and genotyping instrumentation. It serves as a centralized facility supporting research and training to conduct gene expression analysis, genotyping, gene tagging and mapping, and marker-assisted breeding. It also provides access to the latest genomic tools to researchers from developing nations.

A grain quality and nutrition laboratory: opened in December 2004 after an investment of $1.2 million, the lab works with IRRI rice breeders and cereal chemists around the world to ensure that new rice varieties reach the highest possible standards in terms of quality and nutrition.

A biotechnology laboratory: opened in June 2006 after an investment of $1.7 million, this lab is a state-of-the-art, high-throughput transgenic research platform to enable developing countries to obtain new technologies and training. It also provides a unique capacity to develop public biotechnology products designed to benefit those nations without access to such facilities.

"It will be a tragedy if the poor miss out on the benefits provided by our new scientific knowledge simply because they don't have the facilities to use it and learn from it," Dr. Otsuka said.

Achievements

The president of India, A.P.J. Kalam, who visited IRRI in February 2006, has nominated former IRRI Director General and World Food Prize laureate **M.S. Swaminathan** (1982-88) for the upper house of the Indian parliament. In an opinion column in India's *Hindustan Times*, JSS Rural Development Foundation adviser M. Mahadevappa also touted Prof. Swaminathan as India's next president.

IRRI crop physiologist **Shaobing Peng** has been invited to be one of five Changjiang (Yangtze River) Chair Professors of Huazhong Agricultural University.

TIME magazine (14 May 2007) has voted former Africa Rice Center (WARDA) breeder **Monty Jones**, from Sierra Leone, as one of the world's 100 most influential people. In a profile written by Jeffrey Sachs, director of Columbia University's Earth Institute, Dr. Jones was cited for leading the development of New Rice for Africa (NERICA), high-yielding varieties suited to African conditions, which have dramatically helped improve African rice productivity, an achievement that also earned him the 2004 World Food Prize. Read more about Dr. Jones in *The rice man of Africa* on pages 28-29 of *Rice Today*, Vol. 6, No. 2.

IRRI Deputy Director General for Research **Ren Wang** was recognized on 19 May for his contributions to Vietnamese agriculture and rural development. At a ceremony in Hanoi, Bui Ba Bong, vice-minister of Vietnam's Ministry of Agriculture and Rural Development, honored Dr. Wang for his leadership and commitment in ensuring that IRRI helps poor rice farmers and consumers improve their lives in Vietnam, and for his unqualified support for a more effective Vietnamese agricultural research and extension system.

MARD

REN WANG (*center*) **receives a plaque from Bui Ba Bong** (*left*)**, vice-minister of Vietnam's Ministry of Agriculture and Rural Development, as IRRI scientist Gary Jahn looks on.**

Guy Trébuil and **François Bousquet**, along with co-author **Tayan Raj Gurung**, have been awarded the 2006 Ralph Yorque Memorial Prize by the editorial board of the *Ecology and Society Journal* for their article *Companion modeling, conflict resolution, and institution building: sharing irrigation water in the Lingmuteychu Watershed, Bhutan*. The 500-euro prize was awarded for the most novel paper [*Ecology and Society* 11(2):36] integrating different streams of science to assess fundamental questions of the ecological, political, and social foundations for sustainable social-ecological systems. The field work for the study was carried out when Drs. Trébuil and Bousquet were assigned to the IRRI-Thailand Office in 2001-04.

Former IRRI agricultural economist **Prabhu Pingali** was among 72 new members and 18 foreign associates inducted into the U.S. National Academy of Sciences in May 2007. Dr. Pingali, currently director, Division of Agricultural and Development Economics, Food and Agriculture Organization of the United Nations, was elected in recognition of his distinguished and continuing achievements in original research, which includes work on technological change and agricultural development policy.

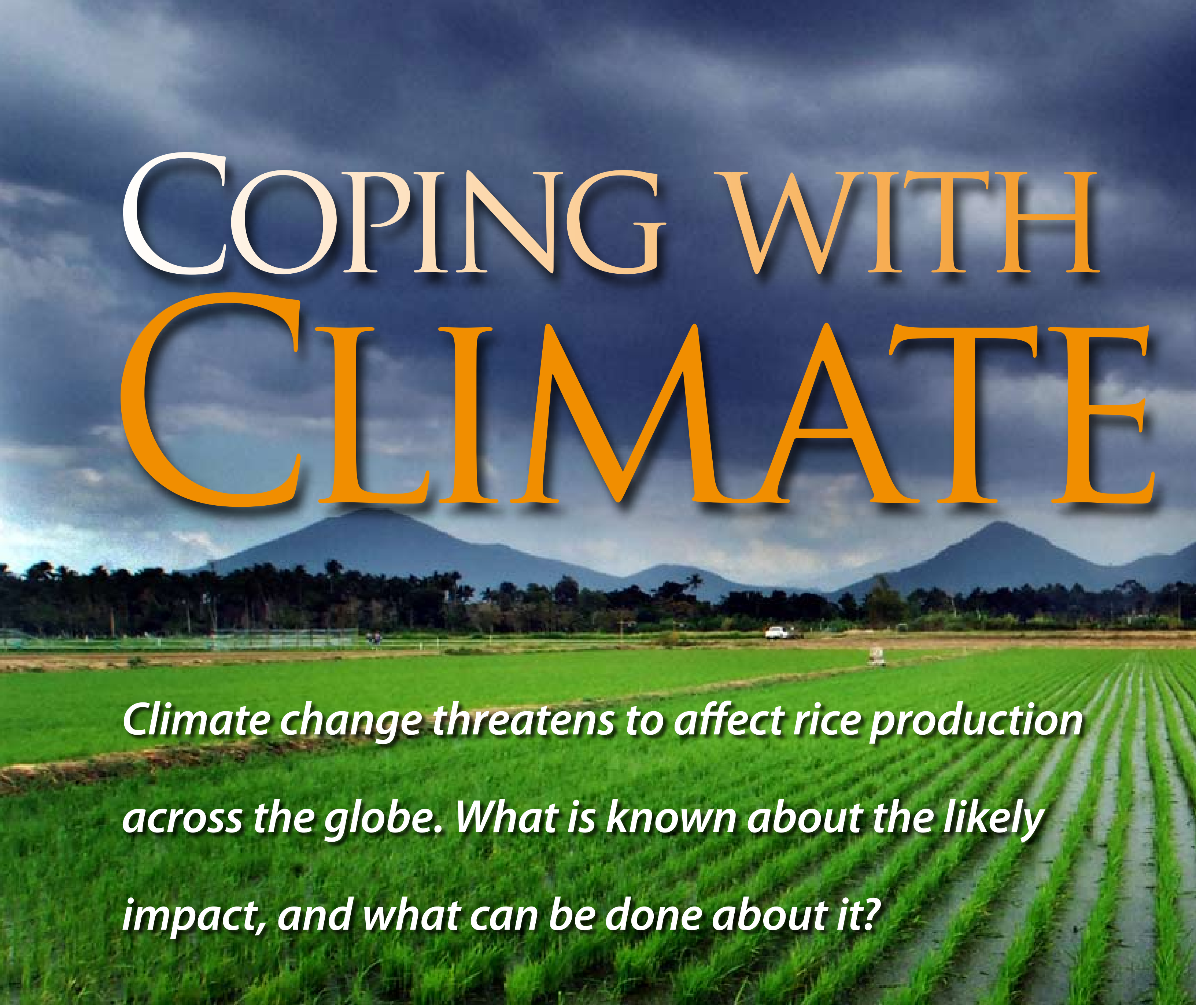
Keeping up with IRRI staff

AILEEN DEL ROSARIO

IRRI Director for Management Services **Kwame Akuffo-Akoto** (pictured, *above*) bid farewell to the Institute after more than 5 years of innovative and productive service. He provided IRRI with excellent financial leadership, developing and promoting best practices in fiduciary management and financial reporting. Mr. Akuffo-Akoto was instrumental in aligning the financial practices of IRRI and its partner institutes supported by the Consultative Group on International Agricultural Research with global standards, and in formulating a single financial policy for the entire group.

Hung-Goo Hwang, senior scientist seconded from Korea's Rural Development Administration (RDA), leaves after 3 years of outstanding work in japonica rice breeding and strengthening of IRRI-RDA collaboration through leadership in the genetic improvement of japonica rice. Dr. Hwang is replaced in the Plant Breeding, Genetics, and Biotechnology (PBGB) Division by **Kyu-Seong Lee**. **Kumi Yasunobu**, seconded from the Japan International Research Center for Agricultural Sciences (JIRCAS), left the Social Sciences Division (SSD) in March 2007. She was replaced by JIRCAS scientist **Shigeki Yokoyama**. **Zahirul Islam**, international research fellow in SSD, left in June 2007. **Xuemei Ji** has completed his contract as a postdoctoral fellow in PBGB.

Also departing were **Ren Wang** and SSD Head **Mahabub Hossain** (see more about them in this issue of *Rice Today*). **Randolph Barker** will serve as acting head of SSD.



Coping with Climate

Climate change threatens to affect rice production across the globe. What is known about the likely impact, and what can be done about it?

As if rice farming weren't hard enough. It is patently clear now that humans have gone and made it a whole lot harder. And, in a cruel irony, while the rich, developed countries are the ones that have produced most of the greenhouse gases that are causing climate change, it will be the poorer countries in the tropics—many of them reliant on rice to keep their populations from hunger—that will be worst affected.

As Earth warms up, one of the biggest concerns is the effect on agriculture—yet there has been relatively little research investigating the fundamental question of how humanity will feed itself in a changed climate. How will higher temperatures and the attendant increased incidence of extreme weather such as droughts, storms, and floods affect agricultural production? What are the implications for feeding the world's burgeoning population, especially the billions of poor who rely on small-scale and subsistence farming? And, of course, what can we do to lessen the impact?

To start answering these questions, *Rice Today* spoke to Reiner Wassmann, International Rice Research Institute (IRRI) senior climate scientist and coordinator of the IRRI-led Rice and Climate Change Consortium. Dr. Wassmann is seconded to IRRI from the Research Center Karlsruhe (IMK-IFU) in Germany.

What is IRRI's past record on climate change research and what are the current activities?
IRRI has a long history of studying the effect of climate on rice. The first experiment on temperature effects on rice was conducted in 1961, one year after IRRI's inception. Remarkably, the

FLOODED RICE FIELDS, like this one at the International Rice Research Institute in the Philippines, release significant amounts of the greenhouse gas methane.

ARIEL JAVELLANA

first work on high carbon dioxide (CO_2) concentrations affecting rice plants was performed in 1971, long before the issue of climate change became known to a broader audience. Likewise, the first workshop dealing with climate and rice dates back to 1974.

In 1991, IRRI started research explicitly examining climate change impacts, namely, a project funded by the United States Environmental Protection Agency (U.S.-EPA), titled *Effects of UV-B and Global Climate Change on Rice*, which used open-top chambers to study increased CO_2 and temperatures and included a modeling component. More recently, IRRI has dealt with temperature effects on rice yields in several research activities, including modeling work and analysis of high night-time temperature effects, led by IRRI crop physiologist Shaobing Peng.

In 2007, IRRI established the Rice and Climate Change Consortium to assess direct and indirect consequences for rice production, to develop strategies and technologies to adapt rice to changing climate, and to explore crop management practices that reduce greenhouse gas emissions under intensive production.

In the initial phase, our focus is on improved resilience of the rice crop to heat stress. To attain this goal, we are pooling some of IRRI's research thrusts—plant breeding and plant physiology, for example—and we will add new tools for screening and impact assessment. Moreover, we are now establishing monitoring sites to test the effects of emerging crop-management trends (diversification from rice-rice to rice-maize systems, for example) that will alter crops' budgets of carbon and nitrogen and thus significantly attempt to reduce greenhouse gas emissions. Data gathered from these sites will be used to develop predictive models and guide future research.

OPEN-TOP chambers were used in an IRRI study in the early 1990s to investigate the effect of increased CO_2 and temperature on rice.

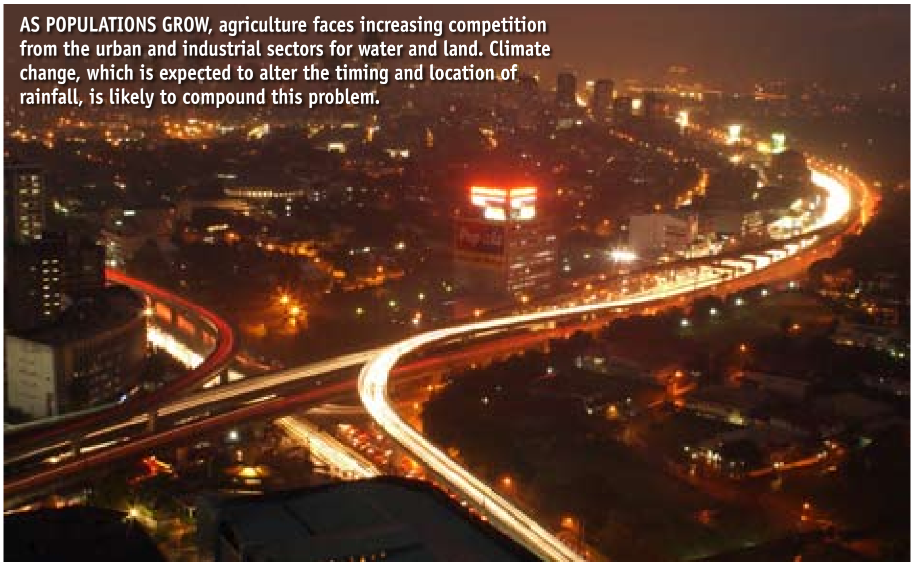
Do higher temperatures and CO_2 levels affect rice yields?

Overall, much uncertainty still exists about the true direction of the impact of CO_2 and temperature on rice yields. In the open-top chamber experiment at IRRI in the early 1990s, rice was grown at ambient and elevated (doubled) concentrations of atmospheric CO_2. Plants were also grown at ambient and elevated (plus 4 °C) air temperature to study the interactive effects of elevated CO_2 and temperature on growth and yield.

Over the 2 years of the study, the elevated CO_2 + ambient temperature treatment increased total biomass by 40% and yields by 27% over those achieved under ambient CO_2 and temperature. Under the high air temperature treatment, however, this stimulation decreased. Compared with ambient conditions, the combination of increased CO_2 and increased temperature resulted in a small increase in biomass and yield in the dry season and a small decrease in the wet season.

The results of these studies are in line with so-called Free-Air CO_2 Enrichment (FACE) experiments examining the effect of increased CO_2 on rice. FACE experiments allow researchers to increase CO_2 concentrations in the field—as opposed to in greenhouses or chambers—and so offer a more realistic assessment of the effect on plants. On the other hand, there is no FACE system in tropical countries, so all our knowledge comes from a limited number of small-chamber studies.

IRRI crop modeler John Sheehy determined that, as a general rule, for every 75 ppm increase in CO_2 concentration, rice yields will increase by 0.5 ton per hectare, but yield will decrease by 0.6 ton per hectare for every 1 °C increase in temperature. However, nobody has studied the interactions between CO_2 and temperature under controlled, realistic field conditions. The technology to do this is now available, and, if funding can be found, IRRI hopes to develop an experimental system in which both CO_2 and temperature can be controlled in rice fields.



AS POPULATIONS GROW, agriculture faces increasing competition from the urban and industrial sectors for water and land. Climate change, which is expected to alter the timing and location of rainfall, is likely to compound this problem.

Will climate change result in higher or lower rice production?

One component of the U.S.-EPA project dealt with modeling climate change impacts on rice production. In a comparative approach, climate data from three general circulation models (GCMs; a class of computer models used for understanding the global climate and projecting climate change) were coupled with crop yield models. The bottom line of this study was that the global yield forecast largely depended on the GCM used; one GCM resulted in a predicted net increase in rice yields (plus 4–7%) while two GCMs predicted net decreases (minus 4–13%). Moreover, the range of different climate change scenarios effectively defies a straightforward, single-figure prediction of future yields.

Uncertainty about global impact is caused by both GCMs and the crop simulation models used for such global predictions. In particular,

ARIEL JAVELLANA (3)

we lack a good understanding of the complex interactions of CO_2 and temperature effects at the process level of plant physiology and development. Likewise, the combined effect of temperature and humidity is not taken into account in the available crop models. All in all, there is much scope and much need to improve these models and also incorporate mechanisms that will allow us to more reliably explore ways to adapt to climate change, through, for example, genetic improvement of specific traits or shifting crop management.

How will climate change affect rice grain quality?

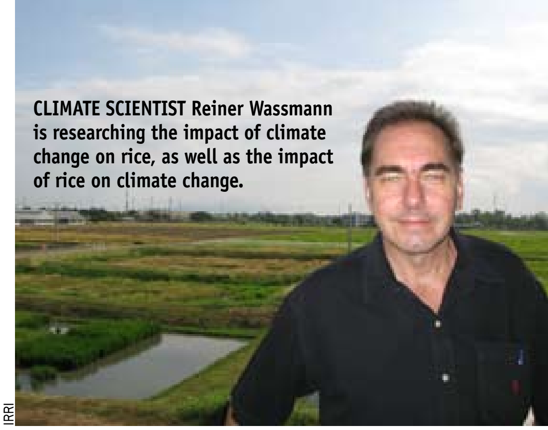
The quality and characteristics of the rice grain itself are likely to become one of the key parameters for determining the impact of climate change. The trends for grain quality take directions similar to those for the quantity of rice produced. In a study conducted by Ph.D. student Rachelle Ward, under the supervision of IRRI cereal chemist Melissa Fitzgerald, elevated CO_2 decreased chalk content. As high chalk content is generally an undesirable trait, this meant that grain quality was improved by increasing the proportion of marketable grains. Despite this, the most damaging effects of climate change on rice quality will occur from higher temperatures, which will affect several quality traits, including chalk, amylose content, and gelatinization temperature. The positive effects of elevated CO_2 do not compensate for the overall decrease in rice quality from the effects of global warming.

How will we ensure enough rice production in the future?

There is a lot of genetic variation across varieties of both cultivated rice (*Oryza sativa*) and its wild relatives. We are therefore optimistic that IRRI will be able to develop new varieties that can cope with higher temperatures. Scientists are also confident that the resilience of rice production systems to climate extremes, such as floods and droughts, can be improved within certain boundaries.

While IRRI sees plant breeding at the heart of improvements in rice production, the efficiency of adaptive measures can be increased significantly by other efforts, including

- Molecular marker techniques to speed up the breeding process;
- Geographic analysis of vulnerable regions (where the rice crop is already experiencing critical temperature levels);
- Regional climate modeling to identify future "tilting points" of rice production (temperatures or CO_2 levels above which major yield losses are experienced, for example); and
- Site-specific adjustment in crop management (shifting planting dates and improved water management, for example).



IRRI

CLIMATE SCIENTIST Reiner Wassmann is researching the impact of climate change on rice, as well as the impact of rice on climate change.

At the same time, the envisaged adaptation of rice production to climate change will require substantial funds to support vigorous and concerted efforts by national and international research institutions. Climate change has recently received enormous attention in the media and in policy statements, such as the *Stern Review on the economics of climate change*—which included a section on rice contributed by IRRI—and the *Intergovernmental Panel on Climate Change 4th Assessment Report*. All of these have identified adaptation of the agricultural sector as the key to limiting damage. Despite this unanimous assessment of the importance of research on adapting agriculture to climate change, adequate funding has yet to materialize.

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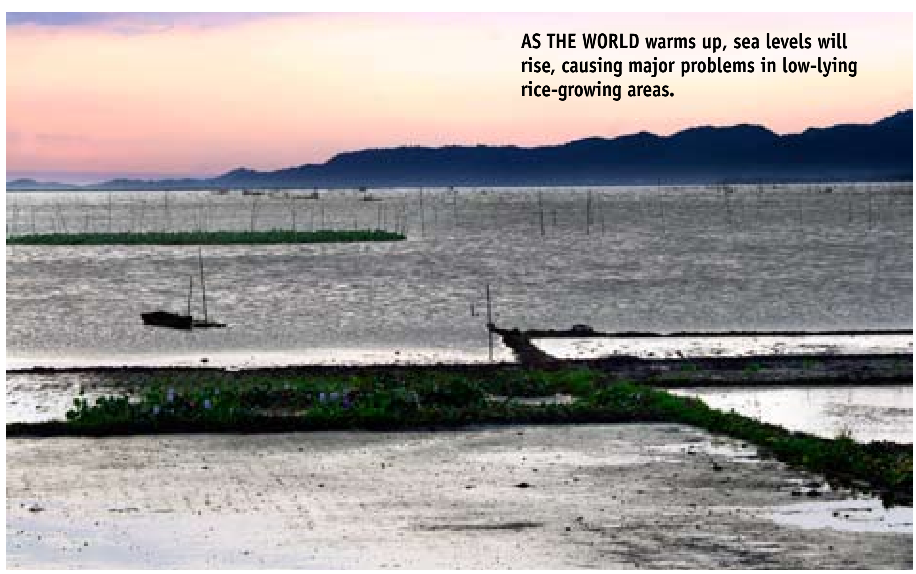


AS THE WORLD warms up, sea levels will rise, causing major problems in low-lying rice-growing areas.

Goodbye gas

YASUKAZU HOSEN (2)

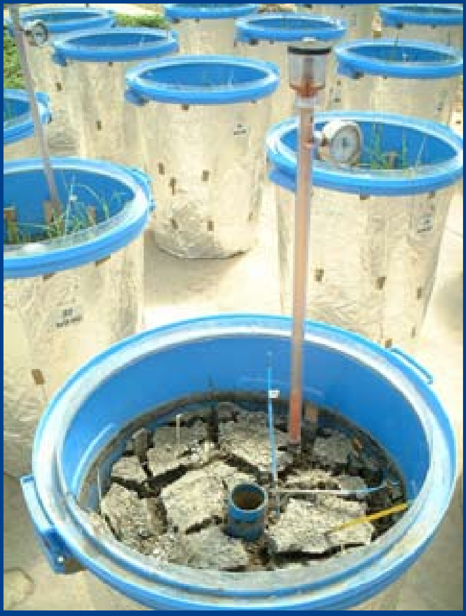
Although rice production will be affected by climate change, rice farming also has the capacity to amplify the problem. Because much rice is grown in flooded fields under anaerobic (oxygen-depleted) conditions, it is likely to contribute to global warming more than any other crop. The chemistry of flooded rice soils means that they release significant amounts of methane (CH_4)—a greenhouse gas about 20 times more potent than carbon dioxide (CO_2), and which accounts for a fifth of the global atmosphere's warming potential.

Methane is the final product of the microbial breakdown of organic matter. In rice soils, the source of organic material can be residues of the preceding rice crop, root secretions from the growing crop, or manure applied as fertilizer. The significance of rice production as a cause of rising CH_4 levels in the atmosphere over the last century was recently re-emphasized in a report by the *Intergovernmental Panel on Climate Change,* which was released in May 2007.

YUICHI FURUKAWA (2)

However, some ways of managing rice production help reduce CH_4 emissions. Yasukazu Hosen, a soil scientist seconded to the International Rice Research Institute from the Japan International Research Center for Agricultural Sciences, is leading a project to develop crop management strategies that increase the efficiency of water use and therefore reduce the amount of water required, without sacrificing yield. In principle, such a strategy can significantly cut CH_4 emissions.

Dr. Hosen and his team are assessing the environmental impact of existing water-saving technologies such as alternate wetting and drying irrigation and aerobic rice (a production system in which specially developed, high-yielding varieties are grown in well-drained, nonpuddled, and nonsaturated soils). The team's next step is to analyze the effect on greenhouse gas emissions of the timing of various aspects of crop management, such as nitrogen fertilizer application, irrigation, and incorporation of crop residue into the soil during the fallow period. By growing the rice in specially designed chambers (see photos, *above*), the team can capture and measure gases emitted by the rice plant and its field soil.



Although alternate wetting and drying has the potential to reduce methane emissions from rice fields, it is likely to result in increased nitrous oxide (N_2O) emissions. N_2O, also a greenhouse gas, is more than 300 times as potent as CO_2. The trick is to find a way to minimize the environmentally negative effects and maximize the positive results.

Dr. Hosen and his team developed several other hypotheses, including

1. N_2O emissions can be mitigated using an appropriate combination of nitrogen application and irrigation timing.
2. When crop residue is incorporated into the soil early in the fallow period, it decomposes faster than when it is simply scattered on the soil surface. This causes higher CO_2 emissions during the fallow period, but lower CH_4 emissions during the following cropping period. Thus, the global-warming impact of rice farming can be reduced with earlier crop residue incorporation.

Dr. Hosen cautions that it is premature to make any solid conclusions, but early results are promising, with preliminary data indicating much lower CH_4 emissions but significant N_2O emissions under alternate wetting and drying. At the time *Rice Today* went to press, the field experiment was continuing, and a pot experiment (see photos, *left*) had been established to set guidelines for also reducing N_2O emissions.

AN AERIAL VIEW of IRRI's open-top chamber experiment in the early 1990s.

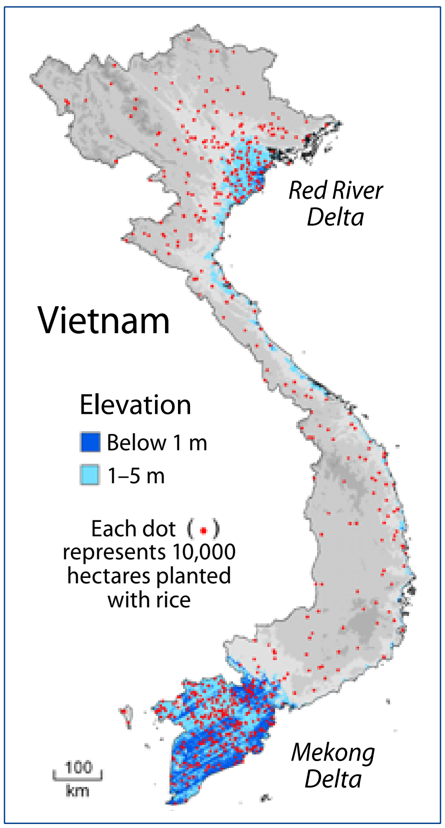
IRRI

What's really going to happen?

The impact of climate change on rice yields will depend on the actual patterns of change in rice-growing regions. Both higher maximum and higher minimum temperatures can decrease rice yields due to spikelet sterility and higher respiration losses, respectively (respiration is the process by which cells or tissues obtain oxygen and so generate energy for their growth and maintenance). However, these production losses may be averted or at least mitigated through the concerted efforts of agricultural research and policies aiming to improve rice varieties and accompanying management strategies.

At the same time, rice production may be threatened in some especially vulnerable regions, such as those affected by a rise in sea-levels. Some of Asia's most important rice growing areas are located in low lying deltas, which play a vital role in regional food security and supplying export markets. It is unclear to what extent the impact of higher sea levels can be compensated for by improved water control and what the costs and socioeconomic consequences of these changes are.

However, what is clear is that the risks stemming from a sea-level rise—which is projected in the range of 10–85 centimeters over the next century depending on the climate scenario used—are enormous for some countries. IRRI geographer Robert Hijmans has constructed a map of Vietnam displaying the rice area that is below 1 meter and between 1 and 5 meters above sea level, respectively (see map, *left*). With Vietnam so dependent on rice grown in and around low-lying river deltas, the implications of a sea-level rise are ominous indeed. The Rice and Climate Change Consortium is currently cooperating with the Southern Institute for Water Resources Planning in Ho Chi Minh City, Vietnam, on an impact assessment of different sea-level rise scenarios on hydrological conditions in the Mekong Delta, the rice "granary" of Vietnam.



VIETNAM'S RICE industry depends heavily on low-lying farm areas in the Mekong and Red River deltas. Relatively small increases in sea level could have disastrous consequences.

Moreover, climate extremes such as more frequent or more intense droughts, cyclones, and heat waves pose incalculable threats to agricultural production. Given the significance of rice as a staple crop, IRRI will strive to incorporate a range of "defensive traits" into modern rice varieties and to improve crop management to develop more resilient rice production systems.

STICKY RICE, prawns, and water chestnut dumplings—one of the gourmet rice dishes prepared for participants at the grain quality workshop.

ARIEL JAVELLANA (2)

Rice quality rising

The first coming together of a new international network of cereal scientists has laid the foundation for major advances in rice grain quality

By Duncan Macintosh

"Barbecue by pool to discuss the future of amylose" is not your typical dinner invitation. For most people, the first part of the request is probably very enticing, but the last part has the potential to provoke responses of "Er...sorry, I'm busy that night." But, if you're one of 75 cereal chemists and grain-quality experts who received just that invitation in April 2007, it promises a great night out.

The proportion of amylose (a starch) in the rice grain contributes to all traits of cooking and sensory quality. Its future is therefore a matter of great concern to the researchers from more than 20 countries who met on 17-19 April 2007 during a workshop entitled *Clearing old hurdles with new science: improving rice grain quality* at the International Rice Research Institute (IRRI) headquarters in Los Baños, Philippines.

The workshop was part of a major international initiative by the International Network for Quality Rice—which first came together electronically in 2006—to try to boost the income of the world's millions of poor rice farmers and at the same time provide consumers with more nutritious, better tasting food. The gathering was also the network's first face-to-face meeting.

New scientific knowledge is allowing rice researchers to develop better quality rice varieties that could fetch a higher price from consumers, especially increasingly affluent rice consumers in Asia.

The main aim of the new International Network for Quality Rice is to help rice breeders around the world develop varieties with improved quality traits such as better taste, aroma, and cooking characteristics as well as higher levels of nutrition. Once provided to farmers, the new varieties are expected to command a higher price among consumers, especially many in Asia, who, as they become wealthier, are seeking—and paying for—better quality food.

"Much of this research would not have been possible 10 years ago because we simply did not have the knowledge or the understanding of quality that we do now," Robert Zeigler, IRRI's director general, said. "It really is a very exciting time to be involved in such research, especially because we can take the new scientific knowledge generated by activities such as the recent sequencing of the rice genome, and use it to improve the lives of the poor by providing either better quality food or increased income."

"It's very clear from the great response we got to the workshop that rice quality is becoming a very hot topic in rice research almost everywhere," the convener and head of IRRI's Grain Quality, Nutrition, and Postharvest Center, Melissa Fitzgerald, said. "Many of the issues we discussed may not have even been considered a few years ago, but, with the recent advances in molecular biology and exciting new areas such as metabolomics, we can do things now that we could only dream about before."

Metabolomics is the whole-genome assessment of metabolites (the molecules involved in metabolism, which is the set of chemical reactions that occur in living cells), including the study of the chemical fingerprints that metabolic processes leave within cells.

During the workshop, the latest research was presented in several new areas, including breeding for better quality and genetically mapping specific quality traits in rice such as taste and aroma, the cooking and eating qualities of rice and how to measure sensory qualities more accurately, and the role of important substances such as starches like amylose in cooking rice and how they are measured.

To give participants a break from the intellectual rigors of the workshop program—and to make sure that theory was put into practice—dinners and lunches showcased rice dishes from around the world. Attendees were treated to gourmet meals that included European and Central Asian rice dishes, as well as "a banquet of rice in all its Southeast Asian gourmet forms."

"IRRI has a strong foundation of previous rice quality research to build on," Dr. Fitzgerald said. "We needed that to ensure we made the right decisions as we move into a new era of rice quality research."

For many years, rice breeders have focused on developing varieties that would boost production and provide some insect and weed resistance to help farmers reduce their use of pesticides; quality was not a high priority. However, major new advances in rice research and Asia's continuing economic development have created important new opportunities.

"These are the two key changes driving the whole process and making this research area so exciting," Dr. Zeigler said. "If we can link these two things together—our new and improved knowledge and understanding of rice quality with affluent-consumer desires for better rice—then it's possible we can also help poor farmers improve their lives.

"This would be an outstanding example of using the latest in science to improve the lives of the poor, while satisfying the desires of the affluent," he added.

WORKSHOP CONVENER Melissa Fitzgerald in her lab.

JOSE RAYMOND PANALIGAN

RECIPE

Spicy prawn and chicken patties

Source: *Australian Women's Weekly* cookbooks, modified by Melissa Fitzgerald, head of IRRI's Grain Quality, Nutrition, and Postharvest Center. This is one of the dishes cooked for the workshop participants.

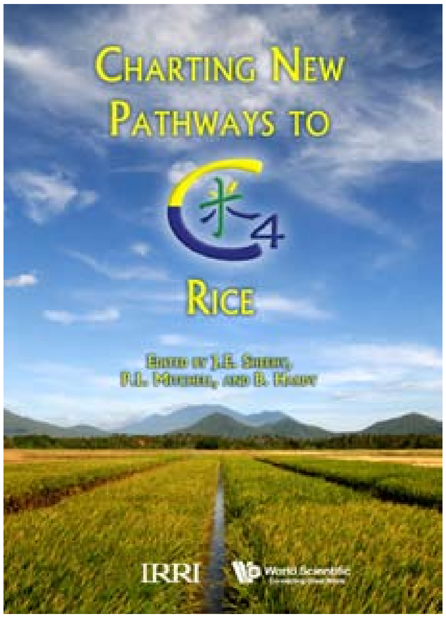
Makes about eight servings

Patties
1½ cups cooked short-grain rice
250 g minced chicken
150 g small cooked prawns, shelled
5 green onions, chopped
2 cloves garlic, crushed
2 teaspoons grated fresh ginger
1 small fresh red chili, chopped
1 tablespoon fish sauce
2 tablespoons chopped fresh coriander (cilantro) leaves
Canola oil for shallow frying

Yogurt Dipping Sauce
1 cup plain (unsweetened) yoghurt
1½ tablespoons mild sweet chili sauce
1 green onion, finely chopped
1 tablespoon chopped fresh coriander (cilantro) leaves

Process rice, chicken, prawns, green onions, garlic, ginger, chili, sauce, and coriander until just combined. Divide mixture into eight portions, shape into patties, place on tray, and refrigerate for 2 hours.

After refrigeration, shallow-fry patties in hot oil until browned and cooked through; drain on absorbent paper. For dipping sauce, combine all ingredients in a bowl and mix well.



Charting new pathways to C_4 rice

(edited by J.E. Sheehy, P.L. Mitchell, and B. Hardy; published by World Scientific Publishing, Singapore; 422 pages).

With unfavorable conditions brought about by climate change and other environment-related issues, feeding the world in the coming century will be no mean feat. The situation offers an enormous challenge to the rice research community, compelled to feed almost half the world's population using less water and nitrogen.

In *Charting new pathways to C_4 rice*, 24 scientists blaze the trail toward another Green Revolution, continuing the fight against hunger using modern technology. According to the authors, future substantial yield increases are likely only if the photosynthetic system of the rice plant (known as C_3) can be converted to the more efficient C_4 photosynthesis of plants such as maize. C_4 plants use water twice as efficiently as C_3 plants; nitrogen use is 30% more efficient, and they are generally more tolerant of high temperatures. When achieved, C_4 rice will be the first non-evolutionary example of reconstructing the primary metabolism of a plant.

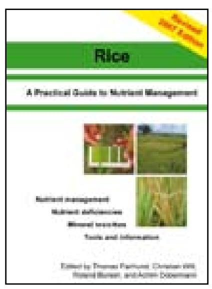
Showcasing alternative ways of achieving C_4 photosynthesis, the book presents papers by crop modeler John Sheehy (*Why build a new rice engine and why start now?*), agricultural economist David Dawe (*Scientific research, poverty alleviation, and key trends in the Asian rice economy*), plant ecologist Rowan Sage (*Learning from nature to develop strategies for the directed evolution of C_4 rice*), and other leading experts in the field.

Charting new pathways to C_4 rice is scheduled for publication in July 2007. To order or inquire, contact IRRIPub@cgiar.org.

Rice: a practical guide to nutrient management (2nd edition)

(edited by T.H. Fairhurst, C. Witt, R.J. Buresh, and A. Dobermann; published by IRRI; 136 pages; US$10).

In the last 5 years, site-specific nutrient management (SSNM) for rice has become an integral part of improving nutrient management in many Asian countries. Nutrient recommendations have been tailored to location-specific needs and promoted on a wide scale. The first edition of *Rice: a practical guide to nutrient management* (2002) quickly became the standard reference for SSNM.



Over the years, SSNM has been refined through research and evaluation through the Irrigated Rice Research Consortium. Conceptual improvements and simplifications have been made, particularly in nitrogen management. A standardized four-panel leaf color chart has been produced, with more than 250,000 units distributed by the end of 2006.

The evolution of SSNM prompted this revised edition of the practical guide, to ensure consistency with newer information provided on the SSNM Web site (www.irri.org/irrc/ssnm) and local training materials. This edition will also be translated into several languages, including Bangla, Chinese, Hindi, Indonesian, and Vietnamese.

The pocket-sized guide introduces the concept of yield gaps and underlying constraints. The functions of each nutrient are explained in detail, with a description of the deficiency symptoms and recommended strategies for improved nutrient management. The 47-page color annex provides a pictorial guide to the identification of nutrient deficiencies in rice.

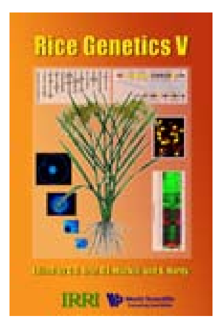
To make this 2nd edition as widely accessible as possible, it is also freely available to download from the Web in PDF (www.irri.org/publications/catalog/ricepg.asp).

Rice Genetics V

(edited by D.S. Brar, D.J. Mackill, and B. Hardy; published by World Scientific Publishing; 350 pages; US$88).

Rice is now the model plant for genetic research on crop plants. Those who work on rice do so not only to help grow and eat it, but also to advance the frontiers of genetics and molecular biology. Progress made since the first International Rice Genetics Symposium (IRGS) in 1985 has made rice the organism of choice for research on crop plants, and the rice genome has become a reference for other cereals.

This volume is a collection of the papers presented at the 5th IRGS in Manila, Philippines, in 2005. It reports the latest developments in the field and includes research on breeding, mapping of genes and quantitative trait loci, identification and cloning of candidate genes for biotic and abiotic stresses, gene expression, and genomic databases and mutant induction for functional genomics.



To purchase the complete electronic publication or select chapters, go to http://tinyurl.com/2lyvl6. A paperback edition, to be sold only within the Philippines, will be available at IRRI for $27 from late July.

MAPS

The where and how of rice

by Robert Hijmans

Rice is grown in more than 100 countries. According to the Food and Agriculture Organization of the United Nations (FAO), the global rice area harvested in 2005 was 153 million hectares. The amount of land used for rice is less, in the order of 127 million hectares, because in some fields farmers plant two, or even three, rice crops each year. One hectare of double-cropped land therefore provides 2 hectares of rice area each year (areas referred to hereafter are harvested areas, as opposed to actual land areas). On this land, farmers produce 628,000,000,000 kilograms of rough (unmilled) rice. This averages out to about 95 kilograms for each person on Earth.

Almost half the global rice area is in India and China and 89% is in Asia. Africa and the Americas each have a little more than 5%. The eight countries with the most rice area are all in South and Southeast Asia (India, China, Indonesia, Bangladesh, Thailand, Vietnam, Myanmar, and the Philippines) and they have 80% of the global rice area.

Rice production agroecosystems are often classified according to the dominant water regime. For example, rice fields are distinguished for being irrigated or rainfed, and for being flooded or not flooded. Irrigated rice, typically grown on bunded fields that retain water to assure flooded conditions, makes up about 44% of the global rice area. This is the dominant system at high latitudes (both north and south), but also in southern India and on the Indonesian island of Java. Flooded rice is the most productive rice ecosystem, producing about 75% of the global output.

Most of the rainfed rice fields are also flooded for at least part of the growing season. This agroecosystem, commonly known as "rainfed lowlands," comprises about 45% of the global rice area and is particularly important in eastern India and Southeast Asia. The remaining 11% of the world's rice area is grown in the "upland" ecosystem, which comprises fields that are neither flooded nor irrigated. In Asia, this system has declined considerably in Thailand and China, but is still important. It is the dominant production system in Africa and Brazil in terms of area planted.

Knowing where and how rice is grown is crucial for assessing threats to and opportunities for production

The reality is always more complex, with fields that are sometimes flooded, or receive very little supplementary irrigation. In parts of northern China, for example, rice is grown as a "normal" (nonflooded) field crop, with supplementary irrigation as needed, while some of the upland rice in Brazil receives water from sprinkler irrigation. It remains a challenge to adequately characterize rice agroecosystems and obtain accurate statistics about their distribution.

The map on the next two pages reflects the International Rice Research Institute's (IRRI) current best estimates based on subnational-level production statistics in rice-producing countries. While IRRI has a long history of compiling such data for Asia,[1] the Institute now considers all rice-producing countries, in collaboration with the International Center for Tropical Agriculture, the Africa Rice Center, and the International Food Policy Research Institute. The map for Africa is a first approximation, and consistency between the classifications used in Latin America and Asia needs improvement. Meanwhile, the technology for this type of work is changing: a recent paper by Xiangming Xiao and colleagues[2] has shown how time series of satellite images from the MODIS sensor can be used to map flooded rice areas.

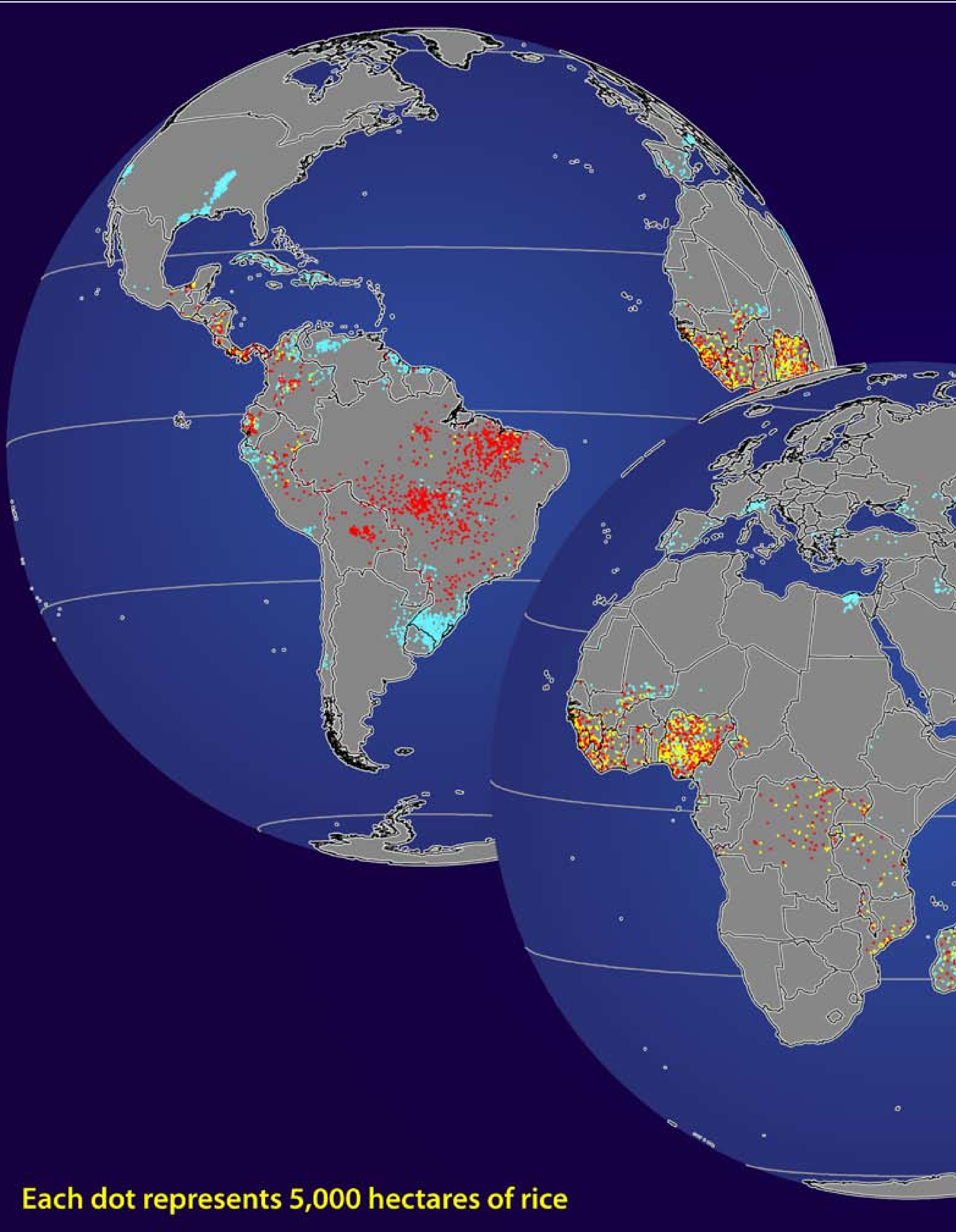
Knowing where and how rice is grown is crucial for assessing threats to and opportunities for production, and hence for determining research needs. For example, to estimate the possible impact of a drought-tolerant rice variety on income and poverty alleviation, you need to know (along with many other things) how much rice is produced in areas affected by drought, what the current rice yields are, and how much yield increase to expect from the new variety. Trends of detailed rice area and yield data can also help us better understand ongoing patterns of change, and the implications for food security and research priorities.

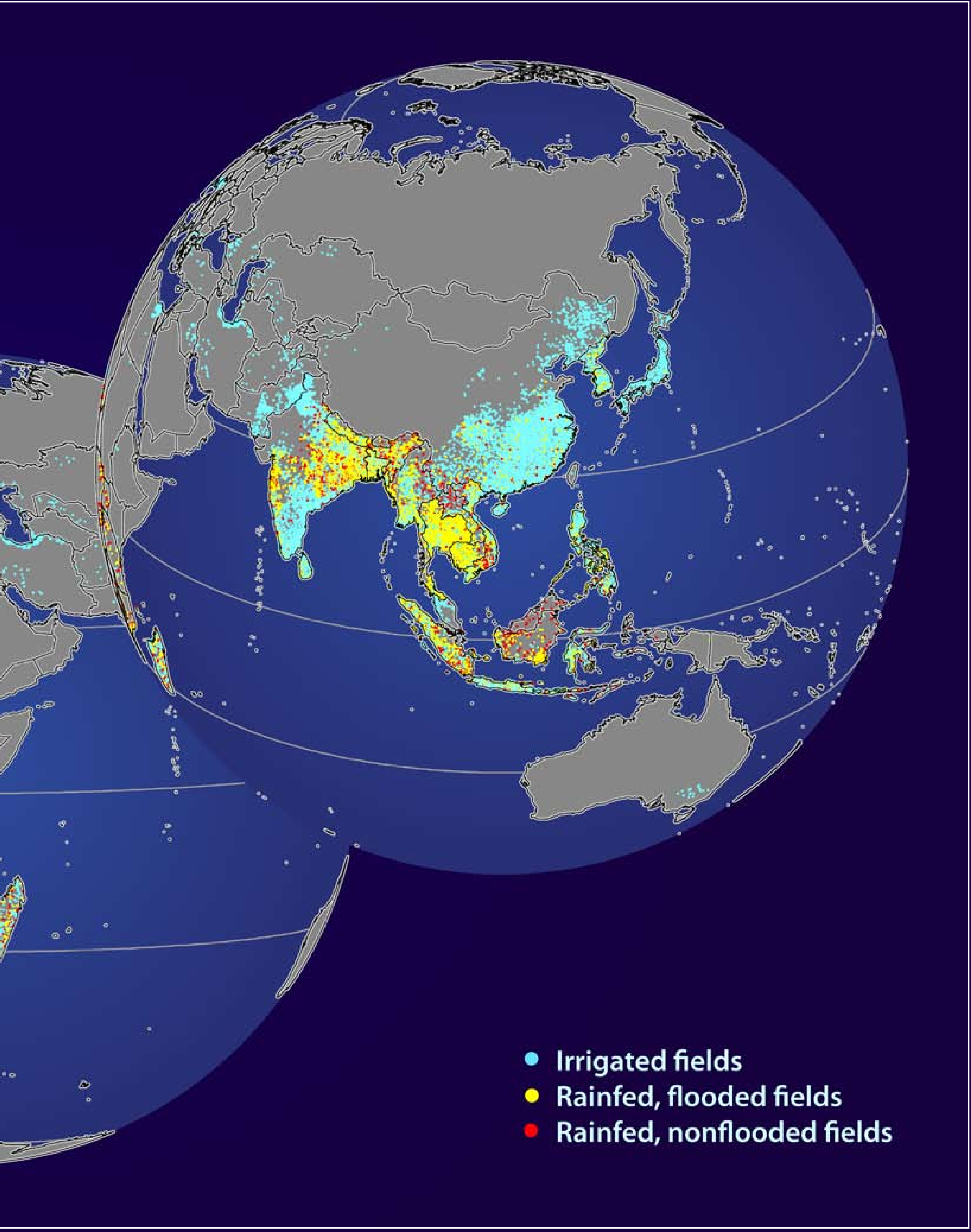
ARIEL JAVELLANA (2)

Dr. Hijmans is a geographer in IRRI's Social Sciences Division.

1. The work of the late Robert E. Huke, a professor of geography at Dartmouth College, New Hampshire, USA, and a visiting scholar at IRRI, has been particularly important and is the foundation for IRRI's current work.
2. Xiao X, et al. 2006. Remote Sensing of Environment 100:95-113.

Map: Robert Hijmans / Design: Juan Lazaro, IV





Where and how rice is grown is crucial information for determining research priorities.

As deputy director general for research at the International Rice Research Institute, Ren Wang was instrumental in elevating both international partnerships and research capacity

Letting a hundred flowers bloom

by Duncan Macintosh

The challenge for any research manager is to find that delicate balance between too many ideas and too few, while making sure the best ideas have the resources they need to blossom.

It's a tough job that requires all the skills of an experienced parent—supportive and enabling most of the time, but willing to take the lead when there are hard decisions to be made. It's a role that Ren Wang, the deputy director general for research (DDG-R) at the International Rice Research Institute (IRRI), has played since January 2000. Now, though, it is time to move on. In July, Dr. Wang was due to step down after more than 7 years as the head of the world's largest and most important international rice research program.

It's a long way from the northern, coal-dominated Chinese province of Shanxi to IRRI's advanced scientific laboratories in the Philippines. But when asked how he would like to be remembered as IRRI's DDG-R, Dr. Wang says, "I hope people will remember me as a great facilitator; as someone who worked hard to enable and support the work of the many dedicated and brilliant scientists at IRRI."

Dr. Wang was the first Chinese national to be appointed as IRRI's DDG-R and one of his most important—and lasting—legacies will no doubt be the Institute's very strong collaborative research relations with China.

On his very first trip overseas after starting at IRRI, Dr. Wang attended a workshop on functional genomics (the discovery of which biological functions belong to specific DNA sequences, such as genes, and how these work together to produce and influence traits) at the Chinese Academy of Agricultural Sciences (CAAS) in Beijing. "One of the most exciting aspects of my work at IRRI," he says, "was guiding new work in areas like functional genomics to ensure it made a difference in the lives of poor rice farmers."

On his next trip overseas—this time to Korea—Dr. Wang was to establish yet another consistent theme to his work at IRRI: this time, his commitment to helping IRRI's partners in the national agricultural research and extension systems (NARES) of rice-producing nations. While in Korea, he signed a new collaborative 2-year work plan that focused on 15 individual research projects.

"IRRI's many partnerships and relationships with the NARES are vital not only to its research but also to its continuing ability to achieve impact and really make a difference in the lives of poor rice farmers and consumers," Dr. Wang says. "My job was to identify those areas where IRRI could play a useful role, and those where it could not."

In addition to building on decades of successful research relationships in Asia, Dr. Wang led efforts to build new relationships in regions such as Central Asia and Africa. However, his biggest challenges remained in South and Southeast Asia.

"The rapid development of many NARES in Asia, especially in nations such as Korea, India, Thailand, and China, meant IRRI had to change also, or be left behind," Dr. Wang says. "During my time at IRRI, several of these nations have moved from being simple research partners to actual donors, so the whole relationship has fundamentally changed."

Fortunately for IRRI, Dr. Wang had the experience to deal with such major changes. For most of his career, he has been surrounded by change and opportunity. Born in 1955 in Taiyuan, the capital of Shanxi, Dr. Wang saw little rice while growing up and, it appeared, was never destined to enter the world of agricultural research.

JOSE RAYMOND PANALIGAN

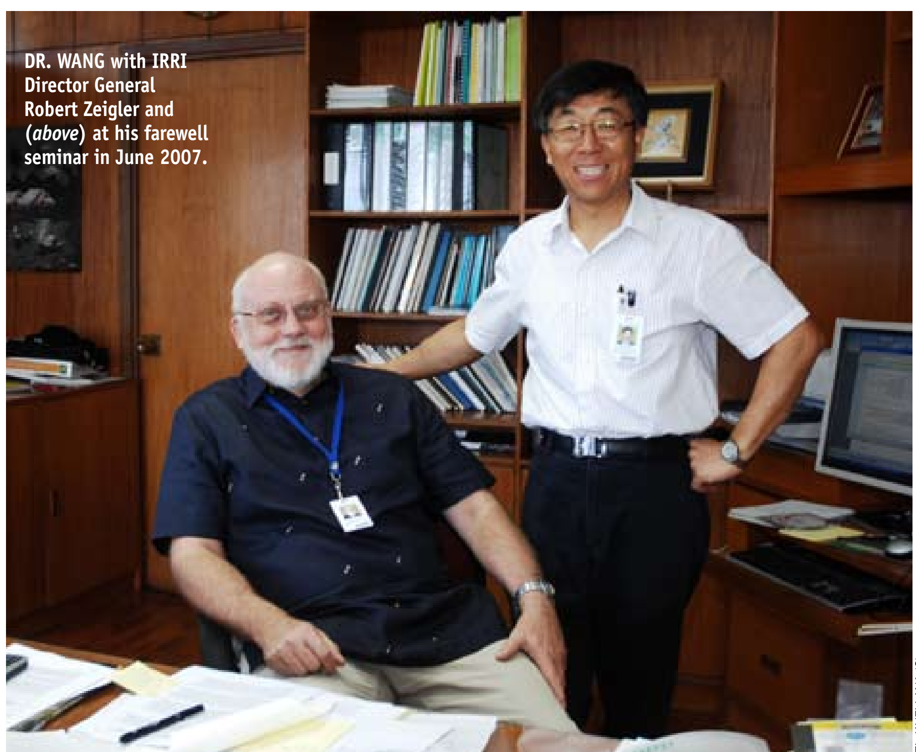
Shanxi is known as the coal capital of China, containing about one-third of the nation's coal deposits. Because of its high altitude and dry climate, little rice is grown there, with the main crops being wheat, maize, millet, sorghum, and potatoes. Dr. Wang's father was a well-known and respected vice governor of the province.

At 18, Dr. Wang started his first job, as a farm worker at the Linfen Agricultural Research Institute in Shanxi, where he worked for 3 years. Originally, he expected to go from the farm into the construction industry, but was so taken by agriculture that, fatefully, he went on to get his first degree, in plant protection, in 1978 from the Department of Agronomy at the Shanxi Agricultural University in Taigu, 60 kilometers south of Taiyuan.

From there, he launched his career in agricultural research by taking a job in 1979 as an assistant lecturer in agricultural entomology at the same university. He then went on to his master's degree in biological control, which he completed in 1982 from CAAS's Institute of Biological Control in Beijing.

Launching his international career on a Rockefeller scholarship, Dr. Wang was one of the first Chinese students allowed to study overseas when he left to get his Ph.D. in entomology in 1985 from the Department of Entomology at the Virginia Polytechnic Institute and State University in Blacksburg, Virginia, in the United States.

Next, he returned to China to work at CAAS, eventually rising to assistant director of the Institute of



DR. WANG with IRRI Director General Robert Zeigler and (*above*) at his farewell seminar in June 2007.

ARIEL JAVELLANA (2)

Biological Control in 1993, when he left to become deputy director of the International Institute of Biological Control at CAB International in the United Kingdom until 1995.

He was then tempted back to China to become CAAS vice president, the post he was holding when he was appointed head of research at IRRI. Dr. Wang says experience has taught him that, as a manager of research, it is more important have a broad understanding of many different scientific areas rather than be an expert in only one. "If you have good people, it's important you let them take the lead," he says. "The difficult time comes when you are presented with many good ideas, and you as the manager have the resources to choose only just a few and not everything."

DR. WANG and his staff (*from left*) Donna Robles, Lucy Gamel, and Velinda Hernandez.

ARIEL JAVELLANA (3)

Dr. Wang says that while at IRRI he tried to focus on two broad areas for scientific advancement. The first was in the general area of germplasm improvement and the second was natural resource management. At the same time, he was intent on continuing the Institute's efforts to strengthen socioeconomic research and provide policy support to developing countries. "During my time at IRRI," he says, "we saw the development of new facilities such as the gene array and molecular marker applications lab—which allows researchers to rapidly analyze a large number of genes to determine their function—and the creation of the new crop research information lab—a bioinformatics unit, which allows the powerful capture, analysis, storage, integration, and dissemination of biological information—as a joint venture between IRRI and the International Maize and Wheat Improvement Center in Mexico."

In the area of natural resource management, Dr. Wang oversaw the establishment of IRRI's first ever environmental council, which provides environmental policies and ideas for not only the Institute's research, but also its operations. In response to requests from its NARES partners, IRRI also strengthened its focus on fragile upland areas, recognizing that this was where many of Asia's poorest rice farmers lived.

Typifying his commitment to the Institute's goals in these areas, in January 2001, Dr. Wang traveled to Nepal to sign a memorandum of understanding between IRRI and the Nepal Agricultural Research Council that led to the development of a detailed research program for rice production in the mountain kingdom.

Later that same year, Dr. Wang led an IRRI team to China to establish what has become the world rice industry's premiere event, the International Rice Congress. Held every 4 years, the first Congress was held in 2002 in Beijing after a grand opening attended by the then president of China, Jiang Zemin.

Dr. Wang says one of the keys to any success he had in China or elsewhere in Asia was the strong support he received from the rest of the IRRI management team. "I was very fortunate to be hired by Ron Cantrell when he was IRRI's director general. He taught me much that I was able to use later on," he explains.

"I firmly believe that one of the secrets to success for any management team, especially at a research institute, is to be able to argue about issues on a professional basis, while still maintaining strong personal relationships. Sometimes, this can be difficult in an Asian context, so it was very helpful to work at an international organization like IRRI, which is based in Asia—I have a lot to thank my management colleagues for."

Dr. Wang says he also tried to place special emphasis on his relations with locally hired staff at IRRI. "I was very proud to be invited to become an honorary member of the IRRI Filipino Scientists Association. It's something that I will always value," he says.

During Dr. Wang's term as DDG-R, the Institute faced a decline in support from some key donors that required a reduction in staff. It was a difficult time, especially for those working on the research side of IRRI.

Most of Dr. Wang's memories, however, are positive. He was also at IRRI when one of the most significant breakthroughs in the long history of rice research was announced. The release of the first draft sequences of the rice genome, by the Beijing Genomics Institute and Syngenta simultaneously in 2002, and the final sequencing of the rice genome by a Japanese-led international consortium in 2004, made headlines around the world.

DR. WANG examines rice in one of IRRI's demonstration fields.

It also triggered a revolution in traditional rice research, the impact of which will be felt for years to come.

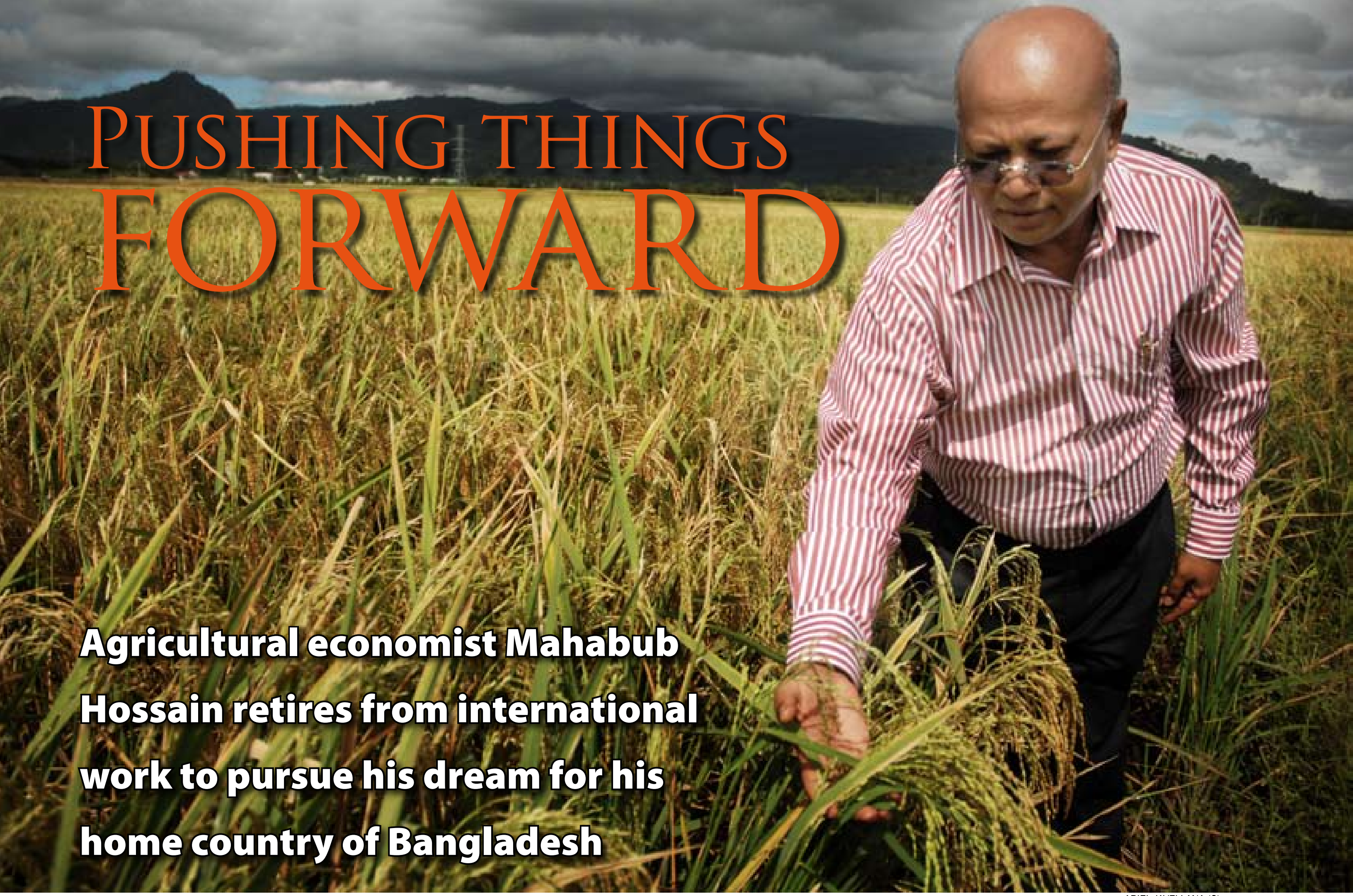
"There's been incredible progress in rice research, not just at IRRI, but all over the world," Dr. Wang says. "That we can take all of this new knowledge and use it to improve the lives of the poor has made my time at IRRI a very rewarding experience and something that I will never forget."

Dr. Wang is leaving IRRI in strong research shape. Not only does it have a new strategic plan for 2007-15 called *Bringing hope, improving lives*, but the Institute has already begun to implement a new medium-term plan for its research to meet the goals of the overall strategic plan.

Although he is departing IRRI, Dr. Wang is not leaving agricultural research. In fact, his next adventure extends his opportunity to influence not only IRRI but also its 14 partner institutes of the Consultative Group on International Agricultural Research (CGIAR). As the CGIAR's new director, Dr. Wang functions as the chief executive officer of the CGIAR system and heads the Washington, D.C.-based CGIAR Secretariat. He also becomes a member of the World Bank's senior management under its Vice Presidency for Agriculture and Sustainable Development.

Dr. Wang says that he is excited by the challenge posed by his new role, and that his time at IRRI will never be forgotten. "I have a lot to learn in my new job and need all of IRRI's support and counsel," he says.

"Let a hundred flowers bloom, let a hundred schools of thought contend." This is perhaps one of the best-known phrases to come out of modern China, but it also sums up nicely the success and management philosophy of a young man who set out from Shanxi more than three decades ago to help make the world a better place—and that he has.



Pushing things FORWARD

Agricultural economist Mahabub Hossain retires from international work to pursue his dream for his home country of Bangladesh

ARIEL JAVELLANA (2)

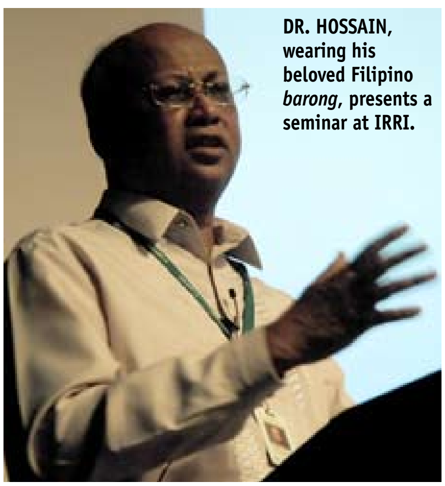
by Meg Mondoñedo

Two things stand out when you listen to Mahabub Hossain: his resolve in stamping out global poverty and his love for his country.

After 15 years of excellence—in research, livelihood analysis, impact assessment, rice sector analysis, poverty mapping, providing policy support to governments and institutions, and training developing-country scientists—International Rice Research Institute (IRRI) economist Mahabub Hossain is ready to return to Bangladesh with a mission.

"I'm taking an early retirement," says Dr. Hossain. "I could stay here until 2010, when I'll be 65, but I'm leaving because I feel that I owe something to my country. Bangladesh has serious problems, the living environment there is very poor, and I'm leaving a good job and a good life here at IRRI. But I want to set up a private-sector development studies institute—that is my aim, to set up an institute and see if I can leave a legacy in Bangladesh. I am going back to my country to share what I have learned."

Dr. Hossain's next move is to join the Bangladesh Rural Advancement Committee (BRAC), the largest nongovernmental organization in Bangladesh and one of the largest in the world, as its executive director. BRAC, whose mission is to reduce poverty and empower the disadvantaged, focuses on income generation for the poor through microcredit and employment in agriculture, and on skill enhancement for the poor through better health care and education. In this role, he will have the chance to focus his decades of experience on the problems facing his home country.



DR. HOSSAIN, wearing his beloved Filipino *barong*, presents a seminar at IRRI.

Dr. Hossain was born in 1945 in a remote village in undivided Bengal under British India—an area that now belongs to the Indian state of West Bengal. He and his family lived through the partitioning of Bengal by the British in 1947. The eastern area of Bengal, home to a Muslim majority, went to Pakistan, becoming East Pakistan. In 1971, East Pakistan became Bangladesh after its civil war with West Pakistan (now Pakistan). The Hossain family migrated to East

Pakistan in 1949 during a time of ethnic cleansing targeting Muslims. In 1958, Dr. Hossain returned to West Bengal to live with his maternal grandparents and take advantage of the better schooling available. In 1966, he returned to East Pakistan after completing his bachelor's degree at Calcutta University.

As a child in West Bengal, India, Dr. Hossain did not dream of becoming a social scientist. "My aim in life was to become a doctor," he says. "But the school in my village did not offer science courses. They only had humanities, arts, and agriculture, not science. My grandparents, who brought me up, did not allow me to go to another area to get a science education, so that was the end of my aim in life. I went to study humanities and then I was attracted to history. It was my favorite subject. But somehow, I ended up majoring in economics."

As head of IRRI's Social Sciences Division, Dr. Hossain provided leadership and tactical input to the development of IRRI's research and institutional plans. He led IRRI's research programs on rainfed environments, along with various research projects, and networks such as the Consortium for Unfavorable Rice Environments. He also provided strong leadership in organizing social sciences research to meet IRRI's priority needs and, in the process, developed a strong and harmonious research team.

Dr. Hossain joined IRRI in 1992, after the then Director General Klaus Lampe told him about the position earlier. "During the Rockefeller Foundation meeting on biotechnology in 1990," he recalls, "I was invited by Dr. Lampe for a breakfast meeting. He told me there was a position vacant at IRRI, and that they had been looking for someone for about a year."

BANGLADESHI MEDIA often shows interest in Dr. Hossain's work in his home country.

BRRI

Following his interview, Dr. Lampe promptly offered him the job.

But getting Dr. Hossain on board turned out to be a difficult task. In 1988, the Bangladeshi government appointed Dr. Hossain director general of the Bangladesh Institute of Development Studies (BIDS), the policy think tank of Bangladesh. He rose above many of his seniors in the institution.

"I told Dr. Lampe that the position at BIDS was good for two terms of 3 years each and I could not betray the trust that they gave me," he recounts. "But I assured him that, after a year, I could decide if I wanted to continue after completing one term. Only then could I decide if I wanted to join IRRI. So that was my polite way of saying no."

Dr. Lampe took Dr. Hossain's words to heart, and, 1 year later—to Dr. Hossain's awe—called again to say that the position was still vacant.

"Dr. Lampe knew that I was approaching the end of my first term as director general at BIDS, he knew I was going to decide whether I would do a second term," says Dr. Hossain. "My thinking was that, obviously, the job at IRRI was good and no one should deny themselves a good opportunity, particularly for better education of their children. I asked Dr. Lampe to write to my boss, Saifur Rahman, the finance minister at that time, who was also chairman of the board of trustees of BIDS, in order to facilitate my release from BIDS. That was how my career at IRRI began."

DR. HOSSAIN with A.P.J. Kalam, president of India, who visited IRRI in February 2006.

JOSE RAYMOND PANALIGAN

Dr. Hossain later found out that IRRI sought him so ardently because of his rich background and hands-on experience in assessing the impact of agricultural technologies on income distribution and poverty. From Bangladesh, he had been a member of the coordinating team of an IRRI project investigating these issues in seven Asian countries. He also had a good grasp of policymaking and planning, a skill that would prove invaluable in helping IRRI carry out its mission to reduce poverty


DR. HOSSAIN, in his late 20s, in front of Cambridge University's Clare College, where he was a postgraduate student from 1972 to 1977. The passport photos on the right show his progression through the years.

HOSSAIN PERSONAL COLLECTION

and hunger, improve the health of rice farmers and consumers, and ensure that rice production is environmentally sustainable.

Dr. Hossain has no regrets about deciding to join IRRI. In 1985-87, while working at the International Food Policy Research Institute, he performed a detailed study on the impact of the Green Revolution—the introduction in the 1960s and 1970s of modern, fertilizer-responsive, high-yielding rice varieties—in Bangladesh.

"I knew how much IRRI was contributing, so I thought this was a very good institution to work for," says Dr. Hossain. "I knew that working at IRRI would tremendously advance my knowledge of what was happening in agricultural development in Asia."

A contented look spreads across his face as he adds that he enjoyed every minute of the 15 years he spent at IRRI.

However, he is still very much troubled by the global issues that form daunting challenges for IRRI. As the population in Asia's low-income countries continues to increase, the goal of providing additional food is becoming more and more difficult to meet. Compounding the problems caused by growing numbers of people is the increasing shortage of land, water, and labor that have been diverted from agricultural to nonfarm activities.

"The challenge is how to meet the demand for rice," says Dr. Hossain. "Every input is scarce and, as long as the population continues to increase at an alarming rate, that challenge remains."

He adds that one of IRRI's pivotal roles is to change the perception of donors from Europe and the United States that the Asian food-security problem is almost solved and the remaining challenges can be handled by the private sector. "I think we need to convince our traditional donors that our job is not yet done," he says. "As a social scientist, one of my responsibilities lies in preparing a story that will convince donors that more support is needed for IRRI to do its job."

Dr. Hossain's research achievements are many and varied. Furthermore, much of his work has been with social scientists from the national agricultural research and extension systems (NARES)—the institutions in the countries where IRRI works—and so has helped boost the research capacity and strength of agricultural social science programs throughout Asia. He has conducted policy dialogues in several countries, including Bangladesh, the Philippines, and Myanmar.

By supervising the compilation and updating of IRRI's freely available Rice Statistics Database (www.irri.org/science/ricestat)—

DR. HOSSAIN is an economist unafraid to get his feet dirty in the field.

IRRI

DR. HOSSAIN with his staff in IRRI's Social Sciences Division.

ARIEL JAVELLANA

which contains data on rice area, production, yield, import-export figures, consumption, prices, land use, adoption of improved varieties, and costs and returns in rice farming—Dr. Hossain has ensured public access to important information that has helped ensure that rice research has been targeted and effective.

Dr. Hossain's work, with NARES scientists, on household surveys to generate primary data on the operation of the rural household economy has greatly increased researchers' and policymakers' understanding of rural livelihood systems. He performed numerous impact assessments, which have expanded and deepened the body of knowledge on such issues as yield losses from pests and climatic stresses, IRRI's role in providing rice-breeding materials (such as seeds) to other countries, and the impact of rice research on the reduction of poverty. This last assessment demonstrated that indirect impact—in terms of, first, availability of year-round employment in rice farming and agricultural growth-induced rural nonfarm activities, and, second, higher purchasing capacity of staple food due to low rice prices—has been substantial.

For Dr. Hossain, IRRI is not just a research institute but a humanitarian organization as well. "If IRRI had not been here," he says, "we would have seen severe food insecurity in many countries. IRRI has done tremendous work to address issues of food security. However, we should not be complacent; we are still engaged in a war against time. If IRRI had not existed, I would have seen many more people die of hunger in my own country, Bangladesh, which experienced famines in 1944 and 1974. IRRI is a household name in Bangladesh and many other countries in South and Southeast Asia have benefited tremendously from IRRI's support."

After 15 years at IRRI, Dr. Hossain will dearly miss many things. First and foremost are his staff. "They are the best," he says. "The national staff are the real contributors to IRRI's achievements, while the internationally recruited staff may be regarded as medium-term visitors. Our external reviewers and participants at international meetings and workshops are always very impressed by the organization and, especially, the assistance and dedication of the secretaries and other support staff. I think the nationally recruited staff are the real assets of the Institute. I will miss my staff; they have become my friends. We are like a family here."

Another thing that he will miss is the traditional Filipino shirt known as a *barong*. Initially, he wore a *barong* to blend in with the Filipino culture but, over time, he grew to love the comfortable shirt, which is traditionally made from fiber derived from banana or pineapple plants. "The only thing that I miss is the pocket," he says with a smile. "It has no pocket for a pen!"

As he prepares to depart IRRI, Dr. Hossain keeps his dreams for the Institute close to his heart and mind. "I want to see this institute prosper further," he says. "I hope that, within the next few years, IRRI will be running with the substantial resources required to implement its mission."

With countless achievements, awards, and immense contributions to IRRI and Asia, Dr. Hossain leaves with gratitude and a single piece of advice for everyone: "Always push things forward."

Forging a rice partnership for Africa

by Savitri Mohapatra

IRRI BOARD MEMBER Ruth Oniang'o admires a NERICA plant.

***"When spider webs unite, they can tie up a lion!"*—so goes a well-known Ethiopian saying. This could be an apt description for the new partnership being forged among international research centers to address sub-Saharan Africa's enormous rice challenge.**

According to the latest figures from the Food and Agriculture Organization of the United Nations (FAO), paddy (unhulled rice) production in Africa has gone up for the sixth consecutive year, reaching 21.6 million tons in 2006, 6% above the 2005 total.

FAO attributes the record harvest to favorable weather conditions and the positive effects of the adoption of New Rice for Africa (NERICA) varieties developed by the Africa Rice Center (commonly known as WARDA) and its partners.

Rice is successfully and economically produced in a wide range of agroecologies in Africa. Advances have been made in understanding the dynamics of rice production systems and in developing technologies designed for African conditions.

However, many challenges remain, and smallholder farmers in sub-Saharan Africa continue to face a blitz of problems, many of which are compounded by new challenges such as climate change.

Demand for rice is soaring across much of sub-Saharan Africa and 40% of this demand is being met by imports at a staggering cost of about US$1.5 billion per year.

PROF. ONIANG'O (*left*) with WARDA board members Tsekede Abate (*center*) and Mary Uzo Mokwunye.

R.V. RAMAN (3)

WARDA economists caution that Africa would be ill-advised to rely heavily on rice imports for its growing demand, because only 4% of world rice production is subject to trade, with most rice being consumed in the country where it was grown. Moreover, global rice stocks are declining and some recent predictions have rice prices doubling in the near future.

To effectively address some of these daunting challenges, WARDA is joining forces with the International Rice Research Institute (IRRI) and the International Center for Tropical Agriculture (CIAT by its Spanish acronym) as part of a new alliance aimed at creating a strong synergy for rice research in Africa. The three research centers are supported by the Consultative Group on International Agricultural Research (CGIAR).

"This research alignment seems very relevant to us because we work on the same commodity and there are certain areas of collaboration that have not been fully tapped before," said WARDA Director General Papa Abdoulaye Seck.

Dr. Seck explained that some of the agroecologies in Asia, Latin America, and sub-Saharan Africa are alike and rice farmers in developing countries face many similar challenges. "Therefore, a research alignment where the comparative advantages of these centers are combined can have a large-scale impact in Africa," he said.

Taking this into account, five thematic areas have been identified for joint research to boost the development of the African rice sector: genomics, seed systems, policy and markets, postharvest technology, and the commodity chain.

One of the priorities of this alliance is to strongly support the International Network for the Genetic Evaluation of Rice (INGER)-Africa, which is coordinated by WARDA.

Based on IRRI's model and adapted to African conditions, INGER-Africa has been so successful that an impact study by WARDA economists showed that, thanks to its catalytic effect, rice varietal improvement in seven West African countries generated a producer surplus gain of about US$360 million in 1998.

WARDA recently recruited a new coordinator for this network, which serves as a vital link between national programs in Africa and international centers, promoting genetic diversity through the exchange and evaluation and use of improved breeding materials originating from worldwide sources.

Capacity building in all the rice-related research and development activities is another thrust of this collaboration, which will be carried out with support from partners such as FAO and the Rockefeller Foundation.

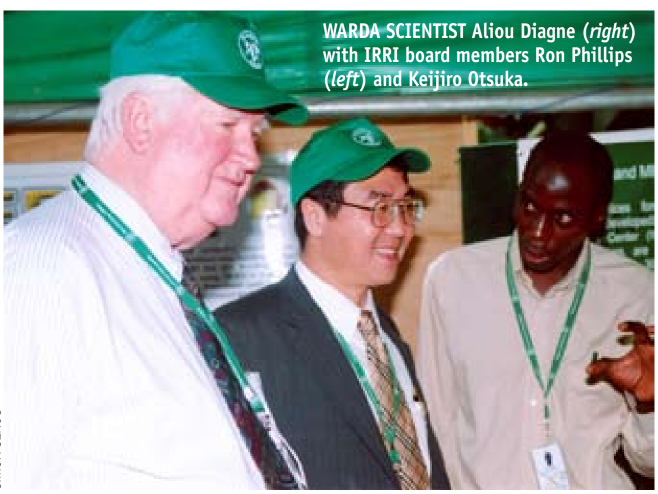
These selected priority themes as well as the proposed strategy of the new rice partnership for Africa were unveiled at the CGIAR Annual General Meeting in 2006 through a joint presentation by the directors general and research directors of WARDA and IRRI.

WARDA DIRECTOR GENERAL Papa Seck (*left*) and IRRI Director General Robert Zeigler at the 2006 annual general meeting of the CGIAR.

Several donors, including the Rockefeller Foundation, Japan, Canada, and France, as well as international nongovernmental organizations such as Sasakawa Global 2000, endorsed the initiative of intercenter collaboration for bigger impact in Africa. Participants from Africa also expressed eagerness and enthusiasm.

As an indication of their genuine interest in this partnership, for the first time and at WARDA's invitation, IRRI representatives—Board Chair Keijiro Otsuka and two board members, Ronald L. Phillips and Ruth K. Oniang'o—took part as observers at WARDA's board meeting in March 2007.

"This testifies to IRRI's firm commitment to work closely with WARDA," remarked Dr. Otsuka, who, as a strong advocate for IRRI-WARDA partnership, is also enthusiastic about the potential of NERICA, after carrying out impact studies on the NERICA varieties adopted in Uganda.



WARDA SCIENTIST Aliou Diagne (*right*) with IRRI board members Ron Phillips (*left*) and Keijiro Otsuka.

SIMON SENOU

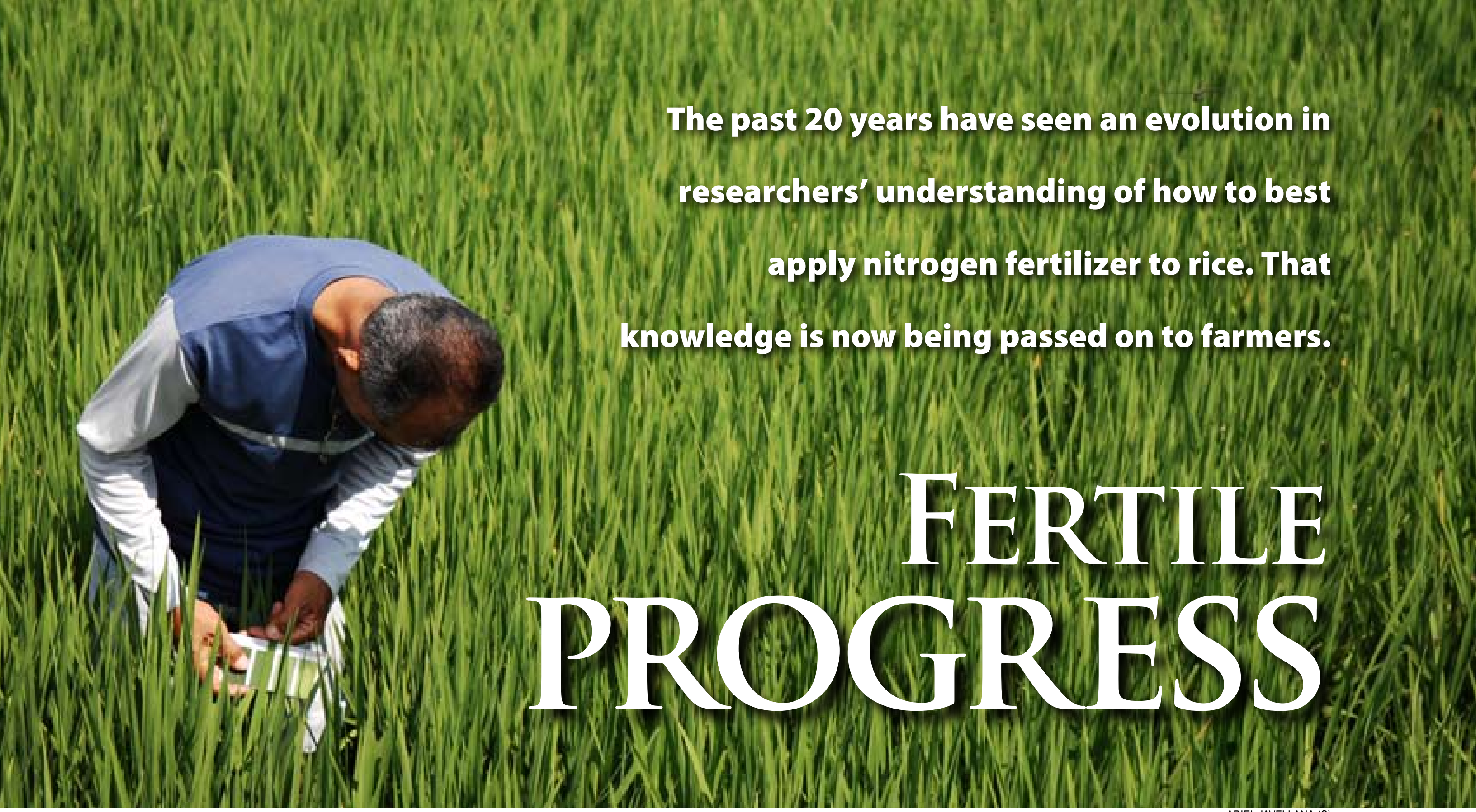
WARDA Board Chair Gaston Grenier warmly welcomed the IRRI delegation at the board meeting. "I agree fully with Dr. Seck that it would be impossible for any single organization to implement an effective research for development agenda in Africa," he said.

Building on this momentum, senior scientists from the centers have already started attending each other's research planning meetings and WARDA and IRRI scientists are contributing to joint scientific publications. IRRI sent a big delegation to WARDA's First Africa Rice Congress in 2006 and has proposed to jointly organize with WARDA and other partners the next Africa Rice Congress, planned for 2009 in Dakar, Senegal.

Already, three joint proposals that were submitted to donors—the Canadian International Development Agency (CIDA), the Gatsby Charitable Foundation, and the International Fund for Agricultural Development—have been approved. The proposals include the organization of a planning workshop, rice germplasm collection in eastern Africa, and improvement of rice production in East and southern Africa.

With support from CIDA, the planning workshop is scheduled for June 2007 to advance this joint initiative. Research directors of the three centers are expected to attend.

Congratulating WARDA on the new developments, Ren Wang, IRRI's deputy director general for research, who is set to become CGIAR director in July 2007, said, "WARDA is on its way toward a center of excellence under Dr. Papa Seck's dynamic leadership and we at IRRI are excited about it."



ARIEL JAVELLANA (2)

The past 20 years have seen an evolution in researchers' understanding of how to best apply nitrogen fertilizer to rice. That knowledge is now being passed on to farmers.

Fertile PROGRESS

by Roland J. Buresh

Nitrogen (N) is without doubt the nutrient that most limits rice production. It is typically required in greater quantities than any other nutrient if rice farmers are to reap high yields and profits. Inappropriate N management also has detrimental effects on crop yield and the environment and aggravates disease and pest incidence.

Large portions of the fertilizer N applied to flooded rice fields are rapidly lost as gases to the atmosphere. As a general principle, about one-third of the fertilizer N applied by conventional farmers' practices to irrigated rice grown in paddies (lowland rice) in Asia is lost within two weeks to the atmosphere as gases. About one-third of the fertilizer N remains in the soil at crop harvest, and only about one-third of the fertilizer N is taken up by the rice crop.

Beginning in the 1970s and continuing through the 1980s, research on N management for lowland rice largely focused on increasing N fertilizer use efficiency through "reducing N loss." The aim was to increase the portion of fertilizer N taken up by the rice crop. A key parameter of success was the "recovery efficiency" or percentage of applied fertilizer N taken up by the mature rice plant.

The recommendations for farmers arising from research in the 1980s and 1990s involved splitting the application of fertilizer N two or three times during the growing season. Rates of fertilizer N were preset and uniform across vast rice-growing areas for a given growing season. The recommended first timing of fertilizer N application was typically before crop establishment (basal), involving use of one-third to two-thirds of the total fertilizer N to be used throughout the season. Thorough incorporation of fertilizer N into soil before rice establishment—preferably without standing floodwater—was promoted as a way to reduce N loss.

Through the 1990s and onward, emphasis was placed on matching the application of fertilizer N to the real-time, field-specific needs of a rice crop. During the past 20 years, the focal message for increasing N fertilizer use efficiency has evolved from "reducing N loss" to "feeding crop needs." This evolution recognizes the importance of managing N to accommodate the diversity in field-, season-, and variety-specific needs of rice for supplemental N. Varying the application of fertilizer N to "feed" the specific needs of a crop enhances opportunities for increasing yield per unit of applied fertilizer N while also reducing N loss and increasing recovery of fertilizer N by the crop.

During the past 20 years, the key parameter of success has evolved from increased "recovery efficiency" of fertilizer N to increased "agronomic efficiency," which is the increase in grain yield per unit of fertilizer N applied. This emphasis on the output per unit of input without compromising on the need for high yield acknowledges the importance of ensuring increased profit for farmers. Over the same period, guidelines have evolved from preset and uniform fertilizer rates across vast areas to an increased awareness of the importance of adjusting rates and timings to site-specific and growth stage-specific needs. Guidelines are now available whereby fertilizer N rates for field-, season-, and variety-specific conditions can be determined from the estimated crop response to fertilizer N and a targeted agronomic efficiency for fertilizer N (see *The evolution of nitrogen management*, right).

The split application of fertilizer N remains an essential component of recommendations. Monitoring of farmers' fertilizer practices in Asia in the past decade revealed that farmers often apply a substantial portion of their fertilizer N either before or within two weeks after crop establishment. Their early application of fertilizer N consequently often exceeds the demand of young rice for N. This can lead to vegetative growth in excess of the optimum, which can increase the susceptibility of the crop to lodging (falling over), pests, and diseases.

Recent advances in N management for rice include as a key component the adjustment of the early N application to match the relatively low demand of young rice for supplemental N. Guidelines are now available to ensure appropriate use of only moderate early N to match crop needs.

The evolution of nitrogen management

	1987	2007
Focal message	"Reducing N loss"	"Feeding crop needs"
Key parameter of fertilizer N efficiency	Recovery efficiency	Agronomic efficiency combined with high yield
Total N rate	Fixed by season	Determined by crop response to N and agronomic efficiency
Key component(s) of N management	Basal (prior to crop establishment) incorporation	Moderate early N; variable N rates and distribution within the season

Another key component of recent advances in N management involves varying rates and distribution of fertilizer N within the growing season to match crop demand for supplemental N. In this respect, the leaf N status of rice, which is closely related to photosynthetic rate and biomass production, serves as a sensitive indicator of the crop demand for N during the growing season.

The leaf color chart (LCC) is an inexpensive and easy-to-use tool for estimating leaf N content. The LCC is usually a plastic, ruler-shaped strip containing four or more panels that range in color from yellowish green to dark green. Several types of LCCs with varying shades of color and varying guidelines for N application have been developed and distributed to rice farmers.

Guidelines initially established with LCCs were based on real-time N management in which farmers monitor leaf color at 7- to 10-day intervals about four to six times during the growing season. Farmers then apply fertilizer N whenever the leaves are more yellowish green than a threshold LCC value, which corresponds to a critical leaf N content.

A LEAF COLOR CHART offers a simple, quick way for farmers to assess the nitrogen needs of their crop.

Rice farmers, when presented with options for using the LCC, often prefer less monitoring of leaf color. An alternative fixed-time option widely disseminated since 2004 enables farmers to monitor leaf color only twice: once at active tillering (when shoots emerge from the main stem of the rice plant) and once at panicle initiation (when the grain bunches of the rice plant first form). These are the two growth stages critical for a sufficient supply of N. Farmers then adjust their applications of fertilizer N upward or downward based on leaf color, which reflects the relative need of the crop for N at these stages.

The International Rice Research Institute, through collaboration with partners across Asia, has developed and calibrated a standardized LCC (see photo, *left*) that enables farmers to select between equally effective real-time and fixed-time N management options for varying within-season N rates. This LCC has been widely distributed and taken up across Asia since 2004. It is to date the only LCC calibrated across large rice-producing areas for both N management options, enabling farmers to opt for less laborious fixed-time N management.

Dr. Buresh is a senior soil scientist at the International Rice Research Institute. For more information on N management, see www.irri.org/irrc/ssnm.

Preparing for the rat race

by Jason Overdorf

A rare species of flowering bamboo puts rodents in a feeding and breeding frenzy that threatens famine in the Indian state of Mizoram

AILEEN DEL ROSARIO (2)

At nightfall in the remote state of Mizoram in northeast India, villagers listen with apprehension to the rustling of thousands of rats foraging and breeding in the jungle. For now, the rodents are gorging themselves on flowering bamboo. But when the bamboo dies and the rice harvesting season begins, a scurrying plague will descend on their paddy fields.

An unusual species of bamboo blankets Mizoram, a remote state with an ethnically distinct tribal population. *Melocanna baccifera* flowers only once every 50 years or so, generating millions of high-protein seeds that turn the local rats into incredibly prolific breeders. But, when the seasonal rains arrive and cause the seeds to germinate, the rodents suddenly lose this source of food. Now present in huge numbers, the rats invade the rice paddies in their quest for food, destroying the crops the villagers depend on for survival.

In a single night, the legion of rodents can clip the ears from every rice stalk in a field, says James Lalsiamliana, the Mizoram Agriculture Department official who heads the state's rodent control cell. During last year's harvest—when the bamboo flowering began in the eastern part of the state—more than 40 villages lost their entire crop. And this year, the flowering has peaked across all of Mizoram.

"They depend on this paddy for subsistence," Mr. Lalsiamliana said. "The state will now have to arrange financial support for these areas."

Local villagers call the once-in-50-years phenomenon *mautam*, or "bamboo death." And the last time it hit, in 1959, it was indeed deadly. The state government dismissed local forecasts as superstitious raving, and was unprepared to fight off the rodents or provide adequate relief for the massive food shortages that followed. This rejection by the government led to the formation of the Mizo National Famine Front (MNFF) to organize and coordinate relief measures.

UNFORTUNATELY for people, rats like rice too.

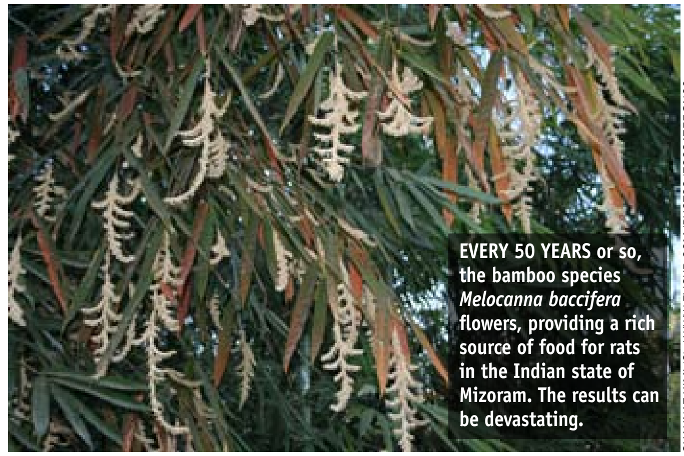
The consequent sense of alienation and marginalization among the Mizo people led to ideas of separatism and secessionism. The MNFF was transformed into a political party called the Mizo National Front and, on 1 March 1966, the Front declared the Mizo people's independence from India. Thus began a violent chapter of insurgency, which continued for 20 years, ending in 1986 through the signing of an accord with the government of India.

The famine was estimated to have caused more than 10,000 deaths, and the conflict itself took more than 3,000 lives. Now, one of the movement's leaders, Pu Zoramthanga, is Mizoram's chief minister.

This time around, the government has released more than US$125 million to fight the problem. And, as many as 5 years back, Mizoram began tapping experts to develop a coordinated plan to limit the effects of the flowering and control the rodent population. The Ministry of Environment and Forests drew on experts from the International Bamboo and Rattan Network (INBAR) and the United Nations Industrial Development Organization (UNIDO) to help find new ways to use the bamboo and thus encourage local villagers to harvest it before it flowers. The ministry also called in Canada's John Bourne, a 30-year veteran of Alberta's rat patrol who helped make the Canadian province rat free, to study the local rodents and develop a plan for killing rats. Last season, the program Mr. Bourne helped develop allowed villagers to kill hundreds of thousands of rodents using homemade traps and poison supplied by the state.

Mr. Lalsiamliana says the state paid villagers 100 rupees ($2.40) for every 50 traps they set and distributed more than 15,000 kilograms of rodenticide.

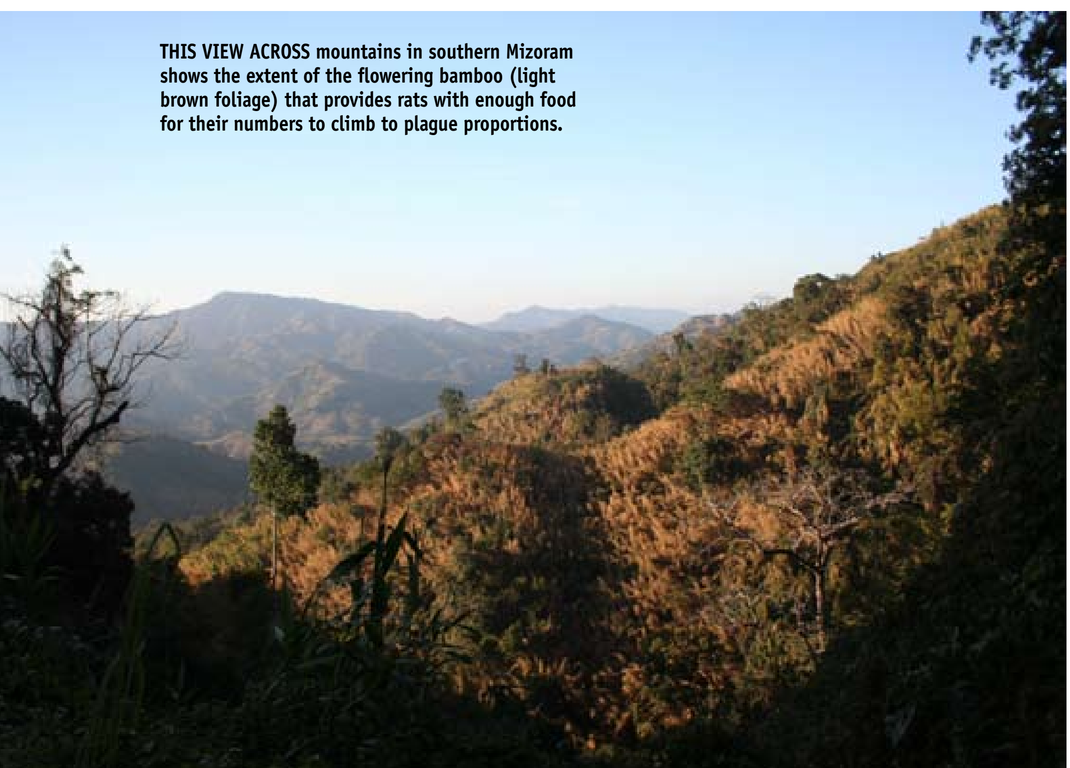
T.P. Subramony, head of INBAR's Delhi office, says India now has a comprehensive plan that covers extraction and management of the bamboo, how to regenerate the forest cover, controlling the rodent population, and dealing with health hazards that may arise with the proliferation of the vermin. But, he says the key to a solution lies in realizing the value of the bamboo itself.



EVERY 50 YEARS or so, the bamboo species *Melocanna baccifera* flowers, providing a rich source of food for rats in the Indian state of Mizoram. The results can be devastating.

SHAHNAZ KIMI (2) / WWW.FLICKR.COM/PHOTOS/73231755@N00

Although locals cut down and burn bamboo to collect ash that they use as fertilizer, experts from the state's Bamboo Development Agency estimate that less than 1% of the 850,000 hectares of bamboo gets harvested, which is why a panel of researchers from UNIDO and India's Rain Forest Research Institute has recommended the promotion of cottage industries such as the manufacture of toothpicks and bamboo mats and a temporary ban on harvesting bamboo in other parts of the country for the paper industry, along with a host of other economic stimuli.



THIS VIEW ACROSS mountains in southern Mizoram shows the extent of the flowering bamboo (light brown foliage) that provides rats with enough food for their numbers to climb to plague proportions.

"One issue is the dying bamboo," Mr. Subramony said. "Then there is the question of how to utilize it. There is a threat, but there is an opportunity also."

Nevertheless, this flowering season, averting a food shortage depends on killing rats. And that may not be enough. Because farmers fear that the rats will destroy their crops, many have simply not planted in 2007. Consequently, the Mizoram Agriculture Department has predicted a rice shortfall of around 75% in 2007-08.

A local government reward of 1 rupee (2.4 cents) per rat has already led to more than 400,000 rats killed by early May 2007. Despite the effort, some districts in Mizoram experienced major destruction of crops in the 2006-07 winter.

"There will likely be a food shortage, and that may lead to famine," said S.N. Kalita, formerly the principal secretary of forests and head of the Environment and Forest Department of Mizoram. "But the situation cannot be compared with 1959. Now our communication by road and air transport are improved, so transporting in food will not be a problem. Already, some reserve stock has been created. All I can say is that the state government and the government of India is fully prepared."

Jason Overdorf is a freelance journalist based in New Delhi. This is an edited version of an article that appeared in the Toronto Globe and Mail *on 30 March 2007.*

THE RICE-FIELD RAT, *Rattus argentiventer*, is the main rodent pest in rice fields in Indonesia, Malaysia, and Vietnam.

Of rice and rats

Story and photos by Grant Singleton

Rats and mice do untold damage to rice crops and stocks across the globe. Here,* Rice Today *presents the facts on the rodent scourge.

"Nature has sent the rats to our homesteads by thousands, and farmers are being eaten off the face of the earth by them."

This quote from H.C. Bartley (1911) appeared in his book *Studies in the art of rat catching*. After a career spent catching rats and rabbits in England for a living, he wrote this book as a reference for teaching his profession at schools. He dedicated his book to the headmasters of Eton, Harrow, Westminster, and Rugby. Alas, given the dearth of specialists in rodent management in Europe, it appears that the book did not become prescribed reading.

The human fascination with rats is highlighted by the recent re-publication of this book and a new best seller published in 2005 simply called *Rats*. The latter is the story of Robert Sullivan, a journalist who spent a year observing the secret lives of rats in Harlem in New York City. He punctuated his observations with historical accounts such as how rats catalyzed major changes in the living conditions of Harlem tenants after many other efforts, including tenant strikes, failed.

Rats and mice, animals that have played a central role in human life for thousands of years, are arguably the most important family of mammals. There are over 2,270 species of rodents (defined as animals that have continually growing incisor teeth and no canine teeth) and 42% of all mammal species are classified as rodents. They are the ultimate mammalian weed, living in almost every habitat on Earth, and adapting well to environments significantly altered by humans.

Rodents have two major impacts. The first is the substantial pre- and postharvest losses they cause to agriculture. The second is as carriers of debilitating human diseases.

Rodents have an enormous economic impact on stored grain in developing countries. Rats need to eat 10–15% of their body weight each day and they contaminate much more rice than that with their droppings. In one year, 25 adult rats would eat and damage about half a ton of grain and produce about 375,000 droppings! Good data on postharvest losses caused by rodents are sparse; however, reports of up to 20% postharvest losses of rice are not unusual. In 1991, a study in the central Punjab in Pakistan found that for every person living in a village there were 1.1 house rats. Extrapolating to the national level, it was estimated that 0.33 billion metric tons of cereal (rice, maize, and wheat) were consumed annually by house rats in Pakistani villages. This is a conservative figure because rodents damage more food than they consume and cause major damage to the structure of grain stores, which in turn leads to increased weather and insect damage.

Taking food from our table

Across Asia, preharvest losses of rice range from 5% in Malaysia to 17% in Indonesia. To put this into perspective, a loss of 6% in Asia amounts to enough rice to feed 225 million people—roughly the population of Indonesia—for 12 months. Rat damage is often patchy and family rice plots small, so it is not uncommon for farmers or villagers to lose half of their entire rice crop to rats. Some farmers

TRAP BARRIER systems, like this one in Banaue, Philippines, help farmers control rodents.

A WOMAN SELLS barbecued rat meat at a market in Pyay, Myanmar.

state that "for every eight rows of rice they sow for their families, they sow two rows for the rats."

In Southeast Asia, the ricefield rat (*Rattus argentiventer*) is the number-one preharvest pest in Indonesia and is one of the top three pests in Vietnam. In Laos, a member of the *Rattus rattus* complex of species causes episodic problems, and Lao upland farmers consider rats as the problem they have least control over. In the uplands of Laos, Vietnam, and parts of India, rat populations occasionally erupt and cause massive problems. Mizoram, in northeastern India, is currently experiencing such an outbreak (see *Preparing for the rat race* on pages 34-35). A previous massive plague in the 1950s led to famine conditions and triggered a change of government. The lowlands of India and Bangladesh have a number of rodent pest species, with the lesser bandicoot rat, *Bandicota bengalensis*, being a major pest.

In many areas, farmers actually abstain from planting a second or third rice crop because of the expectation of severe rodent damage. This "forgone" loss in productivity is rarely taken into account.

Searching for the ideal rat trap

Through understanding the population ecology of specific rodent species, effective rat-control methods that are simple to apply and environmentally friendly have proven effective in lowland irrigated rice crops (see *A simple solution*, right). Each rodent pest species has different behavioral characteristics, breeding dynamics, and habitat preferences. Some species are seasonal breeders, some breed throughout the year, and others breed at very specific times. The ricefield rat, for example, breeds only when rice is in the reproductive phase—if there is one rice crop per year, they have one breeding season, if there are two, they will have two, and, if three crops, they will have three breeding seasons.

Female rats are pregnant for 21 days and mate the day after they give birth. One female can give birth to three litters (12 young per litter) during a rice crop, resulting in a total of 36 rats. These young will not breed until the next crop *unless* neighboring farmers plant their crops more than 2 weeks apart. This will extend the breeding season, allowing the rats (six females) from the first litter to also breed (rats breed at 7 weeks of age). Therefore, the one adult female could potentially give rise to 120 rats in a single season.

Attempting to rid their crops of rats, rice farmers have developed a range of ingenious devices and strategies. Rat traps of all shapes and sizes have been used but mostly with little success in reducing damage to rice. This is mainly because they have been applied by individual farmers after rat numbers are already too high.

WILDLIFE BIOLOGIST Rachel Labador is surrounded by rat-damaged fields (see the bare, brownish patch) in Banaue, Philippines.

The good, the bad, and the not so ugly

The challenge for biologists has another important dimension: on a continental scale, usually less than 10% of rodent species cause substantial impacts. Indeed, many rodent species provide important "ecological services" (they assist cycling of nutrients, for example, and generally play an important role in nature's food web). Given that management programs rarely distinguish between rodent species, often the nonpest rodents are at grave risk. The negative ecological consequences of rodent control can therefore be better managed if the method is specifically tailored to the problem species.

H.C. Bartley's commentary that the art of rat catching should be taught in schools needs to be taken a step further in Asia. Rodents cause tremendous economic hardship to Asian smallholder farmers, yet solutions for management can be simple and effective. More young biologists need to be encouraged to enter the fascinating secret world of rats and work closely with farmers to assist them in their struggle against the hardships caused by rodents.

A simple solution

Once the ecology of a major pest species is understood, scientists and extension specialists can work closely with farmers to develop ecologically sound, cost-effective management strategies that dovetail into normal farming practices, including traditional rat-catching methods. Village-level studies in Indonesia and Vietnam have clearly shown that rat populations can be successfully managed if farmers work together as a community and if they apply their control at the right time and in the right habitats. Such ecologically based actions have also led to a 50% reduction in the use of chemical rodenticides.

One simple technology added to the armory of rice farmers is a trap-and-fence system known as the trap barrier system (see *Building a better rat trap* on pages 34-35 of *Rice Today* Vol. 4, No. 2). Used across much of Southeast Asia, it comprises a plastic fence surrounding a small rice crop planted 2–3 weeks earlier than the surrounding crop, with traps set into the plastic. At night, rats follow the line of the plastic until they reach a hole, which they enter to reach the rice. They are subsequently caught and removed the next morning.

The trap barrier system is most effective when combined with the following community actions:

- keep irrigation banks less than 30 cm wide to make it difficult for rats to build nests;
- conduct community campaigns using local methods to control rats within 30 days of planting the crop (before rats breed); these community actions should focus on village gardens, main irrigation channels, and roadsides;
- clean up any grain spills at harvest; and
- synchronize planting so that crops are planted within 2 weeks of each other.

Dr. Singleton, a rodent expert, is the coordinator of the Irrigated Rice Research Consortium.

grain of truth

The aerobic rice reality

BY BAS BOUMAN

Ask someone to think of a rice field and odds are they'll imagine a flooded paddy. Growing rice in puddled fields works well as long as there's enough water to do it. But, increasingly, that's not always the case. As populations increase and the industrial and urban sectors compete with agriculture for water, "aerobic rice" offers a water-saving alternative to many of the millions of rice farmers worldwide.

Aerobic rice is a production system in which specially developed varieties are grown in well-drained, nonpuddled, and nonsaturated soils. With appropriate management, the system aims for yields of at least 4–6 tons per hectare.

The usual establishment method is dry direct seeding, as opposed to transplanting seedlings into a flooded field. Aerobic rice can be rainfed or irrigated. Irrigation can be applied through flash-flooding, in furrows (or raised beds), or by sprinklers. Unlike flooded rice, irrigation—when applied—is not used to flood the soil but to just bring the soil water content in the root zone up to field capacity (the maximum possible before saturation occurs).

Will aerobic rice replace rice grown in flooded conditions on a large scale?

Aerobic rice also allows farmers to practice conservation agriculture, such as mulching and minimum tillage. Despite these advantages, farmers must overcome several problems that are affecting arobic rice. Rice fields that are not permanently flooded tend to experience more weed growth and more species of weeds. Appropriate herbicide use, plus additional manual or mechanical weeding in the early phases of crop growth, is therefore needed to control weeds.

Soil-borne pests and diseases such as nematodes, root aphids, and fungi are known to occur more in aerobic rice than in flooded rice, especially in the tropics. Currently, aerobic rice cannot be grown continuously on the same piece of land each year without a yield decline. Depending on the cropping history and soil type, low yields can even occur on fields cropped to aerobic rice the very first time.

Achieving high yields under relatively favorable aerobic soil conditions requires new varieties of aerobic rice that combine the drought-resistant characteristics of upland varieties (grown on nonflooded sloping uplands) with the high-yielding characteristics of lowland varieties (grown in irrigated, flooded fields). Several breeding projects, such as the ongoing program at the International Rice Research Institute, are working toward this goal.

First-generation tropical aerobic rice varieties were mostly derived from crosses between tropical parents from the two major subspecies of rice, indica and japonica. Some aerobic rice breeding programs have also developed successful varieties by crossing high-yielding lowland rice varieties with traditional upland types. In northern China, several new elite aerobic varieties with yield potential of up to 6.5 tons per hectare were released in the late 1990s.

Aerobic rice can be found, or can be a suitable technology, in the following areas:

1. So-called "favorable uplands": areas where the land is flat (or terraced), where rainfall with or without supplemental irrigation is sufficient to frequently bring the soil water content close to field capacity, where no serious soil-chemical limitations occur, and where farmers have access to external inputs such as fertilizers. Examples include the Cerrado region of Brazil and newly-formed terraces in the hills of Yunnan, China, where farmers are achieving aerobic rice yields of 3–4 tons per hectare.

2. Fields on upper slopes or terraces in undulating, rainfed lowlands. Quite often, soils in these areas are relatively coarse-textured and well-drained, so that ponding of water occurs briefly or not at all during the growing season. There are no widespread examples of aerobic rice in rainfed lowlands, but these upper fields have been proposed as a target domain.

3. Water-short irrigated lowlands: areas where farmers do not have access to water to keep rice fields flooded for a substantial period of time. A good example is the North China Plain, where aerobic rice is grown on about 80,000 hectares with supplemental irrigation.

Besides these typical rice-growing environments, aerobic rice can also be found in traditionally nonrice-growing areas. Again in the North China Plain, farmers are experimenting with aerobic rice as a means of crop diversification in areas where maize has traditionally been the dominant crop.

Will aerobic rice replace rice grown in flooded conditions on a large scale? It may be too early to tell, but there is no doubt that, as rice farmers are forced to compete for less and less available water, aerobic rice has a major role to play.

Dr. Bouman is a senior water scientist at IRRI.

International Workshop on Aerobic Rice

22-25 October 2007
Beijing, China

The International Workshop on Aerobic Rice is organized by the China Agricultural University and the International Rice Research Institute (IRRI). The workshop is a joint undertaking by the Water Workgroup of the Irrigated Rice Research Consortium and the project *Developing a system of temperate and tropical aerobic rice (STAR) in Asia* of the CGIAR Challenge Program on Water and Food.

Bringing together breeders and scientists who are working on the development and dissemination of aerobic rice in Asia

What is aerobic rice?

Aerobic rice is a production system in which specially developed, input-responsive rice varieties with "aerobic adaptation" are grown in well-drained, nonpuddled, and nonsaturated soils without ponded water, with a management system aiming at yields of 4-6 tons per hectare (and possibly beyond). The target regions are irrigated areas facing water scarcity and rainfed areas where rainfall is not sufficient to grow flooded rice.

The workshop will discuss the results of research on variety development; water, crop, and nutrient management; mapping of yield potentials and water needs of aerobic rice; socioeconomic analysis of farming households growing aerobic rice; and adoption of aerobic rice. With China being the host country for this workshop, special attention will be paid to the "Chinese experience" with aerobic rice.

Workshop goals include: shared learning of aerobic rice development, identification of target domains for aerobic rice in Asia, and new priorities for research.

For oral presentations and poster sessions, the working language will be English.

More information:

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The Thai Rice Department is newly re-established under the Ministry of Agriculture and Co-operatives. Originally established in 1953, the Rice Department was merged with the Agriculture Department in 1972 to become the Department of Agriculture.

The Thai rice industry exports US$2.5 billion annually and is the country's most important staple food and cash crop. In recognition of this, the Thai government re-established the Rice Department on 16 March 2006, giving it responsibility for six bureaus:

- Bureau of Central Administration
- Bureau of Rice Policy and Strategy
- Bureau of Rice Seed
- Bureau of Rice Production Extension
- Bureau of Rice Research and Development
- Bureau of Rice Product Development

The Rice Department's missions include research, production and extension, farmers' development, and rice cultural and local wisdom. One of the department's key goals is to create awareness of rice issues in order to enhance the status, reputation, and value of the farmers who grow rice and feed not only the Thai people but also those in other parts of the world.

Location: Head office, Rice Department,
Agricultural Extension (The Benjasirikit) building,
Pahonyothin Road, Chatuchak, Bangkok 10900
Tel: +66 (0) 2579 3856; Fax: +66 (0) 2561 3624
Web: www.ricethailand.go.th