Annual Report 2009

IRRI

INTERNATIONAL RICE RESEARCH INSTITUTE

IRRI
Annual Report *2009*

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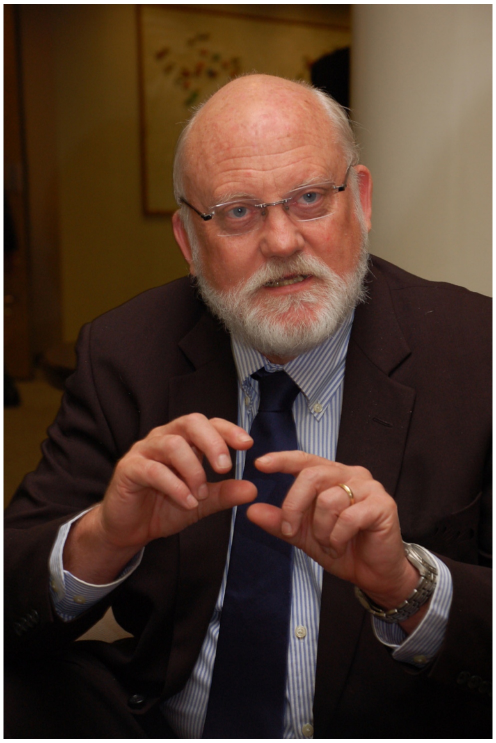
Update for 2009
from the Director General



It's better than first class, it's IRRI class

In the face of unrelenting pressure on rice production in Asia and other parts of the world and as we prepare for our second half century of innovation and achievement, 2009 was a year of rapid and unprecedented growth at IRRI. For a long period during the year, we were hiring 14 new persons every month and a new member of the Institute staff was joining every 0.65 working day.

This sudden growth spurt took place, in part, to sustain our efforts with such exciting projects as Stress-Tolerant Rice for Poor Farmers in Africa and South Asia (STRASA), the Cereal Systems Initiative for South Asia (CSISA), and using the sun to end hunger (C_4). However, to keep these and other projects on course, we need to chart our future very carefully. That is why, in late November, we launched a US$300 million fund-raising campaign at our IRRI Fund Singapore office to support our critical rice research mandate.

Organized to mark our 50th anniversary in 2010, the 5-year campaign has already raised $59 million, with just over $50 million being provided by the Bill & Melinda Gates Foundation (BMGF) to support the three specific projects I just mentioned. Although we obviously have a long way to go, we are very grateful to BMGF for giving the campaign such a strong philanthropic launch. During the special launch program, Mr. Mah Bow Tan, Singapore's minister for national development, stated: "We look forward to more collaboration and greater synergy with IRRI's expertise in rice research to contribute towards the sustainability of rice production in Asia."

Also on the funding front, during the first-ever meeting in Japan of the IRRI Board of Trustees, 28 September-2 October, which was held at the Tsukuba International Congress Center and hosted by the Japan International Research Center for Agricultural Sciences (JIRCAS), it was announced that Japan was pledging $20 million for international rice breeding efforts. An additional $5 million was earmarked for extension training of African rice specialists. So, all in all, I am quite optimistic about the current funding trend for the Institute.

The final phase of IRRI's External Program and Management Review (EPMR7) concluded on 13 February with a summary of the final report to IRRI staff presented by review panel chair Greg Edmeades. In short, Dr. Edmeades said that the bottom line of the panel's findings was that IRRI meets high standards in the conduct and management of science, partnerships with national agricultural research and extension systems and advanced research institutes, financial management, and leadership within and outside, and that, overall, the Institute does things well.

Shortly after the conclusion of the EPMR, I; Achim Dobermann, our deputy director general for research; and the staff began to think about how rice research everywhere on the planet might fit into what is becoming the new CGIAR (Consultative Group on International Agricultural Research). The thinking continued well into 2010 and blossomed into what has become the Global Rice Science Partnership (GRiSP), which most likely will become the first mega-project of the revitalized CGIAR starting in 2011.

In Vatican City during my 18 May presentation at the Pontifical Academy of Sciences Study Week on Transgenic Plants for Food Security in the Context of Development, I pointed out that the recent food crisis and looming future ones have renewed the call for a second Green Revolution that would revitalize yield growth in the face of growing population and a shrinking land base. However, for a second Green Revolution to be successful, the centers of the new CGIAR will have to play a complex role by expanding productivity in a sustainable manner with fewer resources. I am confident that GRiSP will be making a major contribution to the rejuvenated CGIAR. In partnership with AfricaRice, CIAT, and a host of other rice stakeholders, you'll be hearing much more about this exciting global endeavor in the years to come.

There are many exciting research achievements to report on for 2009, including our "assault" on salt in our breeding program; making the most of Bangladesh's rice-maize system; increasing the food supply and stabilizing prices in South Asia's grain basket through the new CSISA, which I mentioned earlier; our eco-smart stand against that persistent insect pest of rice, the rice planthopper; and bringing agriculture in East and Southern Africa up to speed with the rest of the world. The details of these and some other thrilling research thrusts are highlighted in both the following pages of this attractively printed version of the annual report and the award-winning DVD and Web formats that have become acclaimed digital standards over the last couple of years.

Although all of our major events and activities in 2009 are covered in detail in the "Milestones" section of the DVD and Web versions of this report, I would like to call special attention to several here.

In New York City on 20 February, I participated in the Asia Society-Oxfam America panel discussion *The global food crisis—time for another Green Revolution?* I emphasized that we need to be more proactive in communicating that it is not all gloom and doom as some media would like us to believe, but that we have to transform mindsets into a "can do" attitude.

I also participated in the Summer Davos 2009 in Dalian, China, on 10 September, during which I warned of rising sea levels as a result of climate change. I pointed out that this is not a one- or two-year issue, but one that has long-term impact and needs urgent attention.

On 25 October, U.S. Secretary of Agriculture Tom Vilsack visited IRRI (in photo below with Kristie Kenney, U.S. Ambassador to the Philippines; me; and Arthur Yap, Philippine Secretary of Agriculture). Secretary Vilsack said he appreciated the work being done at IRRI and called it "extraordinarily important." He emphasized the opportunities science offered to helping farmers increase productivity "not only to tend to their families but to have sufficient amounts of rice to trade to create wealth and bring about prosperity to rural communities throughout the world." He personally thanked everyone who had been part of giving him the opportunity to visit the Institute, saying, "I will not long forget my experience here." Hopefully, he relayed his IRRI experience to President Obama.

Unfortunately, it seems that, almost every year, the Philippines are visited by a devastating weather event or two. In 2009, it was Typhoon Ondoy (Ketsana) that brought the heaviest rainfall to Metro Manila among recorded typhoons since the start of rainfall record keeping. It caused much damage not only in Manila but also locally around IRRI as 15 barangays in the towns of Los Baños and Bay were underwater. Images taken by the IRRI photography team of the local devastation received half a million views from around the world via IRRI's presence on flickr. Again, I was proud to see how the IRRI community pitched in to assist those in the region who were hit with terrible losses by donating more than 300,000 pesos and in-kind items, especially food, blankets, boots, medicines, and bottled water.

I had my first Royal audience with His Majesty King Bhumibol Adulyadej of Thailand on 26 August at the King's Klai Kangwan Palace. Subsequently, Her Royal Highness Princess Maha Chakri Sirindhorn of Thailand (in the photo above with me discussing flood-tolerant rice) came to the Philippines to officially open the 6th International Rice Genetics Symposium on 16 November at the Manila Hotel and then the next day to IRRI headquarters to formally launch our year-long 50th anniversary activities.

We hosted another anniversary event on 10 December at the Ramon Magsaysay Center in Manila to commemorate the 50th anniversary of the signing of the host country agreement with the government of the Philippines that created IRRI. Luminaries who came to mingle with IRRI staff included Philippine President Gloria Macapagal-Arroyo; former Philippine President Fidel V. Ramos; ambassadors to the Philippines from Asia, Europe, and North America; Philippine government officials; and donors. And finally, on 13 December, all of the 3,400 IRRI staff and family members who attended will never forget the grand fiesta 50th birthday party held at IRRI headquarters.

In closing, I would like to comment on IRRI's values and how these promote excellence in everything we do. This is exemplified in an email I received from Laura Guyer-Miller, consultant for the Training Resources Group, Inc., who conducted the CGIAR Women's Leadership and Management Development Course held at IRRI headquarters, 6-12 September 2009. Ms. Guyer-Miller acknowledged the "extraordinary customer service" offered by the IRRI staff, which she cited as a major reason for the success of the course. She added that the staff "*was so gracious and accommodating, my colleagues and I wanted to ensure you heard from us. I have delivered this course 14 times at various CG centers around the world, and, while each center hosts us with particular care and thoughtfulness, the range of activities and endless support provided last week by IRRI was remarkable*."

This is a noteworthy characteristic that has permeated the IRRI fiber from the early days and has helped us stay viable and relevant over the last 50 years even as the world and challenges facing us have changed. It brings to mind the term "IRRI class," which has been around for quite some time and has come to mean better than first class, as expressed by former IRRI Director General (1973-81) Nyle Brady in a story he told during his IRRI 50th Anniversary Pioneer Interview:

"I'll tell one story that relates to not the scientists but to a member of the support staff at the Institute, a Filipino. The CGIAR was holding one of its annual meetings in Manila and the participants decided to visit IRRI on a Sunday. When checking to see that everything was prepared for the luncheon to be served to this group, I approached one of the young ladies who was helping with the service. 'Well, do you think it is first class?' I asked. 'No, sir,' she said, 'it's better than that. It's IRRI class.' This indicated to me that she had pride in IRRI and in being associated with the Institute, which I thought was just great."

And I think it is great, too—as this long, grand tradition continues!

Robert S. Zeigler

Robert S. Zeigler
Director General

Leaving poverty behind in marginal uplands

This completed project funded by the International Fund for Agricultural Development (IFAD) in marginal rice uplands of India, Lao PDR, Nepal, and Vietnam shows that new technologies can successfully transform landscapes and improve living conditions even in the poorest regions of the world.

Marginal uplands have served as a cradle of poverty that spans from generation to generation in many countries. Many communities are left with no choice and have struggled to survive in these unfavorable and less productive environments that have trapped them in the cycle of poverty for many years.

These marginal lands are vulnerable to soil and water loss, erosion, and moisture deficiency. Their relatively shallow and infertile soils deny farmers better yields. Unfortunately, more than 50 million people in South and Southeast Asia depend directly on these lands for their primary food—rice.

More often than not, these communities are isolated from the mainstream economy and current information—another shackle that chains them to poverty. A case in point: the marginal uplands in Vietnam. Sushil Pandey, senior economist at IRRI, explained that though the country is the second largest exporter of rice in the world, many poor upland farmers are not able to produce enough to feed themselves and their families. They cannot buy rice in the market because they do not have enough money or the rice brought in from these surplus deltas becomes quite expensive due to high cost of transportation to these remote uplands.

Simply put, marginal uplands are trapped in a vicious cycle of low food productivity, poverty, and environmental degradation.

So, the nagging issue is, "How could one break the shackle of hunger brought by poverty in marginal uplands?" The project, *Managing Landscapes in the Marginal Uplands for Household Food Security and Environmental Sustainability* (IFAD TAG706), was conceived by the team, led by Dr. Pandey, for finding solutions to the dire conditions in the uplands. Its goal was crystal clear: to improve household food security of poor farmers in the marginal uplands of South and Southeast Asia through more productive technologies, thereby contributing to poverty alleviation while protecting these fragile environments.

"When farmers' household food security is achieved, then they can start to consider options that will increase and diversify their income such as growing cash crops and raising livestock," said Dr. Pandey.

The rice landscape in uplands consists of rice fields along the mountain slopes, terraced fields, and small pockets of fertile valley bottoms that are interspersed in the mountainous terrain. Since the project focuses on managing landscapes as a whole, the research effort is not restricted to rice fields alone. So, aside from introducing

Managing rice landscapes. The use of improved rice technologies on terraces and on adjoining slopes in a complementary manner enables upland farmers to produce more rice on less land with less labor while conserving water and other natural resources.

new higher-yielding rice varieties, the team sets its eyes on improving the way farmers use their land and water resources.

Instead of simply enforcing innovation, the IRRI-led research project, in collaboration with national research organizations, used two basic approaches, namely, farmer participatory research and rice landscape management.

"Essentially, the project was designed to work with the farmers to develop options suited to their specific situation," said Dr. Pandey. "From the beginning, they were involved in identifying, testing, and selecting the different technologies, crop management practices, and rice varieties."

Rice landscape management was an innovative conceptual framework for developing technologies that can enable farmers to produce more rice on less land with less labor while conserving natural resources. To achieve this, technologies were developed to use efficiently all components of the rice landscape and produce enough rice for the household.

Within the project's four-year lifespan, researchers and farmers were able to evaluate hundreds of appropriate technologies in project areas.

They identified modern and traditional rice varieties that are not only suited to lowland and upland fields, but meet farmers' needs as well. Farmers welcomed these varieties for their ability to produce more grains than the ones they previously planted.

Farmers also received training on the proper way to select and produce seeds to ensure that high-quality seeds would be available continually for farmers to sow, share with other communities, and even sell.

And, to preserve the delicate upland ecosystem, the project team introduced earth-friendly crop and weed, water, and land management practices that can renew the productivity of the fields. Some farmers are already replacing their slash-and-burn agricultural practices with sustainable practices. Hopefully, more will follow in their footsteps.

At the very core of the project's achievements is the strong institutional collaboration formed among the national agricultural research institutions. These institutions will serve as engines to power the series of transformations that are continually being sought in their respective regions in the future. Little by little, changes such as higher crop yields that lead to higher household income; improved food security that can shorten or maybe even eradicate periods of hunger; and farmers' active participation that leads to empowerment will be part of their social landscape.

When the farmers' living conditions in these pilot areas improve, they themselves could play the role of catalysts for changes that move outward from research sites to nearby areas.

"The goal is to spread the benefits from the technologies and rice varieties that our participating farmers have validated," said Dr. Casiana Vera Cruz, IRRI senior scientist. "We want to reach more farmers beyond our pilot villages through them."

It is hoped that these interventions will finally break the hardened chain of poverty and environmental damage that imprison poor farmers, their families, their land, and their future in marginal areas.

Agents of change. Poverty is a vicious cycle that is difficult but not impossible to break. By participating in the project, these Lao farmers have taken the first step in improving their future.

Fast-tracking the seeds of survival

"What good is the grass if the horse is already dead?" says an old proverb on the folly of providing too few solutions too late. When food security of millions of people is at stake, a timely response is critical. To provide faster access to its stakeholders, IRRI and its partners are ensuring that seeds of promising rice varieties get to farmers using the quickest routes possible.

Droughts and floods, among other environmental threats, can literally obliterate rice production in a matter of days. The repercussions of such destruction can be heart-rending, from starvation within the affected areas to food shortages in places thousands of kilometers away. Too much is at stake when it comes to delivering the seeds of stress-tolerant rice varieties to where and when they are needed the most.

Bred to survive and thrive. BRRI dhan 47 in a farmer's field in Noakhali District in Bangladesh shows excellent growth despite high soil salinity.

IRRI has taken a catalytic approach toward working with research institutions, government agencies, nonprofit organizations, the public and private sector, seed corporations and companies, as well as small seed growers in multiplying and disseminating seeds of promising rice varieties to farmers. This ensures that technology transfer is faster and tracking of diffusion is easier.

In 2008, with the help of partners in national agricultural research and extension systems (NARES), IRRI began intensive prerelease seed multiplication of the submergence-tolerant Sub1 varieties. These were developed by marker-assisted backcrossing of the *SUB1* gene into mega-varieties that are popular in India, Bangladesh, and Nepal (see *Scuba rice* on pages 26-31 of *Rice Today*, Vol. 8, No. 2). Swarna-Sub1 was released in India in June 2009 whereas Swarna-Sub1 and BR11-Sub1 were set for release in Bangladesh in March 2010. In *kharif* (monsoon) 2009, farmers started planting Sub1 varieties in flood-prone areas in India at an unprecedented rate.

More than 4,000 tons of quality seed of already released stress-tolerant rice varieties were produced in 2009 through IRRI's seed network partners. This included 180 tons of breeder seed and 380 tons of truthfully labeled seed of the submergence-tolerant Swarna-Sub1, an improved version of popular variety Swarna.

IRRI has linked more than 55 seed companies, government agencies, nonprofit organizations, and research institutions to multiply Swarna Sub1 seed in time for *kharif* 2010.

Through targeted dissemination, IRRI has identified more than 2,000 flash-flood-prone villages in Uttar Pradesh in eastern India. The national government's mega-scheme, known as the National Food Security Mission (NFSM), and the state government distributed 16,000 minikits (5-kilogram seed packets) of submergence-tolerant Swarna Sub1 to these villages. Each village received 5–10 minikits. As more seeds become available in 2011, this variety will be distributed further to less flash-flood-prone villages to replace the traditional Swarna. During the *kharif* 2010, the state government has launched a program for seed multiplication of Swarna Sub1 in 1,500 hectares area. At national level, NFSM has approved the distribution of 69,000 minikits for *kharif* 2010 for planting on more than 11,000 hectares.

Through government support and farmer-to-farmer diffusion, Swarna-Sub1 is likely to reach a million hectares in Uttar Pradesh by 2014. Farmers

Ready for delivery. Dr. David Bergvinson, program officer at the Bill & Melinda Gates Foundation (*second from right*), and Dr. U.S. Singh, coordinator of the Stress-Tolerant Rice for Poor Farmers in Africa and South Asia (*third from right*), show a sack of Swarna-Sub1 certified seed that is ready for distribution, while Dr. Jagdamba Singh, head of plant breeding division (extreme left), and Dr. PK. Singh, rice breeder at Banaras Hindu University (*extreme right*) look on.

said that the improved variety retains the desirable traits of the original variety but yields more than the traditional Swarna by 1 ton per hectare under submergence. One ton of paddy is worth around US$250. Swarna is widely cultivated on more than six million hectares in India, Bangladesh, and Nepal.

Drought-tolerant rice line IR74371-70-1-1 was released in 2009 in India as Sahbhagi dhan and is awaiting final notification (see *Making rice less thirsty* on pages 12-15 of *Rice Today,* Vol. 8, No. 3). In Nepal, two drought-tolerant lines were set to be released in early 2010, namely, IR80411-B-49-1 or Tarhara 1 and IR6144F-MR-6-0-0 or Hardinath 2. The state government of Uttar Pradesh and NFSM, through seed corporations and research institutions, have undertaken large-scale seed multiplication for *kharif* 2010.

During *boro* or winter season, more than 200 tons of seed of salinity-tolerant rice variety BRRI dhan 47 were distributed in south coastal Bangladesh. Moreover, BRRI dhan 47 seeds were also given to six farmers in Noakhali District in southeast Bangladesh, where *boro* rice had never been cultivated. The farmers harvested an average yield of 5 tons per hectare, which heightened awareness and interest among other farmers to adopt BRRI dhan 47 in the next *boro* season.

In the next two years, IRRI foresees the release of more stress-tolerant rice varieties in India, Bangladesh, and Nepal, including two submergence-tolerant varieties, four salinity-tolerant varieties, and two drought-tolerant varieties.

Until science finds a way to be in command of the forces of Mother Nature, farmers will remain at her mercy. We hope that providing them with ready access to these stress-tolerant seeds will enable them to get back on their feet a lot faster than before.

Flood-proof genes. After more than 2 weeks of submergence in a field trial, variety Swarna-Sub1 clearly shows its ability to survive flooding better than Swarna.

An assault on salt

Soil salinity is a global problem that affects approximately 7% of the world's land area. But, it is of major importance in some countries in Asia and Africa especially under the threat of rising sea levels due to global warming, because it has a direct impact on millions of lives. Using conventional and nonconventional tools, plant breeders are launching a counteroffensive by developing tolerant varieties that can thrive on salty soils.

Sea-level rise due to climate change brings about a frightening scenario of sea water intruding into the once-productive agricultural coastal areas, which will definitely add to the many million hectares of unproductive lands that are already affected by salinity in Pakistan, India, Bangladesh, and Vietnam, just to name a few countries.

In Bangladesh alone, salinity affects about 1 million hectares in coastal areas. Considered by some as a silent disaster, salinity has been making rice farmers poor and hungry because salinity-affected lands are unwilling to produce yields, especially of rice.

In 1997, IRRI's rice breeding program for salinity tolerance, currently led by plant breeder Glenn Gregorio, was able to locate a major quantitative trait locus (QTL, or a genome region) that confers salt tolerance in rice on chromosome 1. It is known as *Saltol* (see *Less salt, please* in *Rice Today*, Vol. 6, No. 2).

Since salinity is a complex abiotic stress, it entails a concerted effort of scientists with different expertise such as Abdelbagi Ismail, a plant physiologist; Mike Thomson, a molecular biologist; and R.K. Singh, a plant breeder, who is now based in Tanzania, Africa. Through molecular-assisted breeding, the IRRI salinity tolerance team and its partners in Bangladesh and at the Africa Rice Center were able to introgress *Saltol* into popular rice varieties in Asia such as BRRI dhan 28, BRRI dhan 29, IR64, BRRI dhan 11, Rassie, BG90-2, NERICA L19, and Sahel 108. Each of these varieties has helped translate some unproductive lands in South Asia and Africa into productive ones, making farmers more secure and unafraid to invest in saline-prone areas. For instance, BRRI dhan 47, which has *Saltol*, was released in Bangladesh in 2007 and has assured farmers of a harvest even during high tide when salinity intrusion is at its peak. In comparison, sensitive varieties yield almost nothing at all. BRRI dhan 28-Saltol is now being field-tested in Bangladesh. Moreover, salinity-tolerant BINA dhan 8 (IR66946-3R-149-1-1) is expected to be released in late 2010. This variety is suited for planting during *boro* and *aman* seasons.

An unwanted side effect. A gradual switch to rice production and consequent increased irrigation has led to an additional problem of soil salinity in Timbuktu, Mali.

Saltol contributes about 45% of the salinity tolerance in rice. But, even with this quantifiable success, the work of IRRI plant breeders does not stop

Manuel Rutaquio

Rising global concern. Filipino farmers living near the coastal areas in Quezon Province are devastated by salt water intrusion. They are among the farmers who will benefit the most from salt-tolerant rice varieties.

here. Dr. Gregorio explained that, in the world of breeding, it is important to pinpoint the location of the gene on the chromosome in order to improve the performance of salinity-tolerant varieties and minimize trial and error in breeding. Thus, Dr. Gregorio and his team have embarked on fine-mapping and marker-assisted backcrossing for the *Saltol* gene. They have been combing every recess of the 12 chromosomes of rice in order to locate other genes that can make the plant tolerant at both the seedling and booting stages.

In addition, the team was able to identify 33 simple sequence repeat markers and gene-based markers (easily detectable stretches of DNA) across the *Saltol* region. And, in collaboration with advanced research institutes, they were able to identify three putative candidate genes, *SKC1*, *SalT, and pectinesterase*.

Fine-mapping using recombinant inbred lines and near-isogenic lines showed that some markers are closely linked to the salinity trait. These identified markers are being validated using a number of different breeding populations and the efficiency of the markers is being quantified.

Aside from Pokkali, the team used new sources of germplasm such as FL478, Cheriviruppu, Capsule, and Kalarata, among others, in mapping more QTLs for salinity tolerance and discovered major QTLs on chromosomes 1, 7, 8, and 10. "More efforts in research are geared toward identifying and combining more genes related to salinity for more stable tolerance," Dr. Gregorio said.

Currently, more than 100 salinity-tolerant elite lines have been developed. Lines can be called elite if they exhibit a combination of superior traits such as high yield, good eating quality, resistance to pests and diseases, and tolerance of stresses. Generally, these lines can survive a high salinity of electrical conductivity of up to 12 deci-Siemens per meter, a degree of salt stress at which an ordinary variety simply can't survive.

Moreover, these elite lines have been categorized according to their agronomic characteristics and they are now ready to cater to the specific needs of farmers in salinity-prone areas. In Bangladesh, for example, aside from better grain quality, farmers prefer varieties with less shattering panicles because they transport newly harvested rice to their homes for threshing. Aside from planning the sowing time to avoid salt water intrusion during the critical stage of the plant, farmers prefer late-maturing varieties so that the plants will have more time to recover once affected by salinity. That is why, a trait such as days to maturity is also important.

With all these efforts, it is hoped that, in the future, rice farmers in saline-prone areas can sleep well and will be unafraid to invest in rice production because a combination of genes in the plant fights against salinity and assures farmers of a bountiful harvest whenever salinity strikes.

Screening for promising varieties. Dr. Glenn Gregorio, IRRI plant breeder, and his team assess the effects of salinity on the plants at IRRI's phytotron facility.

Gaining momentum in food security

Since the 1990s, the annual growth rate of cereal production has slowed down, threatening millions with hunger. Overwhelmed by mounting demand, prices soared sharply. Many people found it challenging to get adequate food to meet their needs. The Cereal Systems Initiative for South Asia (CSISA) has its work cut out in South Asia's grain basket: to improve food productivity and enhance farmer incomes and thereby stabilize the prices of staple cereals for the benefit of hundreds of millions of rural and urban landless poor.

In April 2009, IRRI, in partnership with the International Maize and Wheat Improvement Center, International Food Policy Research Institute, and International Livestock Research Institute, launched CSISA. Funded by the Bill & Melinda Gates Foundation, United States Agency for International Development, and World Bank, the project was a calculated move to reverse the deteriorating food security in South Asia.

Using a value chain approach, CSISA rolled out "conservation agriculture" practices and technologies, access to information, market linkages that develop partnerships and investments, and policies based on good business models to solve the complex problems related to crop productivity, resource management, and farmer incomes.

The initiative brings together a range of public- and private-sector organizations to enable sustainable cereal production in nine key "hubs" located across South Asia that work directly with small farmers in deploying existing varieties, hybrids, crop management technologies, the latest market information, new breeding programs, and capacity building, among other activities.

In the next 10 years, CSISA is setting its sight on helping four million farmers to increase their yield by at least half a ton per hectare, and another two million farmers to raise yield by at least 1 ton per hectare. These figures definitely mean at least 5 million tons of additional grain valued at around US$1.5 billion produced annually from 7.5 million hectares of cereal farms in the region as well as other substantial savings in energy, environmental benefits, and a reduction in production costs.

The project is also expected to augment efforts to alleviate poverty and hunger in other parts of the world.

From state to state. Farmers from the states of Uttar Pradesh and Bihar visit the well established zero-tillage wheat crop in Ramba village, Karnal District, Haryana.

The lessons learned in South Asia will be transferred to smallholder farmers in sub-Saharan Africa through new models and strategies applicable to the region.

In its first year, CSISA forged over 200 partnerships across the region. These partnerships cover the entire value chain, including government and nongovernment organizations, agricultural equipment manufacturers, financial institutions, the public and private sector, and national and local media.

More importantly, CSISA has already made a difference in the lives of more than 50,000 farmers and their families. Initial reports indicated the environment-friendly and sustainable technologies that used fewer resources while producing better yields were gaining acceptance in the target farming communities. For these people, the odds that they will not end up as casualties of the war against hunger have been tipped decidedly in their favor.

Grains of opportunity

The rice-maize system has become a trend among farmers in Bangladesh to meet the demand for the two cereals. But, despite their hard work and determination, overall production remains modest. Rural farmers cannot hope to prosper when they do not have improved technology, and IRRI and its collaborators are working together with the farmers so they can produce much more on their land with less effort.

Maize is a fairly new crop in Bangladesh, yet demand for it is increasing as feed for poultry and fish in the country. Maize needs to be incorporated with rice, which is still the country's preferred staple food. Consequently, the rice-maize (R-M) system has become popular as farmers scramble to supply the increasing demand for maize in the local market.

However, R-M farming in Bangladesh is far below its yield potential. IRRI and the International Maize and Wheat Improvement Center (CIMMYT) therefore joined together in a project, Sustainable Intensification of R-M Production Systems in Bangladesh, to assist farmers with this need in 2008.

Taking advantage of the leverage brought about by effective collaboration, the 5-year project enlisted several partners to share proven research and technology on R-M systems in Comilla, Gazipur, Rajshahi, and Rangpur districts in Bangladesh. Institutes such as the Bangladesh Rice Research Institute, Bangladesh Agricultural Research Institute, Bangladesh Academy for Rural Development, Bangladesh Rural Advancement Committee, and Rangpur-Dinajpur Rural Services serve as partners and contribute their organizations' expertise and resources to the cause. The Australian Centre for International Agricultural Research (ACIAR) has financed the project.

Machines of progress. Farmers, machinery operators, and service providers try their hands at operating the machinery during a training in Dinajpur, Bangladesh.

The International Plant Nutrition Institute also joined in to collaborate on site-specific nutrient management (SSNM) under the overall umbrella of the project, which is formally linked to the Cereal Systems Initiative for South Asia (CSISA) led by IRRI, CIMMYT, the International Food Policy Research Institute (IFPRI), and the International Livestock Research Institute.

After fully understanding the challenges faced by R-M systems, the project focuses on elite maize germplasm tolerant of excess moisture during *rabi* and *kharif* seasons; locally adapted management solutions for high-yielding, profitable, resource-efficient, and sustainable R-M systems through on-farm and on-station trials; how improved management options in R-M systems could be useful to and be adopted by farmers; and capacity building.

For instance, the two crops each have their own required soil environment. Excessive tillage for maize can degrade the soil—depleting it of organic matter and nutrients.

The project team operates under the principles of conservation agriculture (CA) and SSNM technology. A key principle of CA is the practice of minimum mechanical soil disturbance so as to maintain nutrients and prevent water loss in the soil, and avoid erosion. For example, the project advocates the use of appropriate and affordable machinery to establish crops under CA-based tillage systems, which include zero tillage, strip tillage, minimum tillage, and raised beds; dry direct-seeded rice (DSR) and unpuddled transplanted rice (TPR); and maize, mungbean, and potato under reduced tillage in flat and permanent raised beds.

CA-based practices such as zero-tillage farming can save much organic matter in the soil for a long time. Thus, SSNM, a tandem technology to CA, will help farmers apply only the necessary amount of fertilizers or they may even need not apply any fertilizer at all.

"Hearing only about these practices and principles in rice farming is not sufficient for farmers to adopt the technology," said Jagadish Timsina, IRRI-CIMMYT senior scientist and project leader. "Farmers need to experience the technology and choose from the options that are presented to them."

He added, "Farmers' participation is a key component of the project because resources, opportunities, and constraints vary from farmer to farmer. In other words, a technology that works with one group of farmers does not necessarily work with all farmers."

So, the project has brought the technologies to the farmers through farmers' field trials. This allows farmers to look for components or ingredients that they can put together to suit their needs.

In 2009, the project made considerable progress in this direction. For example, DSR and unpuddled TPR have been tried in about 40 farmers' fields; researcher-managed *Nutrient Manager (NM) for Rice* evaluation trials were conducted on puddled TPR in about 50 farmers' fields; and CA-based trials on the rice-maize-mungbean system were conducted in about 55 farmers' fields and on the rice-potato-maize system in 10 farmers' fields.

To test the usefulness of SSNM, the project conducted trials on *rabi* maize and on *kharif* maize in farmers' fields. Some SSNM trials with omission plots (meaning no fertilizer was applied) are being conducted in rice and maize to better understand nutrient responses, and evaluate *NM for Rice and Maize* software to provide quick, reliable, and profitable fertilizer recommendations to the farmers.

Aside from conducting farmers' field days, the project team has trained more than a hundred researchers, machine manufacturers and operators, extension workers, and farmers on how to use different machinery for sowing DSR, unpuddled TPR, and maize across project sites.

All these capacity-building activities and participatory approaches are useful for wider dissemination of technologies that can be adopted or adapted by Asian R-M farmers. It is expected that, through this project, Bangladeshi farmers will have better chances to benefit more from the opportunities brought about by the growing demand for maize. IFPRI estimates that 60% of the global demand for maize will come from Asia in 2020.

Playing an active role. Farmers gather for discussions during the farmers' field day in Borura, Comilla, Bangladesh.

An eco-smart solution against a swarm of destruction

Humans and insects are locked in a love-hate relationship. At their best, both species share mutually beneficial partnerships, many of them important to agriculture. And then there are the rice planthoppers. These tiny insects can inflict tremendous crop losses—up to millions of tons each year. Additional damages come from their payload of disease-causing viruses that attack with such ferocity that farmers are often left empty-handed and heavily in debt. So, the Rice Planthopper Project is coming to the rescue.

In 2009, Vichian Insawang, a 50-year-old farmer, planted 3.7 hectares of his land to Pathum Tani 1, a variety of Thai rice. When news of planthopper assaults in the northern provinces of Thailand reached him, Mr. Insawang reacted like most farmers desperate to save their crops from being chewed up by the oncoming swarm.

Resorting to what he thought was his only recourse, Mr. Insawang sprayed his field 10 times with a cocktail of insecticides. Despite his efforts, he still lost more than 70% of his crop to the planthoppers and the viral diseases the insects carried. His gross earnings from his remaining harvest were just US$1,250—not enough to cover the cost of pesticides that set him back $3,200, of which $3,100 was loaned from a bank at 6% interest per year. And now, he has no means to repay the loan.

Mr. Insawang is one of the thousands of farmers in Thailand affected by planthoppers that also plague many parts of Asia's rice bowl. Although he and other Thai farmers received a temporary reprieve from their financial obligation from their government, thousands more are not as fortunate. Among rice planthoppers, brown planthoppers and whitebacked planthoppers are the two main species feared by most farmers. Long-winged forms of the two planthoppers may develop when food is scarce or when there are too many of them. These long-winged planthoppers can travel along with wind currents for hundreds of kilometers in search of food.

Heavy rice planthopper infestations can cause the plants to dry out and turn brown (hopperburn). While feeding, the insects also help spread pernicious viruses that leave infected rice plants severely stunted, discolored, and barren.

Ironically, planthopper infestations are often triggered by the heavy use of pesticides. Like many insect species, planthoppers are masters of short-term evolution. It has been reported that current generations of planthoppers can withstand up to 100 times the level of insecticides that used to kill their ancestors only a few years back. They have also quickly breached the natural resistance offered by certain rice varieties.

A farmer's nightmare. Hopperburn, the trademark of rice planthoppers, is perhaps one of the most heartbreaking sights for farmers across Asia.

The rampant use of pesticides can also bring about secondary pest outbreaks. Farmers inadvertently kill off natural predators such as spiders when they use insecticides to control primary pests such as leaffolders and stem borers. Without the predators, invading planthoppers, which would otherwise be unable to reproduce in sufficient numbers to cause any real

Toxic cocktail. Desperation, fear, and lack of proper information often drive farmers to fight primary insect pests with a brew of different insecticides. In the process, they kill off natural predators and make their crops more susceptible to planthopper attacks.

damage, easily multiply and reach a critical mass to cause a second wave of crop destruction.

In the past few years, planthopper attacks have severely affected rice production across several Asian countries. In 2005, an estimated 7 million hectares of rice farms in China were devastated and farmers reportedly lost nearly 3 million tons of rice to the pest—enough to feed more than 30 million Chinese. Planthoppers continue to be the biggest threat to the sustainability of rice production in the country. In 2009, planthopper outbreaks in central Thailand damaged more than 128,000 hectares of rice lands.

The spread of the threat shows no signs of slowing down despite state efforts to control the situation. In response to the threat to the region's food security, IRRI and the Asian Development Bank initiated the Rice Planthopper Project, a collaborative research network with national scientists in Asia in 2008.

Rather than engaging the swarm in a furious yet ineffective and unsustainable chemical warfare, the Rice Planthopper Project is taking a different strategy for preventing pest outbreaks. It is pushing ecologically driven research and practices collectively known as ecological engineering tools.

"Ecological engineering mainly aims to restore or build up ecosystem services and resilience in order to build crop health or system immunity," said K.L. Heong, insect ecologist at IRRI and the project's principal investigator. "Planthopper outbreaks are symptoms of ecosystem breakdown and they are preventable. The best way to deal with them is to restore biodiversity, particularly of predators and parasitoids, rather than destroy it."

For instance, the sowing of rice can be adjusted to avoid the peak pest migration period. Another method, though not always popular with farmers, is leaving rice fields empty for at least 30 days to cut off the planthoppers' food supply, thereby interrupting their life cycle. High rice prices often motivate farmers to grow rice continuously, but they need to rest their paddies to allow a natural balance to return, Dr. Heong explained.

The Rice Planthopper Project is sending out the message that farmers need to lessen their use of pesticides. "An important impact of ecological engineering will be a reduction in insecticide use by about 50%," said Dr. Heong. "Not only will this lessen the pressure on the environment and the ecosystem, but it will also lessen the risk to the health of farmers and wildlife."

Flower power. Wild flowers that produce nectar are very good at attracting predators and parasites that attack planthoppers.

A revolution gets a green makeover

Although the Green Revolution was a huge success, it inadvertently had some adverse effects on the environment such as fertilizer runoff and pesticide accumulation and resistance. But, as the recent food crisis illustrated, the world can barely survive without these intensified agricultural practices. Enter the Green Super Rice Project. This Chinese Academy of Agricultural Sciences (CAAS)-IRRI initiative aims to develop new varieties that promise high yield and at the same time are gentler on the planet.

The Green Revolution is arguably the greatest triumph of modern agriculture. Through the development and introduction of new varieties of cereals and technologies, it helped feed millions of people that would have otherwise been casualties of a global food shortage.

But, the revolution had unintended far-reaching consequences. Industrial agriculture is its dependence on pesticides and chemical fertilizers. The high-yielding varieties performed best with large quantities of costly nitrogen-rich fertilizers that eventually drained into and polluted ponds, lakes, and underground water. The widespread use of agrochemicals for controlling pests and diseases in some crops has affected ecosystems and human health.

Additionally, many farmers do not have the resources to buy agrochemicals. If they use high-yielding varieties without using appropriate fertilizers, those varieties will fail. This can push already cash-strapped farmers into bankruptcy.

Can agriculture continue to feed the world without these trade-offs? The answer could already be growing on several trial farms in South and Southeast Asia through an CAAS-IRRI project, Green Super Rice (GSR) for the Resource-poor of Africa and Asia, which is funded by the Bill & Melinda Gates Foundation. Dr. Zhikang Li, IRRI senior molecular geneticist who is based at CAAS, is the project director. But, the research work for developing GSR materials is being carried out both in China and at IRRI.

Setting the green standard. Dr. Jauhar Ali, IRRI plant breeder and Green Super Rice (GSR) project coordinator for Asia, shows that an early-duration GSR hybrid variety performs better than the regular hybrid in Sri Lanka.

Unlike most modern varieties, strains of GSR retain their high yield potential even with less use of costly chemical inputs. Depending on the trait, GSR can thrive under environmental conditions that would make other varieties less productive.

"The GSR breeding technology is very important," said Jauhar Ali, plant breeder and GSR project coordinator for Asia. "We never did this kind of activity in the past. Now, we are assessing the entire breeding population and we screen for particular traits such as lower chemical fertilizer and pesticide requirements; tolerance of drought, salinity, and floods; and resistance to serious pests and diseases such as blast and planthoppers."

For instance, a GSR variety with a high ability to grow fast can compete strongly with weeds. "It establishes itself much faster than the weeds," said Dr. Ali. "What happens is that farmers do not have to use chemicals to control weeds." This weed-tolerant rice variety performed well in Bangladesh and is being further tested.

In 2009, field trials conducted in Indonesia, Vietnam, Laos, Cambodia, Pakistan, Bangladesh, Sri Lanka, and China showed some promising GSR varieties. The project has identified five GSR strains in an IR64 varietal background that perform well under low-input and severe drought conditions. Moreover, their yields are comparable with those of checks under irrigated conditions. Another 10 salinity-tolerant varieties are ready for seed exchange and germplasm distribution through the International Network for the Genetic Evaluation of Rice. Seeds of 56 GSR varieties with multiple disease and insect resistance were distributed to the GSR trial countries.

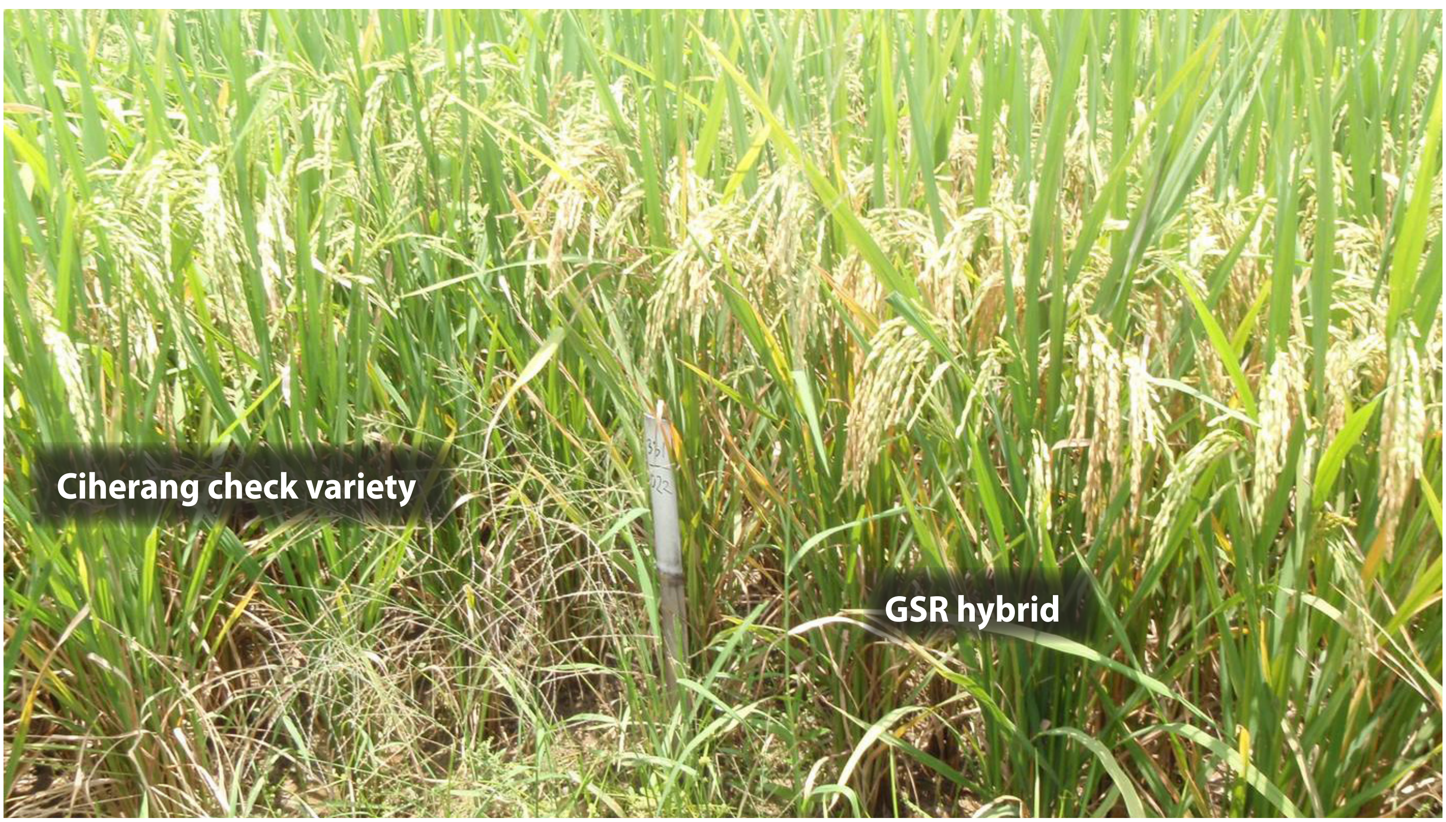
Forty-one GSR varieties that have been identified as best-performing lines under drought, salty soils, and flooded conditions are being multiplied and shared with the project's national agricultural research and extension system partners.

The GSR project is not limited to producing hardy, environment-friendly lines. It also promotes the GSR concept to encourage adoption in target countries. Rice production has an effect seen across the globe because rice production and consumption patterns are not linked within a country, Dr. Ali explained. If rice production in India goes down, this will affect countries in Europe and the Middle East because India exports rice there. If Thailand stops exporting rice, many countries will be affected.

"It is global, so we have to think in a global way," he said. "This kind of concept is very important. We have to think from this perspective and GSR has to be taken into this perspective."

In this regard, the GSR project has held several discussions with policymakers and researchers, and training courses and workshops that focused on GSR technology. In Sri Lanka, extension agents have already received training from the project on how GSR varieties can fill the needs of farmers from the target sites. To ensure that farmers will have a sufficient and steady source of GSR materials, the project has provided training to small- and medium-sized private-sector companies in Bangladesh, Indonesia, Sri Lanka, Vietnam, and Pakistan.

In recent years, rice scientists were forced to face the additional challenge of balancing food security with preserving natural resources and protecting the environment. For IRRI, the key is a doubly green revolution: the development and diffusion of conventional environment-friendly agricultural practices and innovative varieties such as GSR.



Growing evidence. A field trial shows that Green Super Rice hybrid variety performs better than Ciherang, a popular variety in Indonesia.

The power of many

Hybrid rice helped significantly increase domestic rice production in China, where 20% of the global population depends on a mere 7% of the world's farmland. But, this miracle plant is no random accident. Originally developed in the 1970s by China's Yuan Longping, hybrid rice technologies are the fruit of years of work in fields conducted all around the world by public entities and private corporations working together to eliminate hunger on the planet.

Undeniably, hybrid rice technology has been a key tool in increasing rice production. It gave China food security during the Green Revolution, which confounded predictions of famine in the 1970s.

In 2008 alone, the area covered by hybrid rice reached 20 million hectares globally, including 3 million hectares in countries outside China.

IRRI's collaboration with public and private partners has been crucial in hybrid rice research and development in the tropics for 30 years. Because of this collaboration, many hybrid rice varieties and parental lines have already been shared with partners and have been released for commercial production.

Fruits of collaboration. Hybrid rice varieties, the result of international scientific efforts, show great yield potential under field conditions.

To further improve hybrid rice research and development, the Hybrid Rice Development Consortium (HRDC) was established by IRRI with 38 public and private organizations in 2008. In 2009, its membership expanded to 47 organizations as it aimed to renew and strengthen collaboration between the private and public sector and to disseminate hybrid rice technology more effectively and efficiently.

Both the public and the private sector are working together complementarily. The public sector has expertise in scientific research, product assessment, germplasm development, technology dissemination, and capacity building. On the other hand, the private sector has the comparative advantage in large-scale commercial seed production, seed processing, and marketing—areas in which IRRI and public institutes have no direct involvement.

This public–private sector partnership helps shift hybrid rice from academic research to commercialization. It makes the stream of innovation and research outputs steadier and the product more accessible and, in the end, used by rice farmers.

During the past 2 years, HRDC members, like architects of change, painstakingly identified research areas that are urgently needed to be improved such as the yield of hybrid rice seed production and yield vigor. They also identified the importance of resistance to biotic stresses (bacterial leaf blight, blast, sheath blight, brown planthopper, and stem borer) for sustainable growth of hybrid rice.

Having a resolve to meet these goals, the hybrid rice group at IRRI developed more specific hybrid crosses. As more breeding populations are being developed, more breeding lines as well as new hybrids are shared with HRDC members.

Sea of potential. Dr. Fangming Xie, IRRI hybrid rice breeder, selects promising hybrid lines in the field.

IRRI's hybrid rice program recognizes the importance of accessing IRRI's hybrid rice products and information. That's why it has embraced a product-oriented approach—a focus on both product development and delivery.

In terms of product development, the HRDC has built a regional hybrid testing network to assess its members' hybrid rice in varying environments across different countries and locations. Members can now evaluate products they could not assess before. They can select hybrid rice breeding lines developed at IRRI and further evaluate these lines in their own conditions. And then, they can integrate them into their own breeding programs.

At the farmers' level, the latest generation of rice hybrids has considerably outperformed existing inbred rice varieties in yield gain and profitability in eastern India. For example, in the states of Chattisgarh and Uttar Pradesh, hybrid rice yields more than inbred rice varieties by 36 and 24%, respectively, with 13 and 34% of additional profit economically. The condition of India's hybrid rice seed production may no longer pose a constraint to further up-scaling hybrid rice because seed growers in the country can produce 1.5–2.5 tons of seed per hectare.

To promote the commercial release of IRRI's rice hybrids through national partners and private companies, joint release protocols and licensing models have already been developed. For example, IRRI and the Philippine Rice Research Institute have developed a joint licensing protocol for hybrids, through which a first, nonexclusive hybrid license was issued to a private company. This protocol and the concrete licenses have become models for future IRRI hybrid rice development and promotion in collaboration with other national research and extension systems.

At the end of all this, farmers are the ones who will benefit the most because they can obtain more and better rice hybrids that can increase their rice yield at reduced costs in the fastest time possible.

Hybrid rice technology in action. HRDC members compare IRRI hybrid rice lines in the field.

Outracing rats on their own turf

Regarded as pests by ancient Egyptians as far back as 4000 BC, rats continue to wreak havoc across the rice fields and grain stores of Asia to this day. In a single year, 25 adult rats can eat and contaminate about half a ton of grain. In Asia, rodents can destroy rice that could feed 400 million people for 12 months.

Being cunning, adaptive, and tenacious are traits that enable rats to thrive in a world where other species face extinction because of human activity. It is in rice fields where rats and farmers cross paths, where preharvest losses of rice alone range from a low of 5% in Malaysia to a staggering 17% in Indonesia. "It is not uncommon for farmers or villagers to lose half of their entire rice crop to rats," said Dr. Grant Singleton, coordinator of the Irrigated Rice Research Consortium (IRRC) that oversees a project on ecologically based rodent management (EBRM). "Many Asian farmers do not rate rats among their most important pests simply because they believe—misguidedly—that rats are a problem they have least control over and therefore they have to accept the losses."

Rats can also spread alarming health risks through their urine, feces, fleas, and mites. These include hantaviruses, typhus, salmonella, meningitis, leptospirosis, and, of course, bubonic plague. In 2009, Dr. Singleton co-authored a major review on the diseases that rodents can pass on to humans.

Rodent control has no magic bullet because rodents have more than 200 pest species and most behave differently. Some species prefer to eat immature grains; others do damage at the later stages of rice production.

Good rodents, bad rodents. EBRM encourages specific rodent management that targets pest species of rats while conserving beneficial species of rodents, such as the "good rats" (above).

The rodent population also gets a boost from both humans and Mother Nature. For instance, studies conducted in 2003 in Indonesia and Vietnam revealed that spikes in rat populations occur when fields are planted with rice. If only one rice crop is planted in a year, then the rats will have one breeding season; if there are two crops, then they have two breeding seasons; and three crops have three breeding seasons.

Female rats give birth 21 days after mating and then mate again the day after they give birth. In a breeding season, the female bandicoot rat can give birth to three litters of eight, producing 24 rats in a single rice crop. Normally, this generation will not breed until the next crop unless neighboring farmers plant more than 2 weeks apart.

From 2007 to 2009, subsistence smallholder farmers in the hill tracts of Bangladesh, India, Lao PDR, and Myanmar experienced severe food shortages because of rodent populations responding to the masting of bamboo. These masting events occur when bamboo of the same species produces blossoms and fruits *en masse*, which also triggers rat floods. The fruits are a steady supply of food that enables the rats to start breeding a few months earlier than usual.

It takes a village. Community action is a key management strategy in EBRM. In An Giang province in the Mekong River Delta of Vietnam, villagers are working together to control pest species of rats during the monsoon season.

When farmers fight back, it is usually too little and too late. They rely heavily on chemical poisons, which became the *de facto* standard since their introduction in the 1960s. But sometimes farmers use rodenticides incorrectly, presenting risks to the rodents' natural predators such as wild and domesticated cats, dogs, and birds of prey, Dr. Singleton said. When these chemicals enter the food chain, they eventually find their way to humans.

Like most pests, rats have ramped up their tolerance of rodenticides. Generally, research activities have focused on increasing the toxicity of rodenticides and making them more palatable to rats but less attractive to nontarget species. However, many, including the IRRC, have questioned the effectiveness of relying primarily on pesticides to control rats.

In 2003, the IRRC, together with the Commonwealth Scientific and Industrial Research Organisation in Australia and national agricultural research and extension system partners in Indonesia and Vietnam, launched a rodent management approach that requires an ecological, not a chemical, approach. EBRM focuses on reducing the economic losses of smallholder farmers, improving health through reducing rodent-borne diseases, and reducing the use of chemical poisons. "The objective was to enter the fascinating secret world of rats and work closely with farmers to develop cheap, environment-friendly management strategies," Dr. Singleton said.

The trap barrier system is one simple but effective technology if losses are chronic and greater than 10%. It uses a plastic fence, with traps set into the plastic, surrounding a small rice crop planted 2–3 weeks earlier than the surrounding crop. Rats follow the line of the plastic until they reach a hole, which they enter to reach the rice and are subsequently caught.

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. In Vietnam, EBRM has reduced rodent damage by 50% and farmers have lessened their use of chemicals by more than 60%. Also, because it requires community action, EBRM fostered more social cohesion among farmers in their communities.

In 2009, EBRM was adopted nationally in rice programs in Indonesia, the Philippines, and Vietnam. About 100,000 rice farmers in Vietnam and 75,000 farmers in Indonesia have adopted it. EBRM is now expanding to Bangladesh, Laos, Myanmar, Tanzania, and Namibia.

Adoption of EBRM is expected to halve the average annual loss to rodents across Asia, thus saving enough rice to feed roughly the entire population of Indonesia for a year. Finally, humans are getting a head start in this rat race.

New rice for the masses

Plant breeding, the art and science of improving the hereditary traits of crops, has enabled agriculture to meet the growing world demand for food. But, by 2025, the growing need of the human population will require 25% more rice. At the forefront of this challenge are IRRI elite lines—rice varieties that combine high yield and other multiple superior characteristics to meet the challenges of increased rice productivity and sustainability.

New rice varieties have transformed rice production around the world. Annual world rice production increased from about 250 million tons in 1966 to more than 640 million tons in 2009, mostly through the development and adoption of new high-yielding, fertilizer-responsive varieties with a high degree of resistance to insects, pests, and diseases, accompanied by appropriate production technologies.

"The most significant technological accomplishment of this century in international agriculture is the development of high-yielding cereal crop varieties," Dr. Nyle C. Brady, IRRI director general (1973-81), once wrote. "They have given rise to the Green Revolution, which has helped many nations increase their food production in the face of a substantial increase in human population."

However, rice production is continually threatened by pests, diseases, erratic weather, drought, floods, salinity, and soil toxicities, among other stresses. The major challenge is to overcome these stresses and produce more rice with less land, less water, fewer chemicals, and less labor in the context of global climate change. This is where breeding new and adaptive elite lines of rice varieties comes in.

Art and science of rice breeding. Through crossbreeding, Dr. Parminder Virk, IRRI plant breeder (right), Benito Romena, associate scientist, among other members of the team develop varieties with desirable traits such as high yield, good eating quality, and resistance to pests and disease.

Recent advances in molecular marker technology and genomics have offered plant breeders a new suite of tools to move at a faster clip and accelerate the release of superior varieties to farmers. But, typically, it takes plant breeders such as Parminder Virk of IRRI's Plant Breeding, Genetics, and Biotechnology Division (PBGB) many years to develop elite lines.

Essentially, Dr. Virk and his team of researchers create a new line by putting together a mosaic of genes by crossbreeding plants that exhibit particular desirable traits. These hereditary traits are high yield, good eating quality, and resistance to insects, diseases, and environmental stresses.

IRRI-developed elite breeding lines are released as cultivars by national programs if they perform well in at least 2 years of yield trials at various locations that represent target ecosystems.

In 2009, three IRRI-bred superior rice lines, IRRI150 (IR77495-10-2-6-2), IRRI151 (IR78566-1-2-1), and IRRI154 (IR78581-12-3-2-2), were recommended by the Philippine National Rice Technical Working Group to the National Seed Industry Council (NSIC) for release as commercial national rice varieties, namely, NSIC Rc212 (Tubigan 15), NSIC Rc214 (Tubigan 16), and NSIC Rc222 (Tubigan 18), respectively. These three IRRI-bred lines have high yield, wide adaptability and tolerance of major rice pests, and acceptable grain quality.

Comprehensive evaluation of these lines was carried out under the National Cooperative Testing Project during 2005-08. The results of adaptive trials across various locations in the Philippines showed that these varieties outyielded the most popular check variety by an average of 11.5% for IRRI154, 10.1% for IRRI150, and 9.1% for IRRI151 as against the 5% benchmark for releasing a variety.

Breeding line IRRI154 yielded more than 1 ton per hectare more than the check variety in a rainfed lowland dry-seeded multilocational trial during the 2008 wet season and has been identified for rainfed environments in the Philippines. It has also shown a promising performance under other environmental stresses such as stagnant water and low solar radiation during the rainy season.

"Many more IRRI elite lines are in the pipeline that would significantly enhance rice productivity in different ecosystems," Dr. Darshan Brar, PBGB head, said. "The Institute's plant breeding program will continue to focus on improving rice for human benefit and as international public goods."

GAPs fill the gap

Lack of information is the true adversary of most Asian rice farmers. It leads to practices that harm, not nurture, their land; outdated technologies that result in low gains and high losses; and insufficient market knowledge that puts them at an economic disadvantage. IRRI, through the Irrigated Rice Research Consortium (IRRC), strives to fill this gap in knowledge with GAPs—good agricultural practices— to ensure that farmers benefit from technologies arising through research.

In recent years, the food industry, producers' organizations, governments, and nongovernment organizations have developed good agricultural practices (GAPs) with codes, standards, and regulations that aim to classify agricultural practices at the farm level for a range of commodities.

According to the Food and Agriculture Organization of the United Nations, Good Agricultural Practices are those that address environmental, economic, and social sustainability for on-farm processes, and result in safe and quality food and nonfood agricultural products.

Those practices aim to capture new market advantages by modifying supply chain governance; improve natural resource use, workers' health, and working conditions; and create new market opportunities for farmers and exporters in developing countries.

Countries in Southeast Asia such as Thailand and Vietnam are already exploring GAPs for rice. Research is being done to support rice GAPs and facilitate the diffusion and adoption of GAPs.

In Vietnam, IRRI, through the IRRC, is working with the An Giang People's Committee and the Plant Protection Department in developing An Giang as a model province for sustainable rice GAPs in the lowlands by incorporating emerging new technologies for production. These technologies are validated through adaptive research with farmer partners. Sociological studies are also conducted on the factors that influence farmers' adoption, to give feedback to scientists and extension workers.

Media buzz. Members of the local press interview IRRI scientists about their collaboration with Vietnamese partners in An Giang, the model province for sustainable rice GAPs.

The emerging technologies are being diffused through the *Mot Phai, Nam Giam* (1 Must Do, 5 Reductions) program. It builds on Vietnam's *Three Reductions, Three Gains* policy, and encourages farmers to reduce seed rate, fertilizer use, pesticide use, water use, and postharvest losses. These practices build on the "1 must do"—to use certified seeds.

In May 2009, the IRRC assisted in a message design workshop conducted in An Giang, which resulted in a well-publicized campaign launch of "1 Must Do, 5 Reductions" in November. Some 20 billboards were erected around the province, plus 2,000 posters displayed at public sites such as schools, coffee shops, farmers' clubs, and hospitals, and the Department of Agriculture and Rural Development distributed 17,000 brochures and 8,000 booklets.

The communication campaign was supported by the establishment of 1-hectare demonstration fields in each of the 11 districts of An Giang. After undergoing training on the technologies, about 335 farmers applied some or all of the technologies over an area of 609 hectares.

For the summer-autumn crop in the wet season, four districts reported increases in yield of 0.2 to 0.4 ton per hectare from a mean of 5.3 tons per hectare. In general, farmers' profit increased by US$208 per hectare.

The IRRC has developed a Web site for GAPs for lowland irrigated rice that can be accessed via the Rice Knowledge Bank. The site provides practical solutions to help rice farmers boost yields, and improve grain quality and production efficiency.

"Adopting efficient and effective farming practices promoted on the Web site will help lift farmers and their communities out of poverty and hardship, and provide a clear pathway for environmentally sustainable production of rice," said Dr. Grant Singleton, IRRC coordinator. "Women in particular will benefit from labor-saving technologies, such as improved direct seeding, that reduce the drudgery in tasks such as transplanting and weeding."

The Web site also aims to help farmers reduce pesticide, fertilizer, and water use.

"By providing information on integrated and conservation agriculture, and ecologically based pest, nutrient, and water management, the Web site will also enhance the ecosystem services and resilience of rice environments," said Dr. Bas Bouman, who led the development of the Web site.

The Web site synthesizes decades of collaborative research and development from IRRI and its many partners on best management practices for irrigated rice, and it will continue to incorporate new knowledge in the future.

Future plans for the IRRC include the development of a Rice GAPs network in Asia. Thailand, Laos, the Philippines, and Vietnam have already expressed strong support for a network that will enable countries to share their experiences in establishing and promoting "Rice GAPs." The social scientists of the IRRC will also work closely with in-country partners in assessing the benefits to smallholder farmers and in identifying possible hurdles to adoption.

Getting the farmers on board. This billboard is one of the 20 that were put up around the province of An Giang. These, along with thousands of brochures and booklets, provide farmers with information on best management practices for irrigated rice.

A Green Revolution on red earth

Rice cultivation in Africa started about 500 years ago but only recently has rice gained importance as a staple crop. In partnership with researchers and farmers, IRRI's East and southern Africa (ESA) program is bringing agriculture in the region up to speed with the rest of the world.

Although the annual consumption of rice in ESA is approximately 2.2 million tons—and growing at 6% per annum—the more than 2 million rice farmers in the region produce only approximately 1.4 million tons of rice both for their own consumption and as a cash crop for the local market. This has created a gap between demand and supply, forcing ESA countries to import more than 800,000 tons of rice from Asia every year.

Rice yields have remained low and stagnant because of inadequate research and extension support, poor crop management, and a lack of effective and efficient national mechanisms for developing rice production. On average, most rice farmers grow rice on less than 0.5 hectare of land. The typical rainfed rice area yields less than 1 ton per hectare and irrigated land yields less than 3 tons per hectare.

Studies across the region have found that farm operations are rarely completed in a timely and efficient manner, said Joseph Rickman, IRRI representative for the ESA. In most areas, farmers wait for rain before they begin land preparation, resulting in poorly prepared and uneven seedbeds. More often than not, farmers plant the crop 1–2 months late and use a very high seeding rate of up to 200 kilograms per hectare. Crops that are planted late are more prone to disease problems and often run into dry spells during grain filling.

Mr. Rickman noted that very few new lowland rice varieties have been released in the last 20 years because varietal release procedures across most ESA countries are slow and cumbersome. Most of the varieties being grown are no longer true-to-type, lack early vigor, and have growth cycles of 140–160 days. These varieties also lack resistance to major rice diseases such as bacterial leaf blight, blast, and rice yellow mottle virus, and are susceptible to drought, cold, and iron toxicity, among other stresses.

To jump-start improvement, IRRI's R&D program in ESA adopted an integrated approach, in which IRRI scientists and technicians work closely with national researchers, extension officers, nongovernment organizations (NGOs), the private sector, and, most importantly, farmers.

"By including farmers in the very early stages of development, we are now trying to reduce the time by improving the relevance of research, involving all of the necessary players early in the process as well as trying to better understand other constraints that may not be agriculturally based," Mr. Rickman said.

A combination of on-farm demonstrations, participatory variety selection (PVS) trials, and farmer field schools has proven to be a very successful way of getting all players involved and technologies quickly evaluated.

In the regional breeding program, PVS trials are now an integral component of the whole program. In Mozam-

Reviving African fields. On average, typical rainfed rice area in the ESA region yields less than 1 ton per hectare and irrigated land yields less than 3 tons per hectare. The introduction of new varieties, technologies and crop management practices is expected to make rice production more bountiful.

bique, Tanzania, and Burundi, more than 25 PVS trials were conducted in 2009-10. Using many PVS trials across each country effectively reduces the cost and the time of registration by 2–3 years, with the added bonus that farmers are well positioned to adopt and multiply new varieties after registration.

PVS trials are also being used to develop linkages among players in the rice industry such as extension officers, researchers, farmers, NGOs, the private sector, and other institutes such as universities. Field days and on-farm demonstrations have proven to be effective in bringing them together.

Farmers involved in PVS studies are also being given the opportunity to use and assess equipment such as 2-wheel tractors, peddle threshers, mechanical threshers, and hermetic storage bags. Local rice millers are also becoming involved to help in the testing and dissemination of new varieties and other technologies.

In each of the ESA countries, IRRI is helping to establish a local Rice Knowledge Bank that will gather all of the relevant rice information for that country at one site. A major effort is being undertaken to generate associated extension material in a format that can be readily used by extension officers, private companies, NGOs, and farmers.

With all these efforts, farmers in the ESA region are beginning to see the dawn of modern agriculture slowly move across their lands through more vibrant rice production.

People-powered technology. Women farmers in Mozambique test a pedal thresher, one of the low-cost technologies that is expected to improve rice production in the region.

Hands-on classroom. Joseph Bigirimana of the IRRI office in Burundi conducts a farmer field school, a proven way of getting participants involved and technologies quickly evaluated.

The silence of the genes

Rice plants that are resistant to multiple strains of a pathogen and, even better, to multiple diseases have been the Holy Grail of plant pathologists and breeders. After nearly a decade of searching, scientists from China, the U.S., Canada, and IRRI have made significant progress in revealing the specific genes—and understanding the mechanism—that would give rice the highly desirable but elusive trait known as broad-spectrum resistance.

Manipulating the genes of the rice plant to create varieties with broad-spectrum resistance to diseases has been a long-sought goal of crop scientists. However, it is a goal that's hard to achieve because broad-spectrum resistance is usually quantitative in its effect. This means that the trait is controlled by a combination of sets of genes while the effect of individual genes is small.

Through international collaboration, scientists have moved closer to understanding the genetic basis of quantitative disease resistance. It started with a rice variety called Shan-Huang-Zhan Number 2 (SHZ-2). This variety was widely grown in southern China and exhibited durable resistance to rice blast, which is one of the most destructive and infectious fungal diseases in the world.

On the basis of genetic mapping of SHZ-2, the research team has shown that the quantitative trait loci (or QTLs) are associated with a number of host defense genes in the rice genome. Two QTLs, one on chromosome 8 and the other on chromosome 3, contain members of the germin-like protein (GLP) gene family and the oxalate oxidase (*OXO*) gene family.

These two gene families play a role in host defense against fungal attack by producing hydrogen peroxide, forming papillae on the leaf surface, and strengthening cell walls. Together, they act as barriers that restrict the invasion of the pathogens that cause diseases.

An international effort. Scientists from China, the U.S., Canada, and IRRI are working together in understanding the genetic mechanism that would give rice resistance against multiple diseases.

Using gene-silencing technology, scientists switched off the GLP genes one by one and measured the change in resistance to pathogens. Transgenic plants became more susceptible to rice blast as more GLP gene family members were silenced. Additionally, silencing these genes increased the susceptibility of the plant to a second fungal disease, known as sheath blight, another serious disease of rice that affects yield and grain quality.

For the *OXO* gene family, only one of the four gene members was expressed upon fungal infection and its effect is validated by gene silencing.

This collaborative effort showed, for the first time, that a complex QTL containing multiple gene members can confer resistance to two different diseases, blast and sheath blight, caused by pathogens with different life styles.

The genetic effect shown against sheath blight is of special interest because breeding for sheath blight resistance has been hampered by a lack of effective resistance. By knowing the genetic basis of the quantitative resistance, rice scientists are now in a position to combine these defense genes precisely. By selecting these genes, plant breeders and pathologists can start building up the level of quantitative resistance in rice breeding lines with resistance to multiple diseases.

For poor and subsistence rice farmers around the world, manipulating these genes could mean less dependence on toxic agrochemicals, less cost, less harm to their health and the environment, and less threat to their food security.

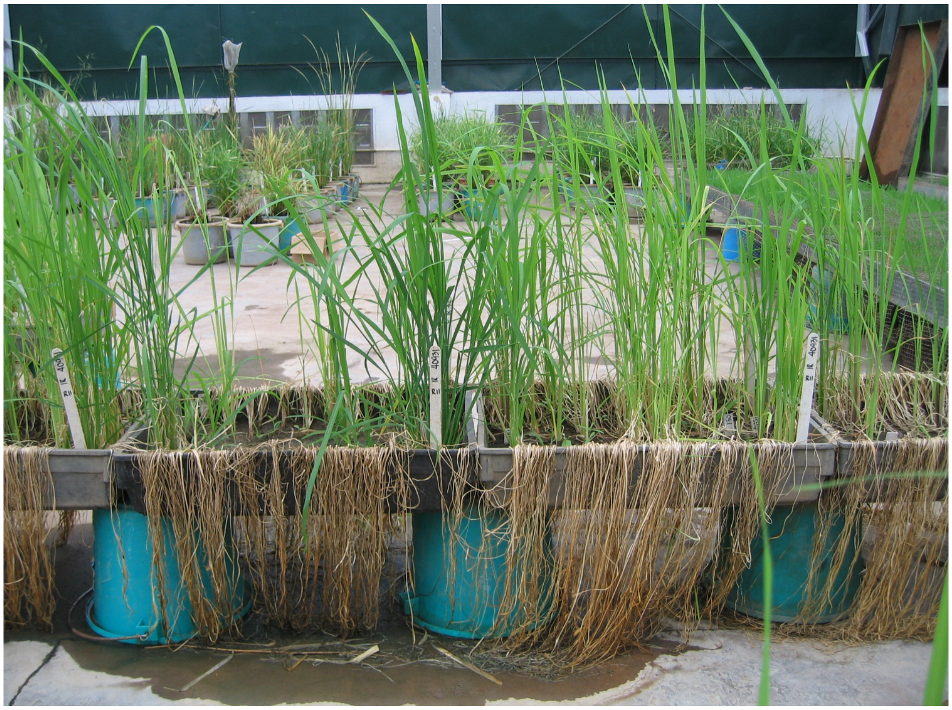
Serendipity in the science behind submergence tolerance

Considering the important role of a study that partly failed to meet its objective uncovers interesting details on SUB1A*–the "scuba rice" gene that enables plants to survive seasonal flooding that affects 10–15 million hectares of lowland areas in South and Southeast Asia and causes about a billion dollars of rice crop losses per year.*

It all depends on genes when plant breeders create rice varieties that help improve the lives of millions of the poorest people in the world. One such gene, *SUB1A,* discovered by a team of scientists from IRRI and University of Davis in an Indian rice variety, enables rice to survive submergence in water for 2 weeks. Through conventional breeding, the *SUB1* gene has been successfully transferred into popular high-yielding varieties (see *Scuba rice: stemming the tide in flood-prone South Asia* on pages 26-31 of *Rice Today,* Vol. 8, No. 2).

The availability of new breeding technologies such as marker-assisted backcrossing (MABC) has shortened the breeding process and greatly improved the precision with which specific traits can be passed on from one variety to another (see *On your mark, get set, select* on pages 28-29 of *Rice Today,* Vol. 3, No. 3). MABC enables breeders to transfer a specific trait without changing other desirable features of the variety, for example, adding flood tolerance to a flood-intolerant but high-yielding rice variety such as IR64. Thus, the discovery of new stress-related genes for designing stress-specific varieties has become a major goal in plant breeding.

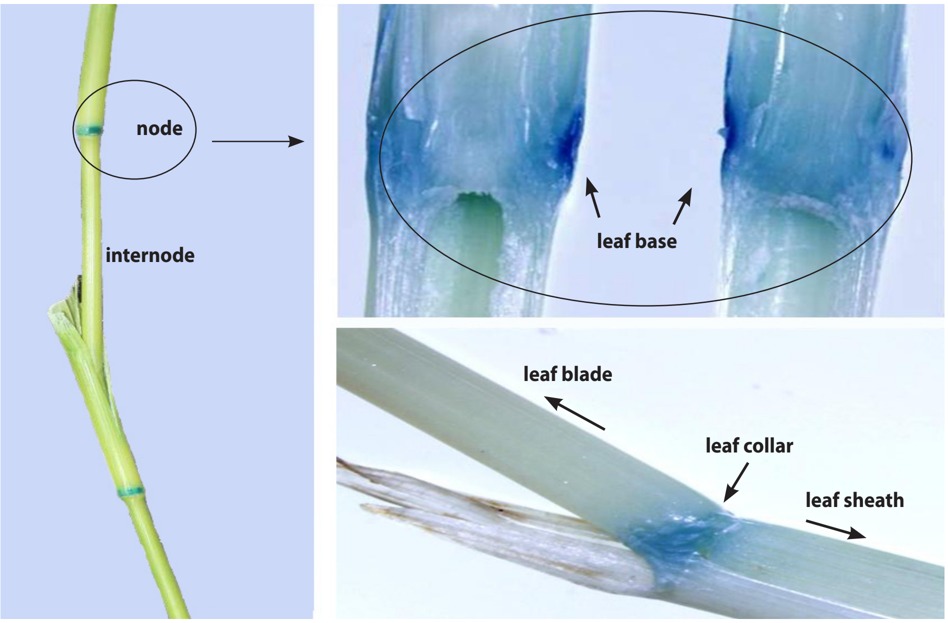
In 2007, a team of researchers headed by Sigrid Heuer, IRRI molecular biologist, started exploring IRRI germplasm to find submergence-tolerant rice that does not have *SUB1A* or that has the intolerant variant of this gene. Since rice fields are often flooded for more than 2 weeks, Dr. Heuer's team was hoping that these new genes could be used to make rice plants survive underwater for more than 14 days.



Gene in action. Rice varieties with the *SUB1A* gene that is switched on can survive submerged conditions.

Indeed, one variety with intermediate submergence tolerance that had the intolerant version of *SUB1A* was identified. "We were quite happy with this; however, we also found that some of the genetic data didn't really match our expectations because some of the screened varieties that have the tolerant type of the *SUB1A* gene were actually intolerant of submergence," Dr. Heuer related.

Studies have shown that the *SUB1A* gene is switched on when plants are submerged underwater. Using genetic analysis of leaf tissue samples, members of the team shifted their focus to whether flood tolerance



Eureka moment. Dr. Sigrid Heuer, IRRI molecular biologist, and her team found that high expression of *SUB1A* in leaves is restricted to the growing parts (leaf base and leaf collar).

was actually determined, not by the type of gene present, but whether the gene was switched on or off. Then, they found that, in the variety with intermediate tolerance, the intolerant variant of *SUB1A* was switched on to about the same level as the tolerant variant. "It is therefore likely that the intermediate tolerance of this variety is not conferred by novel genes but rather by high expression of the *SUB1A* variant that we had considered to be 'intolerant'," Dr. Heuer noted. "However, there were still too many exceptions to the rule in our data. We were still puzzled and we moved on to tackle those issues in more detail."

Because of unanswered questions and inconsistent data, the team examined each step. "If we wanted to know which varieties were tolerant or intolerant of flooding, we thought we could look at the gene sequence and, that's it," she said. "It turned out that everything was more complicated than we anticipated. Eventually, we gave up on analyzing leaves and looked at other tissues. Then, we found that high expression of *SUB1A* in stem nodes and internodes correlated well with submergence tolerance." However, these data were derived from mature plants because nodes and internodes develop only when plants are about to flower. A question then remained, What is going on in young rice plants that do not have a stem yet?

Scuba rice. Rice varieties with the *SUB1A* gene can survive even after more than 2 weeks of submergence.

Thus, the team used transgenic technology to examine the expression of the gene in yet more detail. They discovered that *SUB1A* is switched on specifically only in parts of the leaves that are actively growing. Likewise, in young seedlings, the gene is switched on only in the central part where new leaves are formed. "These findings agree with the function of *SUB1A* in suppressing elongation of plants underwater," explained Dr. Heuer. "After analyzing the data, we understood why our initial data were so confusing. We realized that these specific regions were not always included in our samples that we had analyzed when we had started the project."

Although the team failed to find what they were looking for—new genes for submergence tolerance—they learned important lessons from their studies. "We have to be more careful and specific when we get tissue samples for molecular analyses," Dr. Heuer said, "and we have to take inconsistent data seriously because a lot of information might be hidden in them, as we know now.

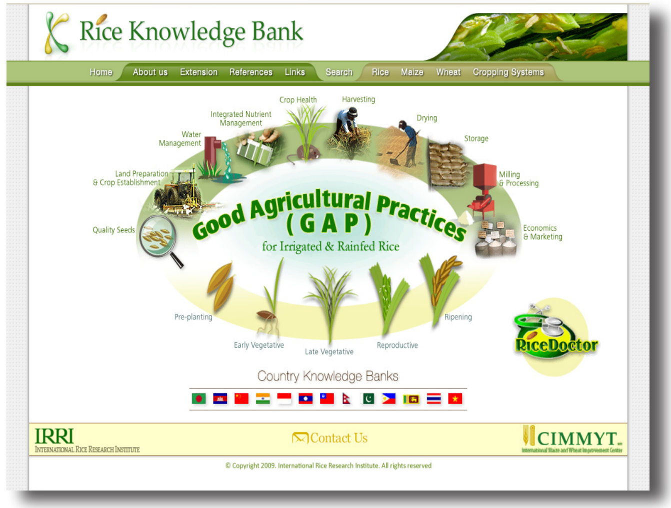
"Most importantly, with what we learned along the way, we can now do a much more specific screening for novel submergence tolerance genes," she added.

The focal point of rice knowledge

Considering the important role of the Rice Knowledge Bank (RKB) in bringing research and extension closer together, the IRRI science community ensures that content in the RKB is comprehensive, accurate, and up-to-date.

Since its establishment in 2002, the RKB has come a long way. It is now well established as the focal point for IRRI's rice-farming knowledge relevant to farmers and the extension community, which includes government extension workers, nongovernment organizations, universities, the private sector, and farmer associations. The IRRI RKB team, which has worked initially and extensively in Asia, has recently expanded its operations in Africa in facilitating the development of national rice knowledge banks for each participating country.

Over the past 2 years, the IRRI RKB has undergone a major revision to see to it that its content is comprehensive and up-to-date. To attain this, the IRRI science community has contributed much time and effort in revising the content to ensure that the "messages" keep up with standards in terms of accuracy. To improve the comprehensiveness of the IRRI RKB, the Irrigated Rice Research Consortium (IRRC) has integrated "good agricultural practices" into the RKB, which now complements the original seed-to-market strategy. Importantly, quality control of the content of the IRRI RKB is a responsibility of the senior scientists in each area. In this way, the content remains up-to-date as rice science evolves.



A significant activity is working with countries in establishing their own national RKBs. This includes all Asian rice-producing countries as well as the six countries in East and southern Africa (Mozambique, Burundi, Kenya, Tanzania, Rwanda, and Uganda). This process has enabled countries to build a coherent RKB that reflects their own local research and indigenous knowledge, and has made IRRI communication materials more appropriate. The outcome is a tool for each country to facilitate national knowledge management of rice-farming know-how. A major outcome of this work has been to bring research and extension closer together in the quest to deliver the latest rice-farming knowledge to farmers.

The challenges for the coming years are to continue to nurture the quality control of the IRRI RKB so that all users can have confidence in what they find there, support the on-going development of national RKBs, and link between the IRRI RKB and each country's RKB. The outcome for rice research is an effective channel for reaching the needs of farmers. Meeting these two challenges will ensure that the impact of the global rice research agenda is maximized.

Information across borders. National collaborators like these Tanzanians participate in the development of country-specific rice technology for the Rice Knowledge Bank.

A human face on the Web

In the Internet universe, with an estimated 62 million site domains and subdomains, it is easy to disappear in the crowd. Through social media sites, IRRI is exploring opportunities to get a much larger slice of the Internet pie while putting a human face on the Institute online.

IRRI is continuously transforming its Web site as a primary medium for providing relevant information to the multiple types of users of IRRI.ORG. Over the years, IRRI's Web team has been finding ways to maximize IRRI.ORG's full potential. But, the Web site alone cannot do the job of expanding IRRI's Internet footprint. Using social media sites for collaborating, sharing information, or continuing conversations about ideas, causes, and issues with its communities of stakeholders can extend IRRI's Internet presence further.

The massive popularity of social media sites cannot be denied. Social media sites have racked up some staggering accomplishments. A middle-aged woman named Susan Boyle, then totally unknown, got more than 120 million views on YouTube. Facebook has 500 million users worldwide. If it were a country, Facebook's population would be the third highest after China and India. Twitter became a channel for over 105 million people to read about breaking news without turning on the radio, watching TV, or reading a newspaper. People could respond to events as they occurred. With application, IRRI's developmental messages and topics can be further diffused to interested communities on the Internet.

"Social media sites have a lot of potential for sharing information," according to Sophie Clayton, IRRI's public relations manager. "These are an important communication tool for us to promote the Institute's missions and goals and share our research with more donors, philanthropists, policymakers, scientists, agronomists, farming groups, and other key audiences."

The Institute's initial encounters with social media sites clearly demonstrated their potential for building communities. Images of the destruction caused by typhoon Ketsana taken by IRRI photographers, and uploaded to flickr, helped generate around half a million hits over a few days. The massive interest in the photos proves that sharing via a social network is a good platform for highlighting the plight of rice farmers around the world and the challenges they face—whether they be from natural calamities, the effects of global warming, or pests and diseases—and how IRRI is finding solutions to mitigate the effects of these events. For instance, the submergence-tolerant rice varieties that IRRI has developed can survive floods brought by typhoons.

However, there is more to it than simply generating a certain number of hits for the IRRI Web. Social media sites have made a genuine impact on people's lives. They have blurred the boundary between online and offline communities. They have become places for meaningful discussions and debates. They have turned into powerful tools for raising awareness. They have become the eyes, ears, voice, and, in some cases, the only link to the rest of the world.

For the purposes of IRRI, the ultimate goal of social networking is to transform the Institute's Web site into a dynamic channel of information and an engaging vehicle of communication with its public audiences.

"In addition to providing the opportunity for IRRI to cast its message and what it is doing to a wider audience, social media sites open up direct, two-way dialogues with interested people and communities all over the globe," said Ms. Clayton. "The Institute needs to be a part of relevant online communities to watch, listen, and respond."

IRRI can build up online followers among the people who are present on any of the pervasive social media platforms on the Internet today by effectively engaging them around the core agenda of IRRI. Although participating in social networking is not without risks, it is better to actively engage in social media rather than sit on the sidelines, Ms. Clayton added. This can show that IRRI is made up of real people and it puts a human face on the Institute.

Living, growing grains of knowledge

"Information is a source of learning," according to 19th century Quaker Minister William Pollard. "But unless it is organized, processed, and available to the right people in a format for decision making, it is a burden, not a benefit." Over the years, IRRI's Social Sciences Division (SSD) has amassed a vast database of rice facts and figures. However, scattered and isolated, they served no real purpose. Now, SSD is creating a digital knowledge base in which users and researchers can easily find precisely what information is available.

Taking care of business. The SSD knowledge base is a never-ending task of collecting, organizing, and updating information.

The huge amount of invaluable and irreplaceable information in SSD's database is divided into three components: household survey data, world rice statistics (WRS), and geographic information systems (GIS) data. But, in this random assortment of information, far too many worthy data ended up unused and wasted.

The household survey database holds actual farm- and household-level data on rice production collected through personal farmer interviews, farm record keeping, and periodic monitoring of farm activities from various sites in different rice-growing countries of Asia.

However, the SSD survey data sets are all over the place, according to Piedad Moya, senior research manager at IRRI. Each researcher kept his or her own project data set in a format known only to the researcher. No single person kept a tab on all the research results.

No standard system for collecting and organizing the data sets was available. The lack of standard protocol for the repository of data collected by SSD and its collaborators from different national agricultural research and extension systems aggravated the situation.

In 2009, SSD began transforming its database into a comprehensive digital knowledge base—a centralized data warehouse that serves as an authorized single source of all the data sets collected by SSD. Developing a standard format applicable for all completed data sets and ongoing projects was the first step in establishing the master database. Different and often disparate survey data are also being compiled and linked.

To date, SSD has finished work on 20 data sets (or 566,710 records), which were collected from nine countries between 1993 and 2008. These include inputs and outputs of rice production, demographics, income, land profile, water use, and variety planted, among hundreds of variables.

The WRS and GIS data also underwent a major overhaul. The WRS is a compilation of national and regional data on rice area, production, and yield over time for the major rice-producing countries of the world from various international and national statistical sources such as the Food and Agriculture Organization of the United Nations, the United States Department of Agriculture, and the World Bank. It also includes information on rice imports, exports, national farm-level and world rice prices, and other related statistics on rice supply and demand.

Prior to its restructuring, the WRS was not exactly user-friendly and its archive of information was frequently outdated. The data were packaged in static form available only as either spreadsheet or PDF files. The WRS database is now available in digital form and can be easily retrieved by Internet users.

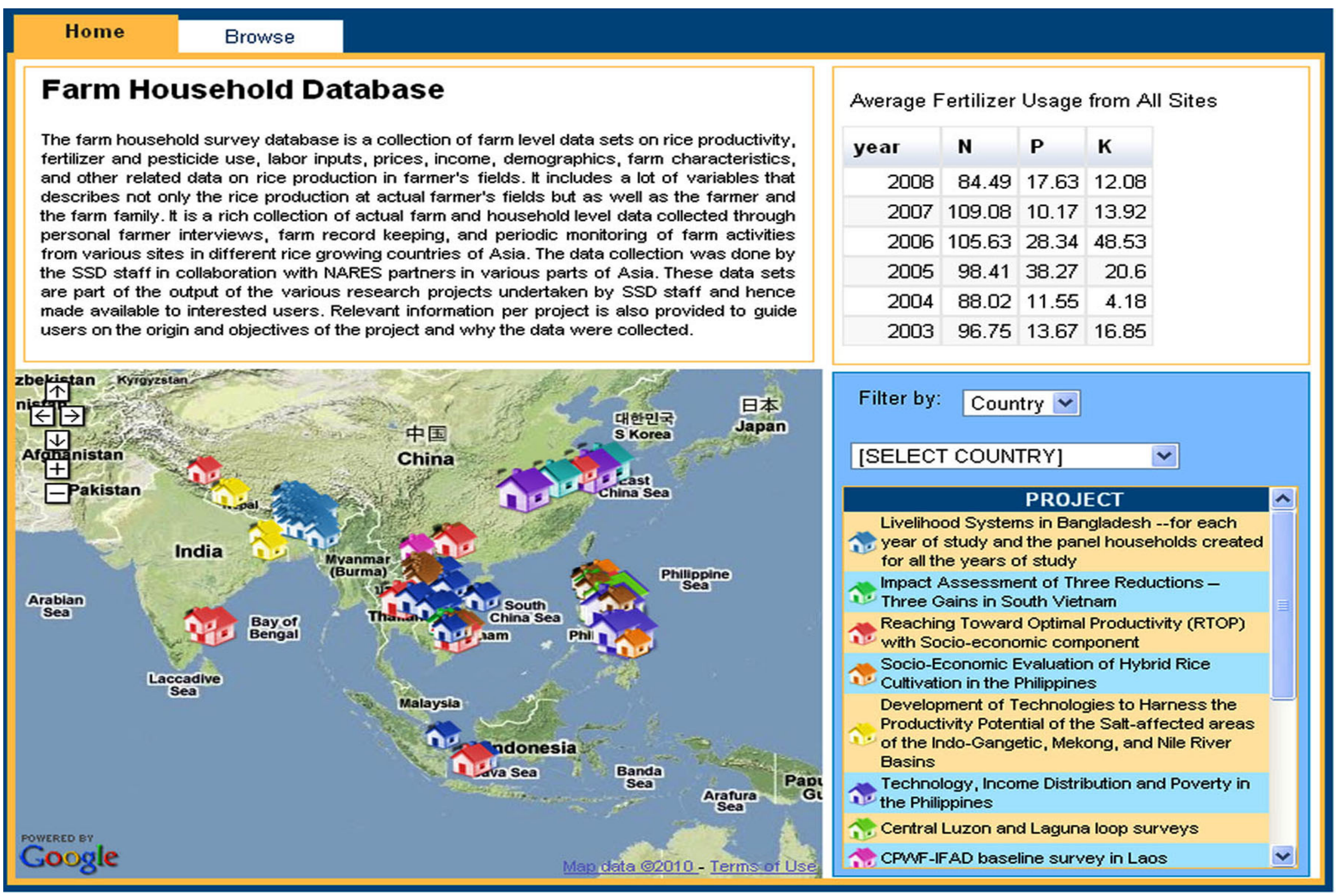
The WRS has a dedicated Web site that features three interactive applications. It gives users the ability not only to query, view, and download data and global rice outlooks, but also to visualize the data in the form of dynamic maps, making this a useful tool for monitoring and forecasting trends in the global rice market. For example, a researcher could map the distribution of rough rice production or arable land over time across countries.

The GIS database consists of a collection of spatial locations, tabular data, and maps and geographic features recorded as points, lines, and polygons on a global, national, and local scale. GIS data are also accessible through their own dynamic Web site that allows users to manipulate and display geographical knowledge in new and exciting ways. The information can be used for reports, posters, and presentation materials.

The new, improved SSD knowledge base is expected to reduce funding and efforts that are wasted when a scientist mistakenly repeats research that someone else has already painstakingly conducted and completed. The knowledge base can also be an effective tool for research and strategic planning. Its contents will be available to IRRI staff while a large portion of it will be accessible to academic institutions, donors, and the public to view and download.

"It will be a gold mine of information on what is actually happening in a farmer's field," Ms. Moya said. "It will be the first comprehensive digital socioeconomic database on farm-level rice production in the rice-growing areas of Asia done by SSD and its collaborators."

Maintaining the SSD knowledge base is a never-ending task. It is a living library that grows with every new fact it acquires. This is the key to keep it from becoming irrelevant, says Samarendu Mohanty, senior economist and head of SSD.



Window to a world of information. SSD has organized its vast database of rice facts and figures from around the globe, making them available to anyone with a computer and an Internet connection.

Financial support from donors

Summary of financial support to IRRI research agenda in 2009 and 2008 (US$000)

	2009	2008
5 Prime	105	484
Aquifer Limited		30
Asian Development Bank	1,614	994
Australia	1,415	1,351
Bill & Melinda Gates Foundation	15,103	5,705
Bangladesh	105	135
Bioversity	68	36
Canada		
Canadian International Development Agency	1,191	1,397
CARE	93	
Centro Internacional de Agricultura Tropical (CIAT)	8	29
Challenge Programs		
Generation	1,397	1,494
HarvestPlus	614	382
Water and Food	245	920
China	1,107	170
Cornell University	114	
European Commission	1,421	1,752
Food and Agriculture Organization of the United Nations (FAO)	40	51
Foundation for Advanced Studies on Agricultural Development (FASID)		22
France	549	353
Germany		
Federal Ministry for Economic Cooperation	853	537
Federal Ministry for Economic Cooperation/ German Agency for Technical Cooperation	419	549
Global Crop Diversity Trust	234	328
Grand Challenges in Global Health through Albert - Ludwigs University of Friedburg	483	483
India	468	594
International Atomic Energy Association (IAEA)	27	17
International Center for Agricultural Research in the Dry Areas (ICARDA)	74	83

	2009	2008
International Crop Research Institute for Semi-Arid Tropics (ICRISAT)	212	
International Fertilizer Industry Association (IFA), International Plant Nutrition Institute (IPNI), International Potash Institute (IPI)	103	121
International Fund for Agricultural Development (IFAD)	952	1,368
International Fund for Agricultural Research (IFAR)	7	11
Iran	92	165
Japan	4,141	4,712
Kellogg Company	20	
Korea	748	825
Malaysia	17	18
Norway	294	382
Nunza BV	13	29
Philippines	159	178
Plan International Cambodia	27	7
Pioneer-Hi Bred International	207	
Portugal	90	58
Rockefeller Foundation	376	116
Sweden	508	516
Switzerland	1,652	1,335
Syngenta	60	
Thailand	40	40
Turkey	20	
United Kingdom	2,143	2,128
United States of America		
United States Agency for International Development (USAID)	5,073	4,867
United States Department of Agriculture (USDA)		101
Vietnam	15	15
World Bank	2,458	1,836
World Vision, Inc.	87	
Others	794	544
TOTAL	**48,055**	**37,268**

For complete information, view IRRI's Audited Financial Statements for 2009 on the attached DVD.

Selected acronyms (in print and DVD versions)

ACIAR Australian Centre for International Agricultural Research
ADB Asian Development Bank
ARI advanced research institute
ASL Analytical Service Laboratories
AWD alternate wetting-and-drying (technology)
BMGF Bill & Melinda Gates Foundation
BMZ The German Federal Ministry for Economic Cooperation and Development
BOT Board of Trustees
BRRI Bangladesh Rice Research Institute
CA conservation agriculture
CAAS Chinese Academy of Agricultural Sciences
CC Creative Commons
CESD Crop and Environmental Sciences Division
CGIAR Consultative Group on International Agricultural Research
CIMMYT Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center) (Mexico)
CORRA Council for Partnerships on Rice Research in Asia
CPS Communication and Publications Services
CLRRI Cuu Long Delta Rice Research Institute
CSIRO Commonwealth Scientific and Industrial Research Organisation
CRIL Crop Research Informatics Laboratory
CSISA Cereal Systems Initiative for South Asia
CURE Consortium for Unfavorable Rice Environments
DDG-OSS Deputy Director General for Operations and Support Services
DDG-R Deputy Director General for Research
DSR direct seeded rice
EBRM ecologically based rodent management
EPMR external program and management review
ES experiment station
ESA East and southern Africa
EVO Events and Visitors' Office
FAO Food and Agriculture Organization
FoSHoL Food Security for Sustainable Household Livelihoods
GAPs good agricultural practices
GCP Generation Challenge Program
GIS geographic information systems
GLP germin-like protein
GQNPC Grain Quality, Nutrition, and Postharvest Center
GR Golden Rice
GRC Genetic Resources Center
GSR Green Super Rice
HRDC Hybrid Rice Research and Development Consortium
IARI Indian Agricultural Research Institute
ICAR Indian Council of Agricultural Research
IFAD International Fund for Agricultural Development
IFPRI International Food Policy Research Institute
IFS IRRI Fund Singapore
ILRI International Livestock Research Institute
IMIS International Maize Information System
INGER International Network for Genetic Evaluation of Rice
IRRC Irrigated Rice Research Consortium
JIRCAS Japan International Research Center for Agricultural Sciences
LDS Library and Documentation Services
MABC marker-assisted backcrossing
META–PHOR Metabolomic Technology Applications for Plants, Health, and Outreach
MOA memoranda of agreement
MOU memoranda of understanding
NARES national agricultural research and extension systems
NGOs nongovernment organizations
NM Nutrient Manager for Rice
NSIC National Seed Industry Council
NUS National University of Singapore
OER Office of External Relations
PBGB Plant Breeding, Genetics, and Biotechnology (Division)
PhilRice Philippine Rice Research Institute
QTLs quantitative trait loci
RD Rice Department (Thailand)
RDA Rural Development Administration (Korea)
RG6 6th International Rice Genetics Symposium
RKB Rice Knowledge Bank
R-M rice-maize system
SDC Swiss Agency for Development and Cooperation
SHU Seed Health Unit
SMTA Standard Material Transfer Agreement
SSD Social Sciences Division
SSNM site-specific nutrient management
STRASA Stress-Tolerant Rice for Poor Farmers in Africa and South Asia
TC Training Center
TPR transplanted rice
TRRC Temperate Rice Research Consortium
TRT The Rice Trader
UPLB University of the Philippines Los Baños