IRRI Annual Report 2011

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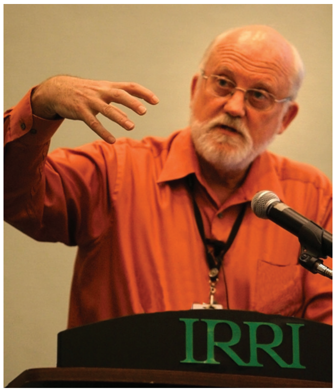


An update from the Director General

What's important—our reputation and our people

Chris Quintana

Reputation and people—these are the two most important basics of any organization such as IRRI. Our reputation integrates our mission, our science, and our impact. Our people make it all happen.

Reputation-wise, IRRI's position as the flagship center of the global agricultural research system is well established. The developed and developing worlds recognize us as a leader in scientific innovation that results directly in measurable impact. For example, the value of our long-term germplasm improvement efforts was validated in 2011 by the Australian Centre for International Agricultural Research (ACIAR) and in a study released in January 2012 by Mywish Maredia of Michigan State University and our own impact assessment specialist David Raitzer.

In its landmark study, ACIAR calculated that the annual benefits to the Philippines, Vietnam, and Indonesia averaged US$1.46 billion per year across the three countries from 1985 to 2009. Indeed, if my math is correct, the annual impact of IRRI's research in these three countries alone exceeds the Institute's total budget since it was founded 52 years ago!

Adding support to the ACIAR report, the Michigan State study showed that around 90% of the total documented benefits of agricultural research over the last 5 decades in Southeast Asia were due to rice research. This means that rice research is a good choice if you want to help people increase the amount of food they produce, which can lead to reduced hunger, better nutrition, higher returns, and better lifetime prospects for farmers, their families, and communities.

These impact studies demonstrate to donors and philanthropists who are investing in rice research that their contributions are making a really big difference where it counts. Hopefully, this will inspire others to also support rice research if they want to improve the lives of people. We always need ongoing investment for ongoing impact.

Our research and resulting impacts continued in 2011. In fact, there was so much exciting progress in global rice research in the past year that we decided to actually produce two reports—this 51st IRRI annual report and, for its successful inaugural year, the 1st annual report of the Global Rice Science Partnership (GRiSP), which highlights the work of this initial research program of the new CGIAR.

In this IRRI report that you are reading, you'll learn among other things about advice from our Grain Quality and Nutrition Center on

Documentation of IRRI's impact:

* Brennan JP, Malabayabas A. 2011. International Rice Research Institute's contribution to rice varietal yield improvement in Southeast Asia. ACIAR Impact Assessment Series Report No. 74. Australian Centre for International Agricultural Research: Canberra. 111 p.
* Maredia MK, Raitzer DA. 2012. Review and analysis of documented patterns of agricultural research impacts in Southeast Asia. Agricultural Systems 106(1):46-58.

choosing the right rice for a healthy diet; our novel experimental platforms for designing future intensive rice-based cropping systems; our efforts to make food production cleaner and greener by finding ways to turn unwanted rice residue into a renewable source of energy; and our "MAGIC" rice populations now in various phases of development. These populations are showing a "magical" wide array of genetic variation for such important traits as good plant type, high yield, and tolerance of both biotic and abiotic stresses. Details of these and other thrilling projects are highlighted in both the following pages of this printed version and the award-winning (most recently, the 2010 annual report) DVD and Web formats that have become acclaimed digital standards over the last 4 years.

Isagani Serrano

The GRiSP report largely chronicles collaborative work with our partners, particularly AfricaRice, CIAT, and JIRCAS. In that report, you'll be brought up to speed on the genes that may beat the "AIDS of rice" in Africa, "Latin" hybrid rice for the tropics (photo above), and networking supported by Japan aimed at "blasting" rice blast from farmers' fields. These and other features showcasing GRiSP's noteworthy achievements can be accessed online at www.grisp.net.

Although all of IRRI's major events and activities in 2011 are covered in detail in the "Milestones" section of the attached DVD and the mirror-Web version, I would like to call special attention to several here.

Keeping in line with the reputation theme, in February, IRRI won the BBVA Foundation Frontiers of Knowledge Award in the Development Cooperation category for our contribution to "reducing poverty and hunger in the world by means of rice research and farmer training," in the words of the awarding jury's citation. IRRI was praised "for the quality of its research work, which has led to the development of new rice varieties adapted to different cropping areas in Asia and providing improved yield and sustainability across multiple climate regimes." We are using the US$550,000 prize money to further support our rice research and training work.

Bill and Melinda Gates are aware of our reputation as well. In March, while visiting the Indian sites of STRASA (Stress-Tolerant Rice for Africa and South Asia) and CSISA (Cereal Systems Initiative for South Asia), they both showed keen interest in IRRI's flood-tolerant rice, anaerobic germination, and the quantity of seeds being distributed to farmers through minikits. They were also interested in the views of women farmers (photo below) on the availability, planting, fertilizer needs, and eating quality of the flood-tolerant rice variety Swarna-Sub1. The couple expressed their appreciation of the efforts of STRASA and CSISA to make new varieties and sustainable technologies available to farmers in the region and for the opportunity to interact with the scientists, partners, and especially the farmers.

In June, agriculture ministers who met in the lead-up to the G20 Summit in Paris later in October declared their support for rice research and the need for better trading environments for rice and other commodities. The Ministerial Declaration: *Action plan on food price volatility and agriculture* stated: "We recognize the importance of rice for food security, as the main crop consumed in Asia and increasingly in Africa. We

BMGF

stress the importance of strengthening rice research and development and the dissemination of its outcome and relevant cultivation technique to accelerate production and productivity growth in rice-producing countries, particularly in Asia and Africa, through among others IRRI, GRiSP, CGIAR, and the Coalition for African Rice Development (CARD)." I am very pleased to see that rice was given prominence—I believe in no small part due to IRRI's reputation.

And then, during the 33rd meeting of the ASEAN Ministers of Agriculture and Forestry in Jakarta in October, the ministers, representing the 10 member countries, officially endorsed GRiSP. They see it representing an important expansion and development of 2008's ASEAN Action Plan, as well as contributing to the proposal on pilot testing of the ASEAN Rice Trade Forum to be implemented under the ADB Technical Assistance on Food Security.

Of course, an institution's reputation can be enhanced best by the people who do the work. 2011 was a banner year for both our national (NRS) and international (IRS) staff members, who garnered numerous high honors and recognition. From the 2011 Norman Borlaug Award to the Glory of India Award, you can read about them all in the Milestones and Honors and Awards sections of the enclosed DVD.

In a bitter-sweet state of affairs, I can't remember a year when we lost so many "pioneer" international staff due to either retirement or beckoning new adventures elsewhere. These were David Mackill, IRRI principal scientist and long-time rice breeder at the Institute over two periods (1982-91 and 2001-11); Darshan Brar, long-time IRRI plant breeder and most recently PBGB head (1987-2011); To Phuc Tuong, principal scientist and water management engineer, CESD (1991-2011); Sushil Pandey, senior agricultural economist, SSD (1993-2011); William Padolina, deputy director general for operations (1999-2011); M.A. Hamid Miah, IRRI liaison scientist for Bangladesh; Richard Bruskiewich, senior scientist, GRC; and Melissa Fitzgerald, senior scientist and head, GQNC.

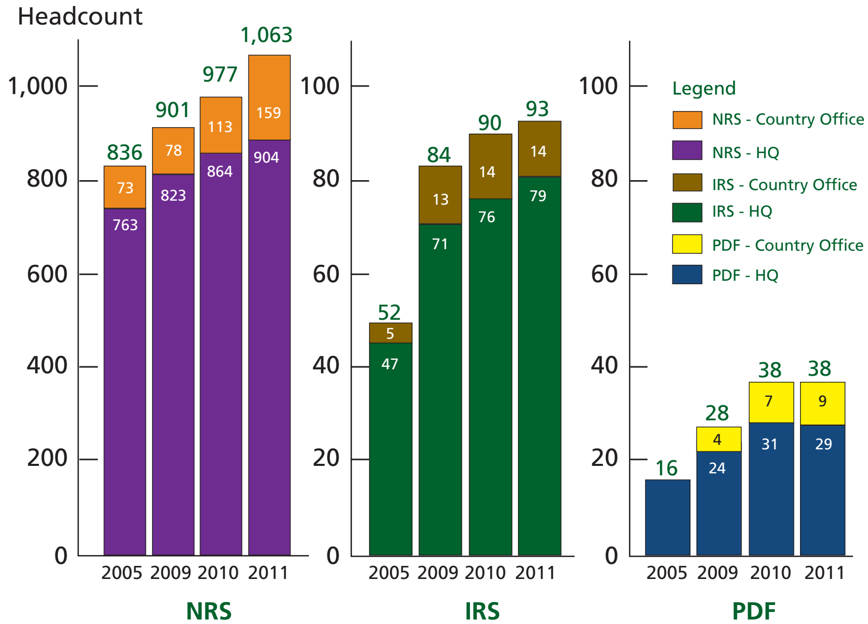
But, even with what some might call an alarming rate of attrition, do I worry? Well, not too much, because I see knowledgeable and enthusiastic young scientific and support staff coming in to take up the slack—lured, for sure, to the Institute by our long-standing reputation and our well-planned portfolio of research activities, projected to be supported by GRiSP and other funding of nearly $94 million in 2012. I can say without exception that each of these—even those who left IRRI for "retirement"—remain deeply engaged in our research programs. Those who have had the good fortune to work with IRRI for any length of time know that they never really ever leave the Institute. They are just paid by someone else!

In 2011, we hired more than 15 new people every month or, in other words, a new staff member every three-quarters of a working day. In December, we were still actively recruiting to fill 69 vacancies across the Institute. As the graphic shows, we have continued to grow since 2009 across all classifications of staff, reaching 1,194 employees at year's end. If we add project scientists, visiting research fellows, collaborative research scientists, short-term consultants and emergency hires, seasonal farm laborers, and the like, the complete num-

Chris Quintana

IRRI continued to grow in 2011

A total of 1,194 IRRI employees



ber of employees is actually pushing 2,000.

Every year in recent times, as part of our holiday celebration in December, we assemble the staff for a family portrait. Although we've published the annual photo in past annual reports, I can't resist doing it again this year to merely cement the fact of what a unique research community we are.

When we put the photo (below) on IRRI's Facebook page, Hubert Zandstra, IRRI agronomist (1975-80) and our deputy director general for research (1989-91), posted from afar: "What a wonderful scope of dedicated persons!" I couldn't have said it better!

Robert S. Zeigler
Director General

A healthy serving of rice

Rice has received a bad rap for its high glycemic index (GI). Foods with a high GI have been associated with increased risk of type-2 diabetes because they are rapidly digested and can cause marked fluctuations in blood sugar levels. In 2011, IRRI research revealed that the GI of rice actually varied widely depending on the type of rice. In fact, on average, rice has a medium GI. This is good news for consumers with health problems who can now choose the right rice that can be safely incorporated into their regular diet.

For people in Asia, rice is a staple food. Its consumption is gaining popularity in the rest of the world as well. But, is rice a healthy dietary choice?

Since carbohydrate-containing foods do not act the same when consumed, they are assigned a GI number based on their effect on blood sugar (glucose) levels. Using glucose as the standard reference (GI 100), foods can be classified as low GI (55 or less), medium GI (56–69), or high GI (70 and above). Low-GI foods are digested and absorbed by the body more slowly and produce gradual increases in blood sugar and insulin levels after meals. High-GI foods are associated with dramatic increases and drops in blood sugar levels believed to be damaging to arteries and various blood vessels while triggering far too much production of insulin. These are linked to higher risks of developing type-2 diabetes.

Unhealthy but undeserved reputation

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

In 2011, Dr. Fitzgerald's IRRI team and her colleagues at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia published a research paper

Chris Quintana

revealing the GI of 235 varieties of rice, including 143 traditional varieties and 92 modern varieties. The varieties came from a number of different rice-growing countries from around the world to get a representative sample of the complete diversity of the GI of rice.

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

The amylose factor

The IRRI research team also found that amylose (a type of starch in rice) affects the GI of rice. As the amylose content increased, the GI decreased, and vice versa. Therefore, rice varieties with high amylose content such as Swarna, India's most widely grown rice, have a low GI. In contrast, sticky or glutinous rice, which has low amylose content, has a higher GI. The popular Basmati rice falls in the middle with a medium amylose content and medium GI.

Rice and diabetes

The finding that different types of rice have different GI values allows consumers to make informed choices about the variety of rice they want to eat. Diabetics or those at risk of diabetes who are trying to control their condition through meal planning do not have to exclude all rice.

Moreover, Dr. Fitzgerald has since collaborated with a medical team in the Philippines to test people's blood sugar levels after eating different rice with different GIs. As results of these trials take shape, IRRI and its partners could establish important clinical evidence in favor of keeping the glycemic load in check, particularly for rice consumers.

Isagani Serrano

Debunking a health myth. That all types of rice are classified as high-GI carbs and bad for diabetics is ill informed according to Dr. Fitzgerald. The actual GI of different varieties of rice ranged from a low of 48 to a high of 92, with an average medium GI of 64.

More information:

Fitzgerald MA, Rahman S, Resurreccion AP, Conception J, Daygon VD, Dipti SS, Kabir KA, Klingner B, Morell MK, Bird AR. 2011. Identification of a major genetic determinant of glycaemic index in rice. Rice 4(2): 66-74.

Running on rice residue

In Asia, more than 700 million tons of rice straw and husks produced annually from rice farms end up as waste. Since farmers have shifted largely to mineral fertilizers, crop residues are often just burned, producing large quantities of the greenhouse gas methane. As part of its efforts to make food production cleaner and greener, IRRI is finding ways to turn what is unwanted into a renewable source of energy.

Angelo Arboleda and Haeckel Navarro

In traditional production systems, rice residues were used as fertilizers, fodder, and building material. However, in the 1970s, when mineral fertilizers were introduced on a large scale, their use declined. Rice straw and husks became waste by-products of food production and are now often considered a problem.

This is particularly true nowadays where farmers typically grow 2–3 crops a year, doubling or tripling the amount of rice "waste" produced. Since farmers don't have enough turnaround time before beginning the next planting season, they resort to the quickest and easiest solution to get rid of the residue—burning. This releases methane, a greenhouse gas that remains in the atmosphere for 9–15 years and contributes to global warming. On top of this, exposure to smoke and soot causes respiratory problems among farmers and townspeople alike.

Therefore, the benefits of using these waste materials through different means are significant and obvious.

Waste not, want not

IRRI scientist Stephan Haefele and his team have been exploring ways to turn rice residue into useful and valuable by-products to support more efficient, productive, profitable, and sustainable rice farms.

"Rice straw and husks offer an immense potential to create bioenergy, an alternative renewable source of power," said Dr. Haefele. "Bioenergy from rice residues can be produced and at the same time reduce the negative effects of rice production systems on the environment. It could also be a source of extra income for farmers."

Moreover, rice residues and production systems have several decisive advantages over many other bioenergy crops, he explained. Unlike crops grown exclusively for biofuels, using rice residues to generate energy would not divert land use away from food production. It has also been shown that, even if all rice residues are removed, the quality of rice soils is unaffected. Residue removal for energy production directly reduces the emissions of greenhouse gases caused by field burning or by residue incorporation into the soil. Also, the high cropping intensity in irrigated rice systems ensures a constant residue supply and keeps transportation time to processing centers short.

Backyard fuel

In 2011, Dr. Haefele and his collaborators conducted an energy and carbon life-cycle analysis of existing gasifiers that turn rice residues, without burning them, into gases that can be used as an energy source. Such gasifiers are increasingly common in Cambodia, where rice millers want to make use of the husks that pile up in their backyards.

Each ton of husk gasified can save about 1 ton of greenhouse gas emissions (CO_2) compared to current uses. The energy needed to build and operate a gasifier was produced by the gasifier within 245 days of operation. And, it took only 109 days of gasifier operation to save as much carbon as was emitted to build and establish it. Looking at the rice production system, a 1-hectare irrigated rice field can produce 12 tons of husk and straw per year, which can be converted to clean energy in a medium-sized gasifier equivalent to about 1,800 liters of diesel.

See related video on YouTube at http://youtu.be/FvnEbrJWM0w

More power to farmers

"These results show the potential of residues as an energy source, and as an option to make rice cultivation even more sustainable," said Dr. Haefele. "We now intend to investigate rice straw. Quite a lot of research has been done on rice husks but little is known about the use of rice straw. We will try to answer how best to collect straw, how to store it, and whether pretreatments, such as leaching, drying, and/or briquetting, are necessary.

"For the most promising systems, we plan to conduct a life-cycle analysis and to develop complete business models," he added. "We are also testing what effects biochar—a by-product from straw and husk burning—has on soil quality in various rice-production systems, and determine its optimal uses and look at how to participate in emerging carbon markets."

RICE = mc². As long as farmers grow rice, there will be rice residues that could be converted into cheap, renewable bioenergy.

Stephan Haefele (2)

Green power source. A gasifier system not only uses renewable energy from bio-waste products but also doubles as a waste disposal system.

Nurturing Nepal's jagged

The rough, formidable terrain of Nepal has hindered the introduction of modern agricultural technology, particularly in rice production, resulting in minimal gains for subsistence farmers. IRRI and its partners are helping improve the productivity of these fragmented plots through better rice varieties and nutrient management practices.

Rice, the most important crop in Nepal, contributes approximately one-fourth of gross domestic product and almost half of the calorie requirements of its people, according to the Nepal Agricultural Research Council. Rice is cultivated on 1.56 million hectares in Nepal and over 70% is grown in the foothills and in the Terai region. More than 75% percent of its working population is engaged in rice farming for at least 6 months of the year. Thus, the development of its rice sector is key to Nepal's fight against hunger and poverty.

A challenging land to till

"But only two-thirds of the nation's entire irrigation network is fully operational during the monsoon season and only a little more than one-fifth of the land is irrigated year-round," said Dr. Stephan Haefele, a scientist at IRRI. This makes farmers in rainfed areas, around 79% of the total rice area in Nepal, highly vulnerable to drought."

The lack of assured irrigation facilities is the most important problem for rice production, according to a study conducted by IRRI scholar Bishnu Bilas Adhikari[1] on crop management practices for rice in the hilly Lamjung and Tanahu districts of the Western Development Region of Nepal in 2011. In these districts, only about 59% of the farmers are self-sufficient in rice for the whole year. Of the 41% food-insufficient farmers, about 36% were able to produce enough rice for more than 10 months, and the remaining 5% produced rice for only 6 months.

When drought affected Nepal in 2009, Mr. Adhikari also investigated management options that could help farmers minimize the negative effect of drought on yield and reduce the so-called "yield gap" in nondrought years.

Management treatments such as a lower seedling density and older seedling age gave comparatively higher yields, and these effects were even more pronounced during the dry season of 2009.

Joe Ibabao (4)

Tradition and innovation. Farmers in the hills of Nepal need new technologies to increase the productivity of the traditional farming systems that maintain diversity and ensure sustainability of rice farming.

Seeds of life

Although rice is a staple food, the supply of good seeds in Nepal is limited. "The availability of good-quality seeds means food security," said David Johnson, IRRI scientist and coordinator of the Consortium for Unfavorable Rice Environments (CURE). "No seeds, no harvest. This is especially true for communities affected by calamities."

In 2010, under the auspices of CURE, partners from a previous re-

[1]IRRI scholar at Sam Higginbottom Institute of Agriculture, Technology, and Sciences, Allahabad, India.

search project on food security in marginal uplands formed seed producers' groups in seven villages in Lamjung, Tanahun, and Gorkha districts. Since the formation of the seed producers' groups, the production of high-quality seeds has grown exponentially from just over 20 tons of lowland rice and 2.1 tons of upland rice in 2009 to 155 tons of lowland rice and 14 tons of upland rice in 2010. Total estimated seed production for 2011 is 320 tons of lowland rice seeds and 51 tons of upland rice seeds. If the estimated yields are correct, the production of lowland rice seeds doubled and upland rice seeds more than tripled since 2010.

The seed producers' groups have also been a means for CURE to introduce new varieties to the communities. Participatory varietal selection approaches showcased the performance of new varieties and revealed what farmers prefer in a variety.

Initially, farmers could not believe that new varieties could improve their low production as they had mostly been producing low-yielding traditional varieties. Now, these farmers can eat rice year-round. In these villages, more and more farmers see the fruits of their labor as they participate in seed production of upland rice and other crops. "Seed exchanges and information sharing among farmers have improved," said Dr. Digna Manzanilla, social scientist at IRRI. "Women are more active now than before in farming."

CURE aims to expand the coverage of seed producers' groups by targeting new locations in Nepal. "We are working toward giving millions of farmers in Nepal and in many Asian countries access to new varieties and technologies," Dr. Johnson said. "And a community-based seed system that provides a mechanism to link 'stress-tolerant seeds' to 'food on the table.'"

Drought-proofing rice production

In 2011, three drought-tolerant rice varieties bred by IRRI in partnership with the Nepal Agricultural Research Council were released—Sookha Dhan-1, Sookha Dhan-2, and Sookha Dhan-3 (named after the Nepalese word for drought, sukha). They have shown a yield advantage of 0.8–1.0 ton per hectare over current varieties under severe drought.

"These new varieties have consistently shown superior performance in farmers' fields under severe drought conditions," said Dr. Arvind Kumar, IRRI plant breeder who helped develop the varieties. "They are likely to have a great impact in enhancing and stabilizing rice productivity in Nepal's rainfed areas."

While Nepal's government is working toward a 10-year strategy of revamping irrigation, these drought-proof varieties provide a solution for its rainfed agriculture.

Bishnu Adhikari

New rice for ancient land. Sookha Dhan-1, Sookha Dhan-2, and Sookha Dhan-3, three new IRRI-bred rice varieties, show superior performance even under severe drought conditions and could help stabilize rice productivity in Nepal's rainfed areas.

Managing the earth's fertility

Another factor that contributes to the sluggish growth of Nepal's agricultural sector is low input use. Most farmers use farmyard manure although they are gradually supplementing it with mineral fertilizers. However, the majority of farmers cannot afford to buy mineral fertilizers.

Another IRRI scholar, Birendra Kumar Bhattachan,[2] is developing recommendations to deal with problems related to soil fertility. "Farmers use very low amounts of mineral fertilizers in Lamjung," he said. "They are not earning enough to buy much fertilizer, but we can still increase rice production per unit area in mid-Hill as well as in inner Terai and Terai regions through proper nutrient management and the use of appropriate rice varieties."

Farmers have a considerable indigenous knowledge of the characteristics of their complex production environment, and of how best to use rainfed lowland rice varieties and manure in this environment, according to Mr. Bhattachan. Building on farmers' practices and incorporating local knowledge is particularly important in this complex and highly diverse environment.

Mr. Bhattachan found that farmers use different fertilizer strategies depending on the situation of the field, be it situated on lower or upper terraces, or close to or far from their house. "Field classifications need to be considered when making site-specific fertilizer recommendations," he explained.

High organic fertilizer rates seem most important for upper terrace fields, and high mineral fertilizer rates should be avoided in these fields because the response to them is small, Mr. Bhattachan indicated. Meanwhile, the use of mineral fertilizer seemed to be most profitable in fields near the house and reasonably good on lower terraces and in fields far from the house. Because the fields in the mid-Hills and the inner Terai that are closer to the house are most fertile, they are best suited for growing hybrid rice varieties, which some farmers did.

"We have to conduct more research on nutrient management for rainfed lowland rice in Nepal, also in combination with different rice varieties," said Mr. Bhattachan. "But our new results are very interesting and will already help to better understand farmers' practices and how to help them improve their rice production."

Stretching field fertility. The majority of Nepalese farmers cannot afford costly mineral fertilizers but proper nutrient management and the use of appropriate rice varieties can still increase rice production per unit area in mid-Hill as well as in inner Terai and Terai regions.

Nutrient cycle. Livestock and crops are closely integrated in Nepal. Farmers feed weeds growing among the crops as well as crop by-products to their livestock. In turn, animal manures are used to fertilize the soil.

[2]IRRI scholar at the Institute of Graduate Studies, Central Luzon State University, the Philippines.

See related video on YouTube at http://youtu.be/Kxc_O4WIYYg

The green menace

Problems are like weeds, according to an ancient proverb: the more you ignore them, the faster they grow. And, when the problem is weeds, it's not only extremely frustrating: weeds pose a serious threat to rice cultivation and can cause up to 100% yield reduction. In 2011, IRRI advanced its work in Sri Lanka to help rice farmers tackle the green menace.

Farmers who transplant seedlings in puddled systems find it easier to control weeds as the standing water suppresses the growth of weeds in fields. But, as more farmers convert to dry direct-seeded systems because of increasing irrigation and labor costs for transplanting, and sometimes declining water supplies, weeds are becoming more difficult to control.

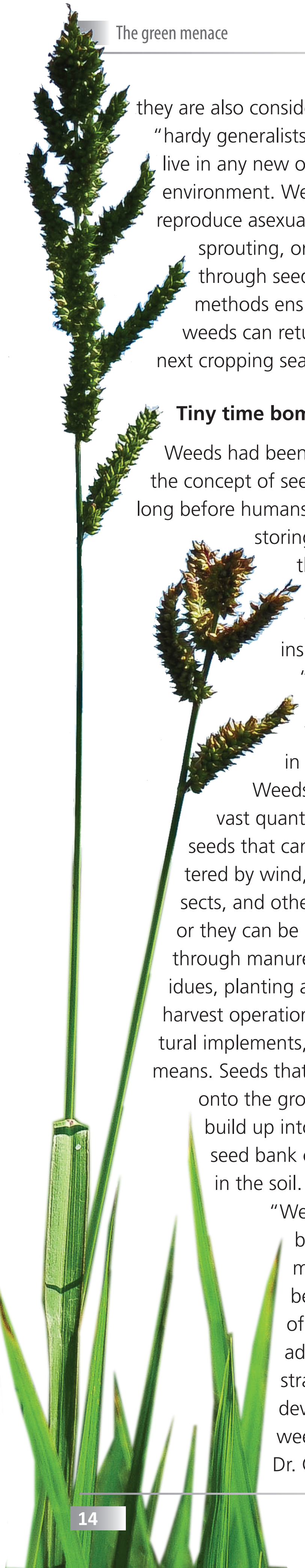
In Sri Lanka, for example, different hard-to-manage weeds, such as weedy rice, have infested rice fields in recent years as more farmers shifted from rice transplanting to direct seeding. High infestation of weedy rice, believed to be a natural hybrid of cultivated rice (*Oryza sativa*) and its wild cousins (*O. rufipogon* and *O. nivara*), or the product of the degeneration of cultivated rice, can cause as much as a 100% yield loss. This troublesome weed is also wreaking havoc in Malaysia, Vietnam, Thailand, and the Philippines. And, weedy rice is not the only persistent weed type in rice fields. At least 20 other species can cause major problems in rice production.

Built to survive

"A weed is simply any plant that grows out of place," says IRRI weed expert Bhagirath Chauhan. "But, sometimes they can grow so aggressively as to invade new areas and even displace existing crops."

Weeds seem to have evolved to become a natural competitor and survivor. They are usually fast-growing compared with major crops such as rice, and

Angelo Arboleda (3)



they are also considered to be "hardy generalists" that can live in any new or harsh environment. Weeds can reproduce asexually by re-sprouting, or sexually through seeds. Both methods ensure that weeds can return in the next cropping season.

Tiny time bombs

Weeds had been practicing the concept of seed banking long before humans started storing seeds of the world's important crops inside the "Doomsday Seed Vault" in Norway. Weeds produce vast quantities of seeds that can be scattered by wind, water, insects, and other animals, or they can be spread through manure, crop residues, planting activities, harvest operations, agricultural implements, and other means. Seeds that are shed onto the ground later build up into a weed seed bank concealed in the soil.

"Weed seed banks may have been one of the best adaptation strategies developed by weeds," says Dr. Chauhan. "For example, rice flatsedge (*Cyperus iria* L.) can produce as many as 5,000 seeds per growing season. They will remain ungerminated in the ground until field conditions become favorable for their germination—ticking time bombs just waiting to explode and take over."

The weed seed banks can be either transient (viable for about a year) or persistent (viable for more than one year), Dr. Chauhan notes.

An arsenal of weed weaponry

Getting to the root of any weed problem requires a holistic set of options and management strategies so that weeds can be effectively diminished in number or controlled over time. No single management technique can effectively control the situation.

In 2011, Dr. Chauhan brought with him two mechanical seeders to Sri Lanka, and conducted a seminar on mechanization with farmers from one district.

"The chief engineer from Kandy District told me that although rice harvesting in Sri Lanka was already quite mechanized, seeding, on the other hand, was not, and that it was the first time mechanical seeders were brought to Sri Lanka," he shares.

The mechanical seeders not only reduce the drudgery and labor of growing rice. They also make planting rice in rows faster and easier. When rice plants are grown in rows, farmers can quickly spot weeds, especially those that closely resemble rice, so they can be pulled out even before they begin to set seed or start a weed seed bank. In Ampara District, which has the highest rice productivity in the country, farmers showed great interest in the machines during Dr. Chauhan's demonstration.

Space invaders. *Echinochloa* species (*far left*) and *E. crus-galli* (*above*) are aggressive competitors of rice that thrive even under poor conditions. In badly managed fields, these weeds cause substantial yield reductions because of severe infestations and rapid growth.

During the same year, farmer field trials also started in several areas of the country to study the effect of different crop establishment methods on weedy rice. Visually, results showed fewer cases of weedy rice where wet seeding was done with a drum seeder compared with broadcasting seeds.

Where water is available, flooding at the appropriate time and depth is still a surefire way of weed control. Additionally, regular mechanical weeding can be done to control or remove weeds. Using crop residues such as rice straw as mulch can also help prevent incessant sprouting of weed seeds in fields. Using weed-competitive varieties, narrow crop spacing, and a uniform plant population can also help reduce competition from weeds.

In another report, the stale seedbed technique—in which weed seeds are allowed to grow before rice seeds are sown in fields and are then killed by herbicides—can reportedly cut weed populations significantly. However, if herbicides are to be part of a long-term weed management strategy in direct-seeded rice, they should be used strategically in rotation and in combination with other management practices to ensure their sustainability.

See related video on YouTube at http://youtu.be/j_paiS_0vcI

Rewriting rice's future

Modern agriculture is part solution and part problem. The surge in rice productivity resulting from the Green Revolution averted widespread famines and kept food prices stable. But, it has also led to unintended consequences: declining natural resources and environmental pollution. IRRI is currently using novel experimental research platforms to achieve a crucial balance between profitability and productivity while making rice production sustainable and eco-friendly.

Farmers are having a tough time. In their quest to produce rice, they are forced to make decisions that can be good in one place and bad in another. In the event of a water shortage in irrigated rice fields, for example, farmers may opt to continue using traditional practices of maintaining standing water on the rice field with no change in the amount of water. But, to ensure that all get their fair share of this scarce resource, they would have to reduce their production area.

Using water-saving practices such as alternate wetting and drying or shifting from continuously flooded to growing rice on nonflooded soils like maize or sorghum (aerobic rice) that provides for the effective use of rain that falls on farmers' fields is yet another choice. But, growing rice with less water brings about new problems, such as nematodes and weeds, which could cause serious crop losses.

Coping with complexity

"Rice production systems are complex," says Dr. Achim Dobermann, IRRI's deputy director general for research. "Experts at IRRI are investigating the impact and consequences of conserving water and other resources that are becoming increasingly scarce, managing different nutrients, selecting appropriate varieties, protecting crops, and attempting to solve other problems that farmers face on a daily basis."

IRRI launched three experimental platforms to get a full grasp on rice production ecosystem functions under different crop management options. Once a better understanding of the whole rice system dynamics—how factors such as water, climate, soil, and crop management affect one another and the impacts that could come about from specific scenarios—is in place, it becomes easier to make informed decisions on making rice

James Quilty (2)

systems more productive, profitable, and sustainable.

An exquisite balancing act

"Through this science-based understanding, we aim to help farmers and policymakers formulate better ways to optimize the use of resources in a rice system, and achieve high yields with acceptable risks in an eco-friendly fashion," says IRRI nutrient management expert Roland Buresh and leader of the research platform on "Ecological intensification and sustainability in intensive rice-based cropping systems."

"In this work, we are focusing on increasing the use efficiency of rice production inputs—water, soil nutrients, and others—since we know that there might not be enough resources in the future," Dr. Buresh adds. "We intend to provide strategies for integrating advanced rice varieties with crop and resource management technologies, which can help secure food production at high economic and environmental standards."

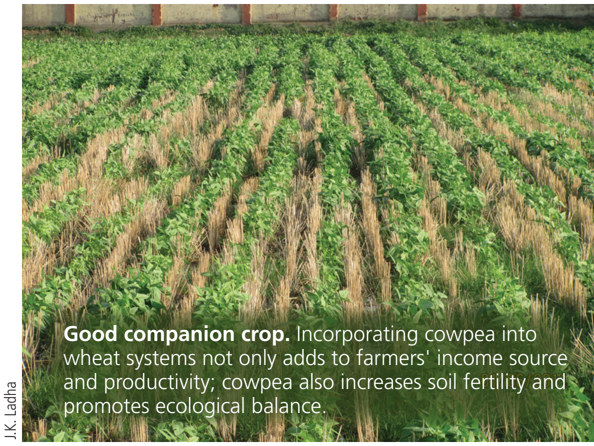
Some of the performance indicators and target values to be worked into these futuristic rice production models are stable yields within 70–80% of the potential yield, high nitrogen fertilizer-use efficiency, high water-use efficiency, minimal use of pesticides, improved or maintained soil quality, and greater adaptation to fluctuations in climate.

Invisible impact

Any rice production system has inherent or unintentional negative consequences such as the release of greenhouse gases that contribute to climate change. Two greenhouse gases can be released from rice production systems. Methane is produced under flooded conditions; nitrous oxide is emitted mostly under nonflooded conditions.

The Impact on Carbon, Nitrogen, and Water Budgets (ICON) project, another experimental platform, focuses on climate change mitigation through management systems and policies that reduce greenhouse gas emissions from rice production systems. This project is part of the CGIAR Research Program on Climate Change, Agriculture, and Food Security.

"Many people are not aware of the number of other potential risks of switching from flooded to nonflooded rice such as land degradation, soil erosion, or groundwater pollution," says IRRI climate change expert Reiner Wassmann. "To better understand these impacts, we are looking into the hydrology of a rice system, its biogeochemical cycles, soil fluxes (i.e., activities of microorganisms), and even biodiversity, which is vitally important to maintaining stable ecosystem services."



J.K. Ladha

Good companion crop. Incorporating cowpea into wheat systems not only adds to farmers' income source and productivity; cowpea also increases soil fertility and promotes ecological balance.

In the ICON project, IRRI is looking at shifting from a flooded to a nonflooded system and conducting comparative assessments of the effects that could come about from a shift in these two cropping approaches (flooded rice alone vis-à-vis intercropped with anaerobic rice or maize), and how the potential losses or risks can be mitigated.

"Clearly, the flooded rice system has advantages and disadvantages," says Dr. Wassmann. "The question is, 'How do you keep flooding in a system without getting all the negative impacts or consequences?' We believe that there are no 'black and white' or 'yes and no' solutions but the ICON project will help us understand the impacts better for more informed decisions."

Angelo Arboleda

Measuring the invisible. Rice cultivation is one of the primary sources of methane emissions. Scientists use the chambers (*above*) and the Eddy Covariance (*see opposite page*) to determine the greenhouse gas emissions of different rice production systems.

Greener fields in South Asia

Cereal production systems serve as South Asia's most important grain baskets and primary source of food for many resource-poor families in the region.

"These cereal production systems are showing signs of yield stagnation or decline over the years," explains IRRI expert Jagdish K. Ladha, who leads the research platform within the Cereal Systems Initiative for South Asia (CSISA). "The situation calls for the role that ecological intensification could play alongside conservation agriculture that started from rice-wheat research in 1994, but is now broadened to a range of crop rotations in CSISA."

Results from simulated scenarios will be tested against developed standards for crop and soil health; nutrient, water, and energy balance; economics; and others. The results can also be used to validate models that evaluate a range of cropping systems and management combinations against production, environmental, and economic indicators. Analyzing these scenarios may also help guide plant breeding and resource conservation efforts toward problems that South Asia is facing, or in targeted contexts of agricultural change.

"We are glad to be taking the first step in resource conservation in South Asia, and the search for smarter cropping technologies and more climate-resilient systems, including management practices that can adapt to changing situations and times," says Dr. Ladha.

"Enduring changes may not happen instantly across all cereal production systems in South Asia in the coming few years, but we believe that investing in solutions to these problems now will be tremendously worthwhile in the future," he concludes.

See related video on YouTube at http://youtu.be/omf04VzJAlk

Jump-starting Africa' stalled farm machine

A lack of mechanization has seriously limited the productivity and competitiveness of rice-based systems in sub-Saharan Africa. At present, more than 99% of all tasks on rice farms in this region are undertaken using human or animal power. Workforce shortages at critical times have meant that crops are rarely planted on time. Postharvest losses are far too high and grain quality is often compromised during storage, handling, and processing.

However, all the countries of this region have large graveyards of old rusting farm equipment, purchased or imported with the best of intentions, but now a legacy of "inappropriate mechanization."

From mechanization to stagnation

"The reasons for equipment failure are many but the basis of the problem is the same," says Joseph Rickman, IRRI scientist and regional coordinator for East and Southern Africa. "Too great an emphasis was placed on importing a machine to do a specific task rather than understanding the machine's total capability, the local political and business environment, and the farming system in which the machine was to operate."

Governments and other agencies often subsidized the purchase of equipment or distributed it free to communities with little follow-up support. Farmers, skilled in working with animals or using a hoe, but with no previous mechanical experience, were asked to operate machines. "They were given very limited or no training, had little product backup or support, and often worked in tough isolated environments where spare parts and basic maintenance inputs were not available," Mr. Rickman explains.

In 2011, IRRI, AfricaRice, Japan International Cooperation Agency (JICA), and the Coalition for AfricaRice Development (CARD) combined their efforts to develop a road map and action plans to boost mechanization in rice-based systems in sub-Saharan Africa to help countries tackle many of these needs.

A team approach to sustainable mechanization

Experience from Asia and some parts of Africa has shown that farm equipment can be introduced in a sustainable way, based on sound business principles and planning. "Many different players need to be involved, each contributing where they have a comparative advantage," Mr. Rickman says. "Governments, training institutes, international organizations, NGOs, financial institutes, and the private sector all have a role to play."

The government's primary role is in the importation and testing of new equipment, as well as developing taxation and importation policies that are supportive to equipment importers, dealerships, and local manufacturers who also need to import raw materials and components. Vocational training institutes need support to develop curriculum and provide training for operators, mechanics, and artisans both technically and in basic business planning. Extension officers and NGOs need training to support and extend mechanized agriculture. Credit institutes need encouragement to structure loans to suit farmers and contract service suppliers.

"Most importantly, champions of rice mechanization need to be found, linked to all of the players and supported by the government, to drive the process," Mr. Rickman says. "These champions can come from any one of the different groups."

Making mechanization work

IRRI, JICA, and AfricaRice in association with national governments have imported many different types of equipment for testing in a wide range of environments.

"Two-wheel tractors fitted with trailers and pumps, mechanical and pedal threshers, mechanical weeders, laser-controlled leveling systems, and bund builders are all being tested and, in some instances, now manufactured in sub-Saharan Africa," Mr. Rickman says.

Through CARD, JICA, and IRRI, governments in sub-Saharan Africa are being helped to develop policies that will support importers and local manufacturers. South-South collaboration between Africa and Asia is also being supported so that African countries can gain exposure to other rice-growing countries where small-scale mechanization is now seen as normal. Networks are also being developed among policymakers, manufacturers, dealerships, and end users from sub-Saharan Africa and other parts of the world, especially with Asia.

"Sustainable mechanization needs all of the players in a country involved and committed," Mr. Rickman says. "IRRI, JICA, CARD, and AfricaRice are well placed to encourage and also help drive the process so that the history associated with 'machinery graveyards' does not repeat itself."

See related video on YouTube at http://youtu.be/hdQgDT6LRz4

Joseph Rickman

Agricultural mechanization has been responsible for massively increasing rice production, productivity, and profitability. It is also an important factor that improves the lives of small farmers. However, previous attempts at introducing machines to African farmers were not always successful. In 2011, IRRI and its partners were turning to holistic programs that ensure sustainable, affordable mechanization suitable to the scale of operations and skills of the small-scale farmers of Africa.

Putting the social into science

Uncovering an emerging power. Data collected over the years reveal an emerging trend: how training, exposure, and education have helped empower women in the rural households of Bangladesh.

Hummath Bhandari (3)

IRRI's "social science databank" paints a clear picture of how the growing adoption of modern rice production technology is changing socioeconomic and livelihood conditions—including the growing role of women—across Bangladesh. Containing household studies collected over the past 25 years, it provides researchers with a glimpse into the kind of societies being created by agricultural modernization.

New social models have always emerged as a result of economic and technological changes. Good or bad, the advent of the Industrial Revolution, for instance, dramatically changed social setups at the turn of the 20th century. Industrialization led to urban development and created new social concerns, interests, and values.

Is the agricultural revolution having the same impact on societies? What new social organizations are being created? Is there potential backlash? What is the price that societies and individuals must pay for breaking age-old traditions in order to increase farming efficiency? An understanding of and accurate insights into present living conditions, socioeconomic trends, and people's behavior are important to determine the cumulative impact of improved farming technologies and practices.

Social science databank

To provide an efficient way to understand farming systems in rural areas and identify the socioeconomic constraints faced by farming communities in Bangladesh, IRRI and the International Crop Research Institute for the Semi-Arid Tropics launched Village Dynamics in South Asia (VDSA), a five-year collaborative project, in 2009. VDSA collects high-frequency data (information collected more frequently) on farming systems, the rural economy, and livelihoods in the country.

"This databank can serve as a social science lab to understand farmers' needs and constraints, to study the impact of technologies, to conceptualize new research ideas, and to support evidence-based decision making," said IRRI scientist Humnath Bhandari, who heads VSDA.

Tracking trends

"The real power of the databank is to provide insights into long-term trends and future development pathways in agriculture and rural livelihoods in the developing world," Dr. Bhandari said.

In fact, several emerging trends can be observed from the data that the team has put together. Some of the important lessons gleaned are (1) declining farm size, (2) aging of the farming population, (3) increased cost of crop production, (4) increased mechanization in farming, (5) increased adoption of high-yielding inbred and hybrid varieties of rice, (6) diversification in farming practices, (7) better access to agricultural support services, (8) the exit of agricultural labor to nonagricultural employment, and (9) the declining importance of agriculture to rural livelihoods.

The social science databank also provided insights into the factors affecting farmers' adoption or rejection of new rice varieties. Among the factors identified were a comparative yield advantage over existing rice varieties, eating and grain quality, the price of grain in the market, associated risk such as resistance to pests and diseases and tolerance of stresses, farmers' preference for varieties with short growth duration, and resistance to lodging.

Raising their voices. Women actively participate in the data-collecting process through interviews with open questions that initiate conversations and the possibility of understanding a range of experiences and nuances of meanings of fellow women.

Firsthand information. IRRI and its partners in Bangladesh interact closely with members of the village households to gather information that provides insights into long-term trends and future road maps in agriculture and rural livelihoods.

Women at work

The databank also revealed trends pertaining to gender in the rural households of Bangladesh. "Women are involved in homestead gardening, postharvest activities, poultry farming, and animal husbandry," explained Dr. Bhandari.

However, cultural and religious differences across Bangladesh lead to differences in the contributions women make to household income and what farming activities they participate in.

"Labor participation of Muslim women in market activities outside the house is nominal," he observed. "In the cases of Hindu communities, tribal communities, and poor households, women are more likely to work outside the home and directly contribute to household income. However, the wage rate for women is substantially lower at only two-thirds that of men."

In recent years, more men have sought work away from the farm, which has resulted in more participation of women in farming activities. On the other hand, more education for girls has also led to a gradual increase in the numbers of women participating in economic activities and contributing to household income through nonfarm jobs.

Narrowing the gender gap

Under the VDSA project, IRRI's Social Sciences Division (SSD) gathers household, individual, and field-specific data from the same households over time (or panel data) on almost all aspects of rural livelihoods from 480 households residing in 12 villages located in different parts of the country. These villages are the subset of the 62 villages in which IRRI first started its benchmark survey in 1987. The same 62 villages were revisited in 2000, 2004, and 2008.

IRRI's social sciences team has been collecting data over the last 25 years and has built a unique databank that examines rice-based farming systems and their associated socioeconomic conditions in Bangladesh. The databank focuses on different scales—from the farmers' plot to the household, to the district, and then to the state and, ultimately, to the national level.

"This is an important step toward documenting the realities on the ground, especially because panel data covering a wide range of information, including on agriculture and rural livelihood, are very rare in the developing countries," said Samarendu Mohanty, head of SSD.

"With women becoming increasingly involved in farming activities, we need to make sure machines such as harvesting and plowing equipment are light and easy to move so that they don't prevent women from operating them," Dr. Mohanty said. "Moreover, with women becoming better educated and contributing financially via off-farm income, on-farm investments should target them."

Better technologies on postharvest, homestead gardening, and livestock; access to credit and markets; and training women on agricultural activities can empower them economically.

Gaining grains

Losses occur at all stages of rice production. In Asia, Africa, Latin America, and the Caribbean, postharvest losses can reach 30%. By working with those who provide farmers with technical and business support to adopt new and promising postharvest technologies, IRRI is strengthening the final link in the value chain. And everyone benefits from every grain gained.

Learning by doing. Hands-on lessons are an effective way of helping farmers understand the importance of postharvest technologies.

As world demand for food grows, rice postharvest losses occurring during threshing, drying, storage, and milling take on greater importance. In Southeast Asia, physical losses in the postharvest chain range from 15% to 25%, while losses in quality from poor handling and processing result in a 10–30% reduction in value. In Africa, a 2011 FAO/World Bank report said that investing in postharvest technologies to reduce food losses could significantly increase the food supply in the region.

Minimizing postharvest losses could mean a sizable gain in income for farmers and other chain actors, and an increase in the global food supply for those who need it most, without intensifying production.

A break in the chain

One component of IRRI's action plan in response to the food shortage in 2008 is accelerating the delivery of new postharvest technologies to diminish losses. New and existing technologies can substantially decrease the considerable postharvest losses suffered by most farmers, according to IRRI Director General Robert Zeigler.

"Achieving food security and improving the livelihoods of farmers speaks directly to the need for reducing postharvest losses to recover more value and more rice from farmers' harvests," said Alfred Schmidley, IRRI's business model development and market specialist.

A variety of postharvest technologies and practices, including flat-bed dryers and storage containers such as hermetically sealed bags, are available and have proved successful. But the existence of improved postharvest technologies is not enough for sustainable adoption to occur.

"Postharvest technologies cannot be divorced from the business model and value chain context in which adoption occurs; they go hand in hand," Mr. Schmidley said. "Business models capture and deliver

Business 101. IRRI and the Cambodia Learning Alliance help farmers develop business plans around postharvest technologies they adopt such as the flat-bed drying services for paddy rice and seeds.

Alfred Schmidley (2)

benefits that improved technologies provide. This requires an integrated approach to the development and delivery of locally suited technologies with multiple actors."

Adapting to adoption

To improve the uptake of postharvest technologies, IRRI fosters multistakeholder learning alliances for "collaborative entrepreneurship" that examine a range of technical, end-user learning, and market support needs in postharvest systems. This participatory "learning-by-doing" approach allows all stakeholders to identify particular sources of postharvest losses and a range of mitigating technology options for piloting and verification. The actors not only become aware of how practices at one end of the chain affect outcomes at the other but also realize how working together to support the adoption of new technologies improves postharvest efficiency and profitability—to everyone's benefit.

IRRI has established national learning alliances in Cambodia, Vietnam, and the Philippines to integrate researchers, extension workers, NGOs and civic organizations, farmer groups, and private-sector actors.

Mixing business know-how and technology

In addition to identifying needs and pilot technologies for verification, the alliances teach farmers how to develop business tools, such as market analysis and business plans, to help them make their business case for specific technologies to micro-financiers in order to obtain additional capital.

The Cambodia Learning Alliance helped farmer Koul Savoeun pilot a flat-bed dryer to provide local farmers and rural processors with contract drying services for paddy rice and seeds. Mr. Koul developed a business plan to communicate his business case for expansion to microfinance in a "business-not-as-usual" forum with institutions, provincial extension agents, key farmers, millers, and traders that concluded in a visit to his enterprise.

In the Philippines, a community of Mindanao farmers successfully developed a business plan with assistance from the local Kaanib Foundation, another learning alliance partner, and with support from Catholic Relief Services.

"We farmers have been given many things to try and do business," said Plenio Atega, a Filipino farmer at a learning alliance workshop. "But no one has ever taught us to do a business plan."

"We hope this will support adoption and scaling out of these technologies in a sustainable business model context," Mr. Schmidley explained. "Building a business case around a technology is making sure that this technology is sustainable, as it covers the complete value chain from production to the market."

Rice tailor-made for Africa

African farmers are no strangers to IRRI-bred rice, but many of the varieties they rely on were actually developed for Asian conditions. For the first time ever, rice varieties bred by IRRI especially for Africa were released in 2011.

One of the greatest milestones in the history of agriculture was the development of high-yielding varieties of rice. The rapid adoption of these varieties by Asian farmers led to the doubling of food production within 30 years and helped avoid widespread famine.

The IRRI-bred miracle rice, IR8, was planted on approximately 25% of Asia's rice land just a few years after it was released in 1966.[1] IR8, which could produce up to 10.5 tons per hectare compared to the average global rice yields from other varieties of only about 2 tons per hectare in the 1960s, is credited for dramatic yield increases that averted famine conditions across Asia.

Many other varieties followed, including the popular IR64 that was commercially released in 1985 and still remains as popular today because of its good yield.

Upgrading Africa's rice

African farmers have previously grown many different IRRI-bred rice varieties, including IR8 and IR64. Newer rice varieties that are more resilient—be it to flood, drought, pests, and diseases—have appeared since these were released. But, more than 30 years after its introduction, IR64 is still cultivated in many African countries. Significantly, IR64 and other IRRI-bred varieties were developed for Asian conditions.

"Now, since IRRI started breeding work in Africa, new rice varieties have been bred especially suited to different growing areas across the continent and to meet different consumer needs," said Joseph Rickman, IRRI regional coordinator for East and Southern Africa. "Critical to the success of the new varieties has been the engagement of farmers in choosing which varieties they liked best."

Rice tailor-made for Burundi

After recognizing the urgent need for better varieties adapted to local conditions and matching farmer and consumer needs, IRRI's liaison scientist and coordinator in Burundi, Dr. Joseph Bigirimana, his team, and many partners in Burundi developed IR77713 and IR79511 rice varieties especially for the country. Both varieties were released in 2011.

The varieties were tested and evaluated for three years in different regions across Burundi in participatory varietal selection trials in which farmers chose the rice varieties they liked most. Farmers and agricultural stakeholders chose the two rice varieties bred by IRRI over the country's locally grown varieties.

The two varieties easily gained favor for their capability to yield up to 7 tons per hectare—1 to 1.5 tons more than the locally grown varieties—and because of their ability to mature 2 to 3 weeks earlier. Early-maturing varieties mean that farmers can grow a second crop, allowing them to produce more food for their families or to sell it. This is important because more than 90% of the population in Burundi depends on agriculture for livelihood.

The farmers also ranked IR77713 and IR79511 highest in grain quality of unmilled, milled, and cooked rice. In addition, a sensory test revealed that farmers found IRRI's new varieties tastier and better looking than the locally grown varieties.


Emmanuel Panisales

[1] Hargrove TR, Cabanilla VI, Coffman WR. 1988. Twenty years of rice breeding: the role of semi-dwarf varieties in rice breeding for Asian farmers and the effect on cytoplasmic diversity. Bioscience 38(10):675-681.

Africa

Surapong Sarkarung

Made for Mozambique. Makassane, the first IRRI-bred rice variety designed especially for Mozambique farmers and consumers, was chosen by farmers as the best locally grown variety.

"I am happy that the varieties I selected are now released," said Ms. Scolastique Simbandumwe, one of the farmers who helped pick the new varieties. "I would like to get seeds now and multiply them so my income can increase."

"We congratulate IRRI for this achievement," said Director General of Agriculture Sebastien Ndikumagenge, Burundi Ministry of Agriculture and Livestock. "By releasing these two varieties, IRRI contributes a lot to our efforts to find food for Burundians. We encourage IRRI to go forward."

Mozambique gets a new designer rice

In Mozambique, the rice variety Makassane was chosen as the best tasting locally grown rice variety. Makassane is the first IRRI-bred rice variety designed especially for Mozambique consumers and farmers.

Farmers from Makassane Village who participated in ranking and evaluating the variety rated it as one of their favorites. They liked that it is tall enough to survive flooding but not too tall to fall over easily, has many grain-producing heads, has long attractive grains, and has a nice texture when eaten. It is also disease resistant, which is very important to local farmers.

Instituto de Investigação Agrária de Moçambique, the government agricultural research institute for Mozambique, played a key role in helping test Makassane across six field sites from the north to the south of Mozambique over the last three years. This variety is best suited to the irrigated areas of southern Mozambique, where soils are fertile, but testing is ongoing in other regions.

Field research shows that Makassane can produce 6–7 tons per hectare, the same amount as Limpopo, currently the most popular rice variety. However, Makassane has two distinct advantages. Its grain quality is significantly better and it is resistant to bacterial leaf blight and blast, two major diseases that can both cause serious grain losses in Limpopo. In addition, the quality of grain recovery of Makassane was better as it delivered more whole grains and much less broken grain than Limpopo.

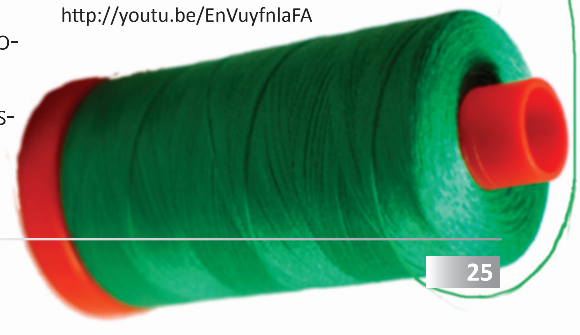
Following the approval of Makassane for release by the Mozambique Variety Release Committee in June 2011, IRRI provided government agencies and farmers with "foundation seed" to use in bulking up the seed so that more can be produced and distributed to more farmers.

"Mozambique has a vast area of land suitable for rice production," said Surapong Sarkarung, IRRI's senior consultant for rice breeding in East and Southern Africa. "If better varieties like Makassane can be more widely adopted, Mozambique could become both self-sufficient in rice and a rice exporter because the grain quality of Makassane meets international quality standards."

Breeding work is already under way to develop other designer rice varieties for Mozambique. "Makassane is just the beginning," said Dr. Sarkarung. "We have recently identified many promising potential new rice varieties suitable for growing in Mozambique that combine superior grain quality with high yield and resistance to major diseases."

This research is made possible through the Stress-Tolerant Rice for Africa and South Asia project, which is supported by the Bill & Melinda Gates Foundation, and the Mozambique Platform for Agricultural Research and Technology Innovation supported by the United States Agency for International Development.

See related video on YouTube at http://youtu.be/EnVuyfnlaFA



Lean, mean drying machines

A dryer for rain or shine. The reversible-airflow flat-bed dryer in Vietnam is an all-weather, low-labor drying method for producing better quality rice, which is especially important during weeks of nonstop rainfall.

Martin Gummert (2)

Proper drying prevents insect infestation and maintains the quality of harvested rice in storage. The challenge lies in developing simple and inexpensive drying technologies that are faster and more efficient than traditional ways, and that work effectively under diverse conditions and settings. IRRI's effort to introduce Vietnamese-designed flat-bed dryers to countries across Southeast Asia reached new heights in 2011 and is proving to be a big help to farmers.

Poorly dried rice is more vulnerable to pests, discoloration, and the formation of a poisonous substance naturally produced by certain molds and fungi (mycotoxins) while in storage. Sun drying, the most common drying method in Asia, is cheap, requires little investment, and is environmentally friendly but has its limitations. It is not possible at night or during overcast days, plus it is labor intensive.

Because controlling the temperature is difficult in sun drying, grains may crack due to overheating and thus have low milling quality. On average, Myanmar farmers usually sell sun-dried paddy at US$0.35–0.42 per kilogram, depending on quality. Poorly dried grains could cut that price by about half.

An alternative to the sun

No single technology can solve all the problems associated with rice drying. But FBDs offer a good compromise between drying cost and benefits in terms of higher quality and avoidance of weather risk.

"An FBD is basically a box with a perforated false floor," said Martin Gummert, IRRI's postharvest specialist. "The grain is placed about 30 cm deep on top of the false floor and heated air is forced through the grain bulk from a chamber of pressurized air underneath."

Whether they dry their paddy under the sun or use FBDs, farmers spend money for either labor (for sun drying) or drying service fees to produce premium-quality rice. But the availability of dryers means more options for farmers when sun drying is not possible, especially during the wet season.

Slowly catching on

In recent years, FBDs have gained traction in Southeast Asia as an all-weather, low-labor drying method for producing better quality rice. In 2011, the number of Vietnamese-designed flat-bed dryers in Myanmar increased to around 350. Around 150 dryers were constructed under private-sector partnership.

Similar developments in South Sumatra, Indonesia, were observed, where IRRI helped a local manufacturer develop a good design for a dryer blower. More than 200 dryers have been installed, 80 of which are equipped with the highly efficient blower introduced by IRRI. In Laos, the local manufacturer has produced more than 20 units that mostly seed producers, farmer groups, and research stations have installed.

Where there's smoke, there's awareness

The increased adoption of FBDs in Myanmar is largely due to years of awareness campaigns on postharvest losses conducted by Myo Aung Kyaw, Tin Oo, and associates from the Myanma Rice and Paddy Traders Association and the Pioneer Post Harvest Development Group.

This iniatiative, largely from the private sector, not only focused on the business of making dryers. It also made provisions for both the hardware (the dryer) and the training, technical assistance, and after-sales services.

Promotional activities targeted policymakers and government staff who were briefed on the potential benefits to farmers, current activities, and new technologies. Millers were provided with updated information on postharvest and drying and farmers were brought together to discuss and observe postharvest concerns.

Most of the dryers are operated by private owners, such as millers, while some are managed by farmer groups. By 2011, some 13,700 farmers were using the dryers. An estimated 35,000 farmers may be benefiting from more than 300 FBDs installed all over the country.

"The information campaign and postharvest management training raised interest in the development and benefits of flat-bed dryers," said Dr. Kyaw, who, along with Mr. Oo, attended postharvest training conducted by IRRI through the Irrigated Rice Research Consortium. "They empowered dryer owners and operators by training them on drying technology, economics, efficient operation, and maintenance."

A sunny outlook for Myanmar

Farmers do not always get a higher price from paddy dried using an FBD. But, those who have used the FBD observed that they get more milled rice when they dry with an FBD than when they use sun drying. For every ton of diesel-powered FBD-dried paddy, farmers can get 100 kilograms more milled rice. Using an electric-powered FBD, farmers reported an 8% increase in income.

"In cases when the weather is not favorable, which often happens during the summer harvest, farmers will greatly benefit from having more FBDs available," Dr. Kyaw said. Without other options, farmers could get only small net returns ($47/ha) or even none at all if they cannot sell their grains because of damage. In comparison, farmers with access to a diesel-fueled FBD can get higher returns ($608/ha). Similarly, they can get net returns of $650/ha if they use an electric-powered FBD.

Thousands of Myanmar farmers now have options to avoid postharvest losses and increase rice quality with the introduction of FBDs. Consequently, this could help the country increase its rice exports in the near future.

Cambodia turns up the heat

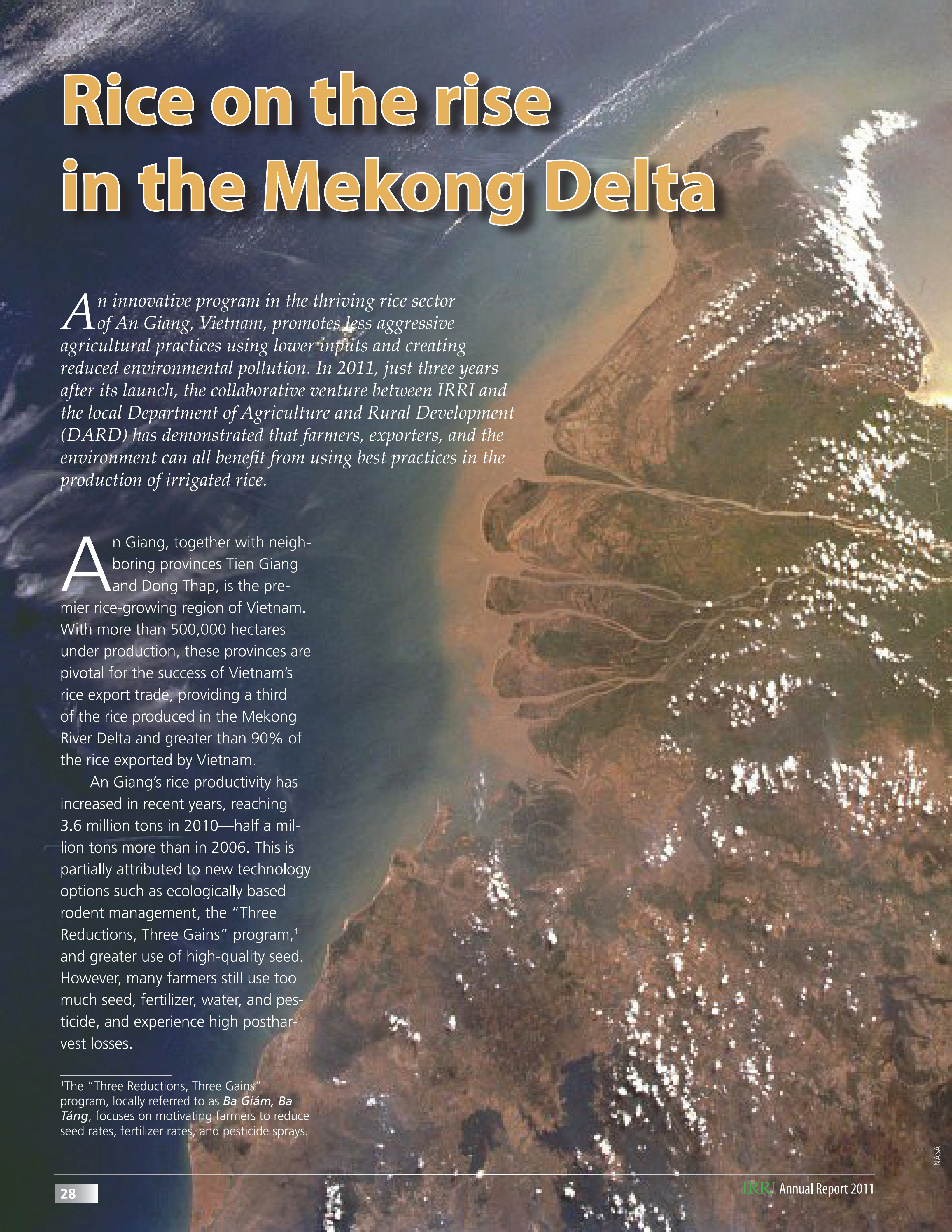
Like Myanmar, Cambodia needs to overcome its postharvest obstacles to be a player in the global rice market.

The FBD was introduced in Cambodia in 2007 through an IRRI training activity in Vietnam and installation of a demo dryer in Battambang Province. By 2011, around 20 dryers had been installed by rice millers, and 3 by farmer groups in Battambang and Prey Veng provinces. The number of dryers is expected to increase rapidly to meet the Cambodian government's target to produce 4 million tons of surplus rice and export 1 million tons of high-quality milled rice by 2015.

To speed up dryer adoption, a business plan was developed for a drying service for farmers in Battambang using a higher capacity FBD. The plan was presented to several microfinance institutions and received a positive response. Similar plans for other technologies will be discussed with microfinance institutions to encourage them to design specific credit lines to encourage the adoption of the technologies.

See related video on YouTube at http://youtu.be/ldsReKPINOE

Dry air across Myanmar. Thousands of Myanmar farmers are becoming less dependent on sun drying, avoiding postharvest losses, and increasing rice quality as the use of FBDs spreads across the country.



NASA

Rice on the rise in the Mekong Delta

An innovative program in the thriving rice sector of An Giang, Vietnam, promotes less aggressive agricultural practices using lower inputs and creating reduced environmental pollution. In 2011, just three years after its launch, the collaborative venture between IRRI and the local Department of Agriculture and Rural Development (DARD) has demonstrated that farmers, exporters, and the environment can all benefit from using best practices in the production of irrigated rice.

An Giang, together with neighboring provinces Tien Giang and Dong Thap, is the premier rice-growing region of Vietnam. With more than 500,000 hectares under production, these provinces are pivotal for the success of Vietnam's rice export trade, providing a third of the rice produced in the Mekong River Delta and greater than 90% of the rice exported by Vietnam.

An Giang's rice productivity has increased in recent years, reaching 3.6 million tons in 2010—half a million tons more than in 2006. This is partially attributed to new technology options such as ecologically based rodent management, the "Three Reductions, Three Gains" program,[1] and greater use of high-quality seed. However, many farmers still use too much seed, fertilizer, water, and pesticide, and experience high postharvest losses.

[1]The "Three Reductions, Three Gains" program, locally referred to as ***Ba Giám, Ba Táng***, focuses on motivating farmers to reduce seed rates, fertilizer rates, and pesticide sprays.

Grant Singleton (2)

Trina Leah Mendoza

From information to action. The *Mot Phai, Nam Giam* ("*One Must Do, Five Reductions*") campaign in An Giang Province relied on strong media presence and information materials such as billboards, posters, brochures, and booklets. Farmers who applied the practices (*right*) used less resources, such as water, and actually increased their income by as much as US$250 per hectare.

A handful of solutions

An Giang's DARD, with strong support from IRRI through the Irrigated Rice Research Consortium (IRRC), introduced the *Mot Phai, Nam Giam* (*"One Must Do, Five Reductions"*) program to An Giang farmers in 11 districts in 2009. This high-profile program was launched in 2009 in the Mekong Delta.

"The program helps rice growers lower production costs and reduce environmental pollution while increasing rice quality and productivity through the adoption of IRRI's best management practices for irrigated rice," said Grant Singleton, IRRC coordinator.

The one "must do" is to use certified rice seeds; the "five reductions" refer to efforts to decrease the amount of seeds, pesticides, fertilizer, water, and postharvest losses.

A firm hold on technology

By the end of the 2011 summer-autumn cropping season, the IRRC had supported 189 training activities for 4,308 farmers. The farmers were taught integrated pest and nutrient management concepts at demonstration sites in different villages.

"After the training course, they were able to identify pests and their natural enemies, and assess the health of their rice crop," Dr. Singleton said. Farmers were encouraged to apply technologies on parts of their fields—to help them see the benefits first—before adopting the practices at a larger scale in the following cropping seasons. "Consequently, they were the ones who decided on the practices to apply on their farms," he added.

Speaking the right language. To get the information across to the target audience, campaign posters and billboards were carefully crafted during a message design workshop in Long Xuyen City.

Forty local technicians were also trained on key aspects of rice production to make them more confident in implementing the program and promoting agricultural development by educating farmers on new technologies.

Measureable impact

A year after the *Mot Phai, Nam Giam* program was introduced, significant changes were observed between farmers who used the technologies and those who did not. Farmers who adopted the package of technologies and reduced the amount of inputs actually increased their income by as much as US$250 per hectare in the 2010-11 winter-spring rice crop and $214 per hectare in the 2011 summer-autumn crop.

The significant impact of the *Mot Phai, Nam Giam* program in An Giang has attracted national attention. In late 2011, the program was submitted to the Ministry of Agriculture and Rural Development for national certification, which provides a strong platform for sustainable increases in rice production in the Mekong Delta.

Growing nature's army

Isagani Serrano

Left on its own, nature has enough predatory species to limit the population of and the crop damage caused by insect pests to a minimum. But the misuse of pesticides kills off these beneficial species and tips the balance heavily in favor of major pests such as rice planthoppers. In 2011, IRRI launched an action plan to stop devastating planthopper outbreaks by focusing on nurturing nature's army of pest killers and reducing the use of pesticides.

"Each species on our planet plays a role in the healthy functioning of natural ecosystems, on which humans depend," said Dr. William Schlesinger, president of the Cary Institute of Ecosystem Studies, about the complex interactions that govern the natural world. This mantra is embraced and advocated by IRRI through its ecological engineering strategy in which the little things count in the rice ecosystem: the flowers in the fields, the spiders, the wasps, among many other life forms.

Through this strategy, farmers work efficiently with natural processes and the natural-born protectors of rice rather than against them to keep pests at bay. IRRI discovered that caring for biodiversity helps in overcoming even the pest that many rice farmers fear the most—planthoppers.

Little grim reapers

The degree of havoc that planthoppers are capable of has been grimly shown in a series of infestations across Asia. In 2010, Indonesia's Western, Central, and Eastern Java lost more than 25,000 hectares of rice to hopperburn (drying of crops and withering of shoots as if scorched by the sun caused by the feeding of planthoppers) and the viral diseases they transmitted. In Thailand, brown planthopper damaged more than 3 million hectares of rice area and more than 1.1 million tons of paddy with an export potential of US$275 million from 2009 to 2011. In China, rice farmers lose 1 million tons of rice annually to planthoppers.

One of the most devastating planthopper outbreaks took place in 2005 when Vietnam lost about 400,000 tons of rice paddy. As the problem persisted, the country suspended its exports in 2007 to protect its domestic supply, and this contributed to the 2007-08 rice crisis.

Ecosystem breakdown

What triggers planthopper outbreaks? IRRI entomologist K.L. Heong has identified one of the main culprits: misuse of pesticides. One of the consequences of using pesticides is the indiscriminate killing of pest predators. The resilience of the ecosystem to fight off pests starts to get off-balance the moment chemicals are sprayed.

"A rice field is rich in diversity, in which natural enemies of pests such as spiders, aquatic bugs, parasitic wasps, and predatory bugs thrive," Dr. Heong said. "These natural enemies keep the pest population under check."

The practice of managing farms so that they harbor sufficient populations of pest predators that happily feast on crop pests is an effective control technique. Rice scientists are learning to make better use of these invisible yet powerful allies by creating safe habitats for them within the rice ecosystem, thus encouraging them to stay and reproduce.

Weaning away from pesticides

The Planthopper Project, a collaborative research network with scientists in Asia co-funded by IRRI and the Asian Development Bank, campaigns for less dependency on using chemicals to control pests. This advocacy is not an easy feat for the planthopper project team because advertising has conditioned farmers to believe they need chemicals to solve their pest problems.

In 2011, brown planthopper infestation in several provinces of Thailand destroyed 104,000 hectares of rice area. To control the pests in a sustainable manner, Thailand's minister of agriculture came up with a $12.8-million initiative to stop the use of two insecticides—cypermethrin and abamectin—which actually causes planthopper outbreaks. Instead, the agency promoted a campaign to improve pest management practices in rice. The move was viewed as internationally significant because Thailand is the world's largest exporter of rice and a leader in the global rice industry.

An eco-friendly counterstrike

In 2011, IRRI launched an action plan seeking to solve the hopper problem in a sustainable manner. IRRI proposed the restoration of biodiversity in rice fields, as well as building ecological resilience.[1] IRRI came up with more detailed ecological engineering approaches, which include the following:

- Planting flowers and other plants to promote the buildup and sustenance of a healthy population of natural enemies of planthoppers.
- Using resistant varieties, or a combination of varieties, that are tolerant of the local or invading planthopper populations. (Farmers are advised against using the same variety for more than 2 years to prevent the hoppers from developing resistance to the variety.)
- Synchronous planting and fallow periods of 1 month in between successive crops of rice, as well as crop diversification schemes.

[1] Action Plan: Preventing planthopper outbreaks in rice. IRRI (2011).

Controlling chemical control

Furthermore, to support farmers in their on-the-ground activities, IRRI is also calling on its partners in national governments and the private sector to regulate the marketing and improve the use of insecticides.

The advocacy is to re-classify pesticides from consumer goods to regulated materials, and to ban or restrict the use in rice of broad-spectrum pesticides that contain active ingredients known to contribute to planthopper outbreaks such as cypermethrin, deltamethrin, abamectin, and chlorpyrifos.

IRRI also recommends that pesticide retailers be certified and trained to prevent sales of fake, banned, or unapproved products, and to promote integrated pest management and proper pesticide use.

"The ecological engineering approaches, which put a premium on biodiversity with its natural protectors, ensure more sustainability in rice production for farmers," Dr. Heong said. "And a healthy rice ecosystem can better withstand and recover from disasters brought by pests."

With a healthy biodiversity in the rice ecosystem, farmers will not end up losing twice: paying the high costs of pesticides and yet still becoming victims of pest outbreaks.

Ho Van Chien

Welcome sign. Planting flowers is one way of encouraging biodiversity. Enhancing the habitat attracts beneficial insects and other species that are essential to natural pest control.

Green MAGIC

What if a rice plant possessed all the traits crucial for it to thrive under every conceivable inhospitable condition? This may sound too good to be true, but a team of IRRI scientists had an elaborate game plan to breed stress-proof rice using MAGIC—multiparent advanced generation intercross.

The development of improved rice varieties that can successfully fight off biotic stresses (pests and diseases) as well as withstand abiotic ones (drought, flooding, salinity, or cold) is crucial to boosting rice production, increasing farmers' income, and reducing poverty. But these are highly customized traits. Relatively few varieties are suitable for specific conditions for which they have been bred to overcome one or two stresses. On the other hand, a superior rice type would be like a sophisticated warrior, trained in all possible forms of combat and weaponry. It will have a host of defensive techniques and survival skills as circumstances require. Such a variety can be planted in any soil, nutrient, or climatic condition, can fight off pests and diseases, and can still produce as much grain as other rice varieties would under ideal conditions.

A genetic card trick

Through a process known as multiparent advanced generation intercross—or MAGIC—a team of IRRI scientists launched an ambitious and elaborate plan to breed multiple-stress-proof rice.

Rice progenies are used for the construction of genetic maps—DNA sequences in or near genes whose locations are known ("markers")—and to compare markers with the occurrence of traits of economic importance. If a desirable trait and the markers frequently appear together, the locations of the genes responsible for that trait are likely to be near the markers. This allows breeders to identify and characterize resistance genes present in their parental cultivars.

A single desirable trait is usually controlled by multiple genes. "Traditionally, genetic mapping and breeding efforts in rice are based on progenies from two-parent crosses," said Glenn Gregorio, IRRI plant breeder on abiotic stress tolerance. "But interactions among multiple genomes, or multiparent crosses, have not been fully exploited."

The MAGIC approach provides opportunities for multiple rice types to exchange genes and traits with one another. "It is like having multiple decks of playing cards and shuffling them over and over again to produce the best combination," Dr. Gregorio added.

MAGIC through science

Using this concept, the IRRI research team began crossing work in 2007. Multiple intercrosses were made within each of the indica and japonica populations to systematically increase the level of recombination.

The team selected eight cultivars each for indica and japonica as founder lines. These cultivars are modern varieties from around the world known to be tolerant of a range of biotic and abiotic stresses, are high-yielding, and have good grain quality.

The value of the MAGIC populations is enhanced further by recent advances in genome-sequencing technologies. The new diversity can be fine-mapped by low-cost sequencing methods (the process of identifying the plant's genetic makeup or genotyping).

The combination of genotyping and trait evaluation makes it easy to identify MAGIC lines that carry important agronomic traits such as flood and salinity tolerance, resistance to bacterial blight, and good grain quality. This information will identify the genes responsible for the desirable traits.

Since traits are tagged by molecular markers, researchers can insert these traits into new varieties faster than traditional trial-and-error breeding to identify varieties that carry desired genes.

Spreading MAGIC across the globe

In 2011, the team developed an indica MAGIC population, or set of breeding lines, that will be tested in the Philippine provinces of Iloilo, Bukidnon, Laguna, and three locations in Africa beginning in the first cropping season of 2012. Field-testing in eight locations around Asia and two locations in Africa will start in the subsequent cropping season.

The indica and japonica MAGIC populations will be further crossed to expand genetic diversity and therefore improve adaptation in various cropping conditions across the world—the results of which will be called the MAGIC global population.

"Our team hopes that by intermixing indica and japonica elite lines we can create new combinations of traits that can bring increased productivity and resilience of rice in difficult environments to a whole new level," said Dr. Gregorio.

Angelo Arboleda

The MAGIC of rice science. The indica MAGIC breeding lines developed at IRRI carry new combinations of traits for improved rice productivity and resilience in harsh environments.

Financial support from donors

Summary of financial support to IRRI's research agenda in 2011 and 2010 (US$000)

	2011	2010
Asian Development Bank	1,537	871
Australia	5,158	2,866
Bangladesh		100
Bayer CropScience AG	237	88
Bill & Melinda Gates Foundation	18,967	16,838
Canada		
Canadian International Development Agency	74	1,273
Challenge Programs		
Generation	1,209	1,011
HarvestPlus	285	1,047
Water and Food	975	88
China	169	223
Chinese Academy of Agricultural Sciences	1,376	1,245
CGIAR Centers and Consortium		
Africa Rice Center	88	13
Bioversity International	2	68
CGIAR/System-wide Genetic Resources Programme/ Special Program Impact Assessment		46
CGIAR Fund Window 1 & 2[a]	35,653	
International Center for Agricultural Research in the Dry Areas		23
International Crop Research Institute for the Semi-Arid Tropics	459	331
International Food Policy Research Institute	93	88
Cornell University	150	292
European Commission	1,401	1,526
Food and Agriculture Organization of the United Nations	95	35
France	275	491
Germany		
Federal Ministry for Economic Cooperation	614	612
Federal Ministry for Economic Cooperation/German Agency for Technical Cooperation	993	476
Global Crop Diversity Trust	232	271
Grand Challenges in Global Health through Albert-Ludwigs University of Friedburg	241	389

	2011	2010
Hybrid Rice Research and Development Consortium	443	324
India	309	479
Indonesia	45	
International Atomic Energy Association		1
International Fertilizer Industry Association, International Plant Nutrition Institute, International Potash Institute	106	122
International Fund for Agricultural Development	1,488	997
Iran	31	48
Japan	5,197	5,681
Kellogg Foundation	45	50
Korea	823	824
Malaysia	7	14
Norway		409
Nunhems BV	5	5
Philippines	752	562
Pioneer Hi-Bred International	191	234
Plan International Cambodia		6
Portugal	115	169
Rockefeller Foundation	382	929
Sweden		547
Switzerland	1,232	2,001
Syngenta	209	93
Thailand	50	80
Turkey	14	
United Kingdom	71	2,533
United States of America	4,908	6,738
Vietnam	89	70
World Bank	71	2,766
World Vision, Inc.	62	93
Others	1,102	742
TOTAL[a]	**88,030**	**56,828**

[a]The CGIAR Fund Window contribution includes $12,316,000 that was spent by AfricaRice and the International Center for Tropical Agriculture for carrying out Global Rice Science Partnership activities.

For complete information, view IRRI's Audited Financial Statements for 2011 on the attached DVD.

Selected acronyms (in print and DVD versions)

ACIAR	Australian Centre for International Agricultural Research
ACSS	African Crop Science Society
ADB	Asian Development Bank
AfricaRice	Africa Rice Center
AIAT	Assessment Institute for Agricultural Technologies
ARRRI	All-Russian Rice Research Institute
ASA	American Society of Agronomy
ASEAN	Association of Southeast Asian Nations
AWD	alternate wetting and drying (technology)
BMGF	Bill & Melinda Gates Foundation
BOT	Board of Trustees
BPH	brown planthopper
CAAS	Chinese Academy of Agricultural Sciences
CARD	Coalition for African Rice Development
CBSS	community-based seed systems
CESD	Crop and Environmental Sciences Division
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement
CLUES	Climate Change Affecting Land Use in the Mekong Delta
CPS	Communication and Publications Services
CRP	Consortium Research Program
CRRI	Central Rice Research Institute
CSB	community seed banks
CSISA	Cereal Systems Initiative for South Asia
CTU	Can Tho University
CVP	Cyber Village Project
CURE	Consortium for Unfavorable Rice Environments
DA	Department of Agriculture (Philippines)
DARD	Department of Agriculture and Rural Development (Vietnam)
DDG-R	Deputy Director General for Research
DFID	Department for International Development
DG	Director General
DRR	Directorate of Rice Research (India)
ES	experiment station
ESA	East and Southern Africa
FAO	Food and Agriculture Organization
FBD	flat-bed dryer
FHS	Food and Housing Services
GAP	good agricultural practices
GIZ	German International Cooperation
GQNPC	Grain Quality, Nutrition, and Postharvest Center
GRC	Genetic Resources Center
GRiSP	Global Rice Science Partnership
GSR	Green Super Rice
HKI	Helen Keller International
HRDC	Hybrid Rice Research and Development Consortium
IAARD	Indonesian Agency for Agricultural Research and Development
IAPPS	International Association for the Plant Protection Sciences
ICAR	Indian Council of Agricultural Research
ICFORD	Indonesian Center for Food and Crops Research and Development
ICIMOD	International Centre for Integrated Mountain Development
ICIS	International Crop Information System
ICON	Impact on Carbon, Nitrogen, and Water Budget
ICRR	Indonesian Center for Rice Research
IFAD	International Fund for Agricultural Development
INQR	International Network for Quality Rice
IRRC	Irrigated Rice Research Consortium
IRS	internationally recruited staff
JICA	Japan International Cooperation Agency
JIRCAS	Japan International Research Center for Agricultural Sciences
LOA	letter of agreement
MAGIC	multiparent advanced generation intercross
MOU	memorandum of understanding
NARC	Nepal Agricultural Research Council
NARES	national agricultural research and extension system
NASC	National Agricultural Science Centre
NEST	Neighborhood Emergency Services Team
NGO	nongovernment organization
NMRice	Nutrient Manager for Rice
NRS	nationally recruited staff
PBGB	Plant Breeding, Genetics, and Biotechnology (Division)
PCAARRD	Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development
PDF	Postdoctoral Fellow
PhilRice	Philippine Rice Research Institute
RDA	Rural Development Academy (Bangladesh)
RDA	Rural Development Administration (Korea)
RSSP	Rice Self-Sufficiency Program
SHU	Seed Health Unit
SRP	Sustainable Rice Platform
SSD	Social Sciences Division
STRASA	Stress-Tolerant Rice for Africa and South Asia
SVPUA&T	Sardar Vallabhbhai Patel University of Agriculture and Technology
TC	Training Center
TRRC	Temperate Rice Research Consortium
UNEP	United Nations Environment Programme
UNL	University of Nebraska-Lincoln
UPLB	University of the Philippines Los Baños