Rice Research for Poverty Alleviation and Environmental Sustainability in Asia

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Abstract: Through its new Strategic Plan, the International Rice Research Institute (IRRI) is setting up a new, innovative, and exciting research agenda by targeting many of the UN's Millennium Development Goals (MDGs). This paper focuses specifically on two of the Plan's five goals, i.e., *Reducing poverty through improved and diversified rice-based systems* and *Ensuring that rice production is sustainable and stable, has minimum environmental impact, and can cope with climate change.* To begin addressing poverty issues as spelled out in Goal 1, IRRI's research focus must shift to placing a new, major effort on improving farmers' incomes in unfavorable rainfed areas. To achieve Goal 2, IRRI will be developing strategies to preserve the natural resource base while improving productivity in intensive rice agroecosystems in the face of a looming water crisis and changing physical and socioeconomic environments. By targeting the MDGs on eliminating extreme hunger and poverty and ensuring environmental stability, among others, IRRI and its partners are seeking profound new opportunities to improve the economic and social well-being of poor rice farmers and consumers who will, in turn, be instrumental in sustaining the economic miracle currently under way in Asia.
Key words: Asia, IRRI, rice, Millennium Development Goals, poverty alleviation, environmental sustainability, unfavorable rainfed environments, intensive rice agroecosystems, natural resources, drought, climate change, aerobic rice, water.

1. Introduction

Since the dawn of the Green Revolution—which began in Asia 40 years ago with IRRI's release of IR8 on November 28, 1966, the first modern, high-yielding semidwarf rice variety (Hargrove and Coffman 2006)—the global rice harvest has more than doubled, racing slightly ahead of population growth. This increased production and the resulting lower prices of rice across Asia have been one of the most important results of the higher yields that rice research and new farming technologies have made possible. Around 1,000 modern varieties—approximately half the number released in 12 countries of South and Southeast Asia over the last 40 years—are linked to germplasm developed by IRRI and its partners alone—a large impact indeed (Cantrell and Hettel 2004). These modern varieties and the resultant increase in production have increased the overall availability of rice and also helped to reduce world market rice prices by 80 percent over the last 20 years. As a result, poor and well-to-do farmers alike have benefited directly through more efficient production and Asian countries have had better prospects for meeting their national and household food security needs.

However, as IRRI approaches its 50th anniversary in 2010, we have been taking a serious look at what we have been doing and why we were doing it. From the mid-1990s until now, progress in science has leaped dramatically. There have been revolutions in biology, genomics, biochemistry, and molecular genetics, and in communications and computational power. In the laptops of the participants of this symposium, we probably have the computational power that the entire world had just 25 years ago. In the light of these huge positive advances, we thought it very important for IRRI to take a close look at its mission and future direction.

Another change taking place in the last decade—a social one—has been that the world development community is looking closely at how it approaches development by establishing the Millennium Development Goals (MDGs; www.undp.org/mdg), which are very impact-oriented. This means asking: What do we want the world to look like and what will it take to get there? As an institution, we at IRRI thought that this is a very powerful tactic for setting up a new, innovative, and exciting research agenda.

a) Five New Goals Unveiled

As IRRI went through its strategic planning process, we brought in a range of stakeholders to seek their specific guidance as to what they thought was needed and what IRRI's role should be. We also brought in external experts, asking them the same questions. Naturally, we consulted quite a bit internally. We also had consultations with farmers to get a perspective at the farm level and we contacted the most advanced research laboratories for points of view. Eventually, we were able to boil down the outcomes of this process into five strategic goals for IRRI, which I unveiled in October during the International Rice Congress in New Delhi (Zeigler 2006; Maclean and Hettel 2006):

- **Goal 1:** Reduce poverty through improved and diversified rice-based systems.
- **Goal 2:** Ensure that rice production is sustainable and stable, has minimum environmental impact, and can cope with climate change.
- **Goal 3:** Improve the nutrition and health of poor rice consumers and rice farmers.
- **Goal 4:** Provide equitable access to information and knowledge on rice and help develop the next generation of rice scientists.
- **Goal 5:** Provide rice scientists and producers with the genetic information and material they need to develop improved technologies and enhance rice production.

Just a brief note on the nature of "strategic goals." We set these goals by imagining a perfect world. We do not realistically believe that IRRI by itself can, for example, eliminate poverty and protect the environment. But, unless these are articulated as "goals," it is unlikely that our efforts will make a meaningful impact on poverty and the environment. For the balance of this paper, I will be referring mainly to our first two goals, regarding poverty and the environment, to stay within the scope of my assigned topic for today.

2. Shifting the Focus for Rice Research to Poverty Alleviation

Up to now, IRRI had been focusing primarily—and successfully—on food security, that is, "filling the rice bowl." However, our new Strategic Plan is shifting our main focus toward alleviating poverty, that is, "filling the purse." This does not much change our required expertise nor does it in any way diminish the importance of maintaining food security. Rice supplies will need to remain plentiful to provide reliable food that even the poorest can afford. In South and Southeast Asia, rice consumption in 2015 is projected to be 22.3 million tons (13%) and 13.4 million tons (11%), respectively, above 2005 levels. But, this does dictate where we work and the kind of work we do. For example, if we were interested only in rice output to produce enough food for the world, we would continue to focus on the intensive, highly productive, irrigated systems. Of course, these systems still remain important, but, if we want to begin addressing poverty issues as spelled out in our Goal 1, *Reduce poverty through improved and diversified rice-based systems*, the equation changes to placing a new, major effort on improving farmers' incomes in unfavorable rainfed areas.

Yields are very low in the extremely large rice-producing areas of South Asia and also the greater Mekong subregion where rice is grown under rainfed conditions. This is precisely why we are establishing a Greater Mekong Regional Office based in Vientiane, Lao PDR, to be inaugurated one month from today (January 12, 2007). It will be supported by country offices in Vietnam, Thailand, Myanmar, Cambodia, and China. This is where many poor Asians live. If we are going to focus on poverty, we have to invest relatively more resources and establish a greater presence in these rainfed areas. And, if we look at the challenges, such as flooding and drought, that face farmers who grow rice in rainfed areas, they are very different from the challenges that face farmers who grow rice in intensive production systems. We should also keep in mind that rainfed rice accounts for 50% of the rice-growing area. So, if we can improve productivity in these locations, not only do we improve people's lives, we also contribute to food security.

So, our new focus implies relatively less research emphasis for IRRI on yield gains for irrigated rice—for which I believe there is now strong capacity among the national agricultural research and extension systems (NARES), particularly here in Asia. Instead, IRRI's focus on intensive production systems will shift more to sustainability (see Section 3 below). In addition, by targeting the MDG on eliminating extreme hunger and poverty, we are seeking profound new opportunities for IRRI to improve the economic and social well-being of poor rice farmers—and rice consumers as well!

a) Program on Raising Productivity in Rainfed Environments: Attacking the Roots of Poverty

Rainfed areas coincide to a large extent with regions of severe and extensive poverty where rice is the principal source of staple food, employment, and income for the rural population. Up to now, success has been limited in increasing productivity in rainfed rice ecosystems—home to 80 million farmers on 60 million hectares. Rice yields in these ecosystems remain low at 1.0 to 2.5 tons per hectare and tend to be variable due to erratic monsoons. Poor people in these ecosystems often lack the capacity to acquire food, even at lower prices, because of poor harvests and limited employment opportunities elsewhere. Our primary objective in this research program will be to enhance household food security and income in these rainfed areas of Asia.

With rapid advances in genetics and genomics, the chances of developing high-yielding, drought- and flood-tolerant varieties for the rainfed system—and, consequently, helping farmers to diversify their farming systems and thus their income—are much greater now than ever before. I would particularly like to briefly mention our recent progress in deploying submergence tolerance in rice. The 10 August 2006 issue of *Nature* (Xu et al. 2006) and the October-December issue of *Rice Today* (Mackill 2006) describe the latest breakthrough that we have achieved with our partners. We have discovered a gene (*Sub1A-1*) that confers submergence tolerance in rice. This was achieved through conventional (non-transgenic) breeding work done with the University of California and its particular impact will be the development of new rice varieties that can withstand flooding. It will contribute greatly to overcoming one of agriculture's oldest challenges and offer relief to millions of poor rice farmers around the world, especially those in the new target areas of Goal 1 who must deal regularly with flooding in their fields.

b) Rice Improvement Still Our Core Work with NARES and ARI Partners

Regardless of our shift in focus, IRRI’s core work will still be research on rice improvement in which we will continue to gain more understanding about the rice plant and how it grows best in different environments. It is just that, from now on, we will be asking questions more and more within the context of unfavorable rainfed environments.

In line with the underlying theme of this symposium, i.e., international research collaboration, our model research partnerships with the NARES, including collaboration with farmers, will certainly continue. I am proud to say that IRRI is one of the lead pioneering institutes involved in participatory work with farmers, particularly here in Asia, especially with our farmer field schools, etc. The only real important change on this front is—again—that we will be focusing more on problems and issues that are characteristic of the rainfed environments. The best example, which I have already given above, involves tolerance of flooding and submergence, which are common in these typically flood-prone areas. We will also be giving more attention to drought tolerance in rice (see Section 2c below) and will also be looking at seawater encroachment, which can cause salinity problems. Of course, the nature of our partnerships will shift. I suspect we will be collaborating more and more with NARES institutions that are actually located in these rainfed environments.

Of course, our shift in perspective also argues for even stronger partnerships with advanced research institutions (ARIs). Developing better tolerances in the rice plant for drought, submergence, and salinity is not a trivial undertaking. It requires some very fundamental research. Again, the best recent example is our very successful partnership with the University of California, Davis and Riverside, and the U.S. Department of Agriculture, which required some very sophisticated genetic work that allowed us to identify the genes involved in submergence tolerance and then to transfer them into a traditional variety (Xu et al. 2006). This was a situation where very basic research with ARIs allowed us to accelerate our work and, together with our NARES partners in India, create a product that is directly suitable for the poorest of the poor farmers in South Asian rainfed systems.

c) Developing Drought-Tolerant Rice to Alleviate Poverty in Rainfed Areas

The development of drought-tolerant rice varieties will make a major contribution to alleviating poverty in rainfed areas. This is why we have attached a special “frontier” project to Goal 1—such a project being a visionary effort we deem so important that we are willing to dip into precious financial reserve funds to support. Drought is particularly frequent in the bunded uplands and shallow rainfed lowland fields in many parts of South and Southeast Asia. We believe that varieties combining improved drought tolerance with high yield under favorable conditions and quality characteristics preferred by farmers are among the most promising and deliverable technologies for alleviating poverty in communities dependent on rainfed rice production.

To date, IRRI has made a long-term and large-scale commitment to rice improvement for drought-prone areas (Lafitte et al. 2006). Our recent research has shown that the drought tolerance trait is strongly influenced by genes and gene networks with large effects. The frontier project will scale up the detection, analysis, and delivery of these genes for use in marker-aided breeding. By incorporating genes for this trait from rice and other species into widely grown rice varieties, we can develop technologies with our NARES partners and provide them to farmers so that they can enhance and stabilize their yields and income. In this project, we will establish broad and new partnerships to take the genetic findings from the laboratory to farmers' fields in a wide variety of rainfed conditions (IRRI 2006a).

3. Ensuring That Rice Production Has Minimal Negative Environmental Impact and Can Cope with Climate Change

It is critical that the stability and productivity of rice agroecosystems in Asia not be taken for granted and that their use by future generations not be jeopardized. Rice-growing areas are among the world's most enduring, environmentally sound, and productive agroecosystems and, as I have pointed out, increased rice production in recent decades has had a significant impact on achieving food security and beginning to alleviate poverty. And, as I move into this area of discussion, I will allay any fears that IRRI has forgotten the intensive rice-based systems in light of what I wrote in the first half of this paper.

a) Program on Sustaining Productivity in Intensive Rice-Based Systems: Rice and the Environment

Rice ecosystems provide basic commodities and regulatory services, including nutrient and water cycling, and biological control to reduce pest and disease outbreaks. Poor people often depend on these "ecosystem services" to provide their needs as they are often without infrastructure to obtain clean water, food, and fuel. Environmental sustainability and ecosystem services are threatened, however, by the loss of biodiversity, climate change, and inappropriate management systems often caused by land, water, or labor shortages.

In achieving our Goal 2, we will be developing strategies to preserve the natural resource base while improving productivity in rice agroecosystems in the face of changing physical and socioeconomic environments. We will be focusing on land management, biodiversity, water availability and productivity, and the impact of climate change to develop and promote technologies and options to sustain rice-producing environments. Certainly, from the perspective of the environment, the sustainability of intensive systems is of paramount importance. These systems have been producing rice continuously for thousands of years. The human race depends upon intensive rice systems for about half of its food. We cannot allow these systems to deteriorate. So, we are looking very closely at what is happening to them.

b) The Looming Water Crisis

Now, the question is: What are some of the forces that are driving changes in these systems? Well, the shift in water availability is certainly one. Almost two-thirds of the fresh water that is withdrawn for human use in Asia goes into rice production. And, that water is becoming less available because of competing urban centers and industries. I would even say golf courses and fish production are important competitors. By 2025, it's expected that 2 million hectares of Asia's irrigated dry-season rice and 13 million hectares of its irrigated wet-season rice will experience "physical water scarcity," and most of the approximately 22 million hectares of irrigated dry-season rice in South and Southeast Asia will suffer "economic water scarcity" (Tuong and Bouman 2002). The water scarcity due to these shifts in use and the need to reduce water inputs will affect many aspects of crop management, variety choice, soil quality and organic matter, pest populations, productivity, and the environmental impact of these intensive rice-based systems (IRRI 2006a).

We are already developing strategies to meet this looming water crisis head-on by developing an "aerobic rice" system. In this system, specially adapted input-responsive aerobic rice varieties are grown under dryland conditions just like other cereals such as maize, with or without supplemental irrigation

(Bouman et al. 2005). Aerobic rice is higher yielding than traditional upland varieties and combines input responsiveness with improved lodging resistance and harvest index. Using early-generation aerobic rice varieties in the Philippines and northern China, water inputs in aerobic rice systems were 30-50% less than in flooded systems, with yields that were only 20-30% lower, with a maximum of about 5.5 t ha^{-1}. New management systems are being developed to optimize water and nutrient inputs and to ensure long-term sustainability. Without the benefit of continuous flooding, soilborne pests such as nematodes and root aphids, which are virtually unknown in flooded rice, may emerge. We are looking at management techniques and varietal tolerance to solve these problems.

c) The Latest on Climate Change

In terms of the rice–environment interaction, climate change is such a very important area that we have established work on it as a Frontier Project linked to Goal 2. We have already moved forward very quickly in 2006. This past March, IRRI hosted a Climate Change and Rice Planning Workshop to review the state of the art and identify priority areas for research on climate change in rice systems (IRRI 2006b). The invited experts told us that climate change is already affecting Asia's ability to produce rice, and that this could eventually slow our Goal 1 efforts to alleviate poverty on the continent. Research has already confirmed that global warming will make rice crops less productive, with increasing temperatures decreasing yields.

Clearly, climate change is going to have a major impact on our ability to grow rice and I don't think we can afford to sit back and be complacent. So, at the conclusion of that workshop, I announced—in what I think was an unprecedented move—that IRRI would put up US$2 million of its own research funds as part of an effort to raise $20–25 million for a major five-year project to be piloted by an IRRI-led Rice and Climate Change Consortium (RCCC; IRRI 2006b) to mitigate the effects of climate change on rice production. We need to start developing rice varieties that can tolerate higher temperatures and other aspects of climate change right now.

And then, on October 30, the British government published a major report—which British Prime Minister Tony Blair stated is the most important document to be published by his government—on the economics of climate change. Authored by Sir Nicholas Stern, former chief economist at the World Bank, the report suggests that global warming could shrink the global economy by 20% (UK Gov., HM Treasury 2006). Reiner Wassmann, recently arrived coordinator of the new RCCC, and the University of Nebraska's Achim Dobermann, who will be joining IRRI in 2007, contributed to this report relevant information on climate change and rice cropping systems (Wassmann and Dobermann 2006). They stated that rising global temperatures may pose major threats to rice production in Asia due to yield losses that may result from heat-induced spikelet sterility or increased crop respiration losses during grain filling. Incidentally, when I met with Sir Nicholas Stern this past June, he indicated that he is extremely impressed with the integrated mitigation–adaptation program that we have put together for the RCCC (IRRI 2006b).

And, finally, just last week in Washington, D.C., during the Annual General Meeting of Consultative Group on International Agricultural Research (CGIAR), in the spirit of international collaboration, I presented the CGIAR's overall agenda for Climate Change and Agriculture. As a concrete example of the CGIAR's contribution to climate change work, I described IRRI's decade-long project on methane emissions. In the early 1990s, rice production was estimated to be a major source of methane. However, our research was the first to quantify that tropical irrigated rice was a much lower source than assumed (Wassmann et al. 2000a,b)—an important lesson that assumptions must be validated! Dr. Wassmann will present more details on methane emissions far better than I have during tomorrow's workshop on Monsoon Asia Agricultural Greenhouse Gas Emission Studies.

4. Conclusions

Today, I have discussed briefly two of the five goals in IRRI's new Strategic Plan—the ones that time would permit and certainly related to the topic at hand. However, I urge everyone to take a look at our other interrelated and complementary goals involving human nutrition and health, information and knowledge exchange, and access to genetic resources. Details of our exciting Strategic Plan, *Bringing Hope, Improving Lives* (IRRI 2006a), and an excellent overview article (Maclean and Hettel 2006), which appeared in the October-December 2006 issue of *Rice Today* magazine, can be accessed online through links provided in the reference section below.

Our new Strategic Plan endeavors to take us over a modest nine years so that we can contribute significantly to reach the MDGs by 2015. Nevertheless, much of the work outlined here to alleviate poverty and secure environmental sustainability will obviously extend well beyond that date. So, I believe IRRI's long-term future is cemented and that, all in all, we are well positioned for moving forward aggressively to take advantage of new opportunities and, most importantly, to take up difficult challenges that we could only dream about not too many years ago. I am excited about what IRRI will accomplish over the next years and am sure that our partners and colleagues will join in and support us.

I am happy to have been able to use this forum—created by this NIAES International Symposium—to get our important message across to you today. If you remember nothing else of what I've discussed in this keynote, please do remember that, by targeting the MDGs on eliminating extreme hunger and poverty and ensuring environmental stability, among others, we seek profound new opportunities for IRRI and our partners to improve the economic and social well-being of all rice farmers and consumers who will, in turn, be instrumental in sustaining the economic miracle currently under way.

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