Rice Research in Asia: An Introduction

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Guest Editor

With more than 2.7 billion people – most of them poor – relying on rice as their major source of food, it is but appropriate that the importance of rice is commemorated by declaring year 2004 as the 'Year of Rice'. According to the International Rice Research Institute (IRRI), the number of people relying on rice as a major source of food, would go upto 3.9 billion by 2025. Historians following rice cultivation and evolution record that it is the Asia region, more particularly the Korat region of Thailand, the longitudinal valleys of Myanmar, Southwestern China and Assam, that domesticated rice in early times. *Oryza fatua* was one of the early rice species that was recorded from the farmlands. Rice is perhaps the only grain that fed more people in history than any other crop. Asia accounts for 90 per cent of world's production and consumption of rice because of its favourable hot and humid climate.

Demand Specific Challenges

With increasing demand for qualitative production as against quantitative production, the benefits of cultivation of nutritionally rich rice varieties will be realized by farmers only if they get either better yield or market price. It is estimated that one-third of India's rice area was occupied by seven popular varieties. Fifteen per cent of this area

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was planted with varieties released before 1980 while farmers continued to plant traditional varieties on 19 percent of the area.[1] This demonstrates the need to breed varieties which have proven benefits for the farmers. The success of green revolution, many times, is attributed to the fact that adoption of new varieties by farmers was based on the proven yield increase and supportive extension service. New developments using rice biotechnology is still to reach that level of refinement to receive public support.

Studies by IRRI and the International Food Policy Research Institute (IFPRI) indicate that the growing economic prosperity of Asia might force farmers out of rice cultivation due to poor returns and increasing costs of agronomy in the coming years. Reducing per capita availability of land, water and labour are also reducing the rice production in the world. However, to meet the projected demand, the rice production should go up by 70 per cent in terms of the yield during the next three decades. With 45 per cent of rice growing areas in the rainfed conditions, there is a potential for increasing yield from the current 2.0 t/ha to 5.0 t/ha, while in irrigated conditions, such potentials are limited.[2] Ensuring sustainable cultivation of rice, developing suitable production systems adapting to changing conditions and using the genetic diversity available are the key challenges we face today.

New Technologies

One of the possible options for further increases in rice production is through the application of new technologies such as biotechnology and improved agronomy, complimented by traditional farming systems that need to be adapted to changing environment and needs of local people. Rice improvement in many parts of the world, especially Africa and Latin America has benefited from some interventions of biotechnology such as embryo rescue and anther culture achieving yield and quality improvements.[3] Genetic engineering, supported by gene mapping, gene tagging and gene transfer techniques is emerging as a potential area in rice improvement. The rates of success, commercial application, socio-economic impacts of genetic engineering are often debated – some with facts and figures and some with assumptions. However, it is true that biotechnology is certainly moving the pace of rice improvements both in terms of quantitative as well as in qualitative terms.

Undoubtedly rice biotechnology has seen much of advancements in the recent past. Small genome size of rice (about 430 Mb), availability of whole genome sequence (the first food crop for which such information is available)[4], proven public-private partnership in research, availability of genetically diverse germplasm have all contributed to this advancement in rice biotechnology. Studies on Quantitative Trait Loci (QTLs) mapping and Linkage Disequilibrium (LD) mapping have provided needed information on how gene combinations might work under specific environments against particular genetic backgrounds. Pyramiding of genes and multiline constructions in rice has proven to offer precise and authentic information on specific traits, including those controlled by polygenes. More than 60 cultivars belonging to indica, japonica, javanica and elite African cultivars have been used for transformation (genetic engineering) activities. Characters such as herbicide resistance, insect resistance, viral, fungal and bacterial disease resistance; tolerance to drought, salinity, chilling; fortification with micronutrients such as iron and vitamins (Vitamin A in particular) have all been subjected to genetic manipulation.[5] While commercialization of rice varieties that were genetically modified is still to reach critical levels[6], the potential is significant.

While progress in rice breeding using biotechnology seems promising, there are several challenges that still exist. These include: expanding the base of the beneficiaries of the technology, minimizing the risks associated with adoption of the technology for socio-economic systems at various levels industry to environment, misuse of genetic resources for privatisation of information and knowledge, impacts of regional and international trade on such products, linkages to emerging areas of nanotechnology and public good. Addressing these issues is complex given the multiplicity of actors involved and the capacities to address these issues. However, such complexity should not be an excuse for inaction.

Emerging Challenges

Risk assessment and management of genetically modified rice is not only a scientific issue but also a policy and socio-economic issue. Clear national policies on such issues of biosafety supported by suitable awareness raising and capacity building can only help future adoption of the technology and varieties developed through the technology. Consumer choice and public support are important to adoption of rice varieties modified through genetic engineering. Scientists and policy makers need to be clearer on the approaches used and be transparent in their efforts to support adoption of biotechnology. Similarly there needs to be a mechanism to ensure adequate exchange of fact and figures and as a society we assess issues more objectively. It is important here that the missing links between scientific facts and public opinion do not cost dearly the potential use of technology for rice productivity enhancement.

While the need for genetic diversity and characterization of such diversity is the backbone for any future improvements in rice – both by traditional and biotechnological means – the ability of countries to use the diversity for increasing local production is a critical challenge. The centers of origin of rice such as south and Southeast Asia need to work with local communities so that improving traditional cultivars become a potential option through interventions such as participatory plant breeding. Supporting such actions coupled with identification of markets for such varieties is sure to enhance the value of genetic diversity we all are proud of. This brings us to the issues related to trade and intellectual property rights (IPR) offer significant challenges to commercialization of genetically modified rice, the production and consumption patterns at national level would decide on who will use the produce and how. Maturing debates on issues of identifying sources and countries of origin of genetic resources through the Convention on Biological Diversity (CBD) and the World Intellectual Property Organization (WIPO) through debates on Access and Benefit Sharing (ABS) are bound to make issues of patenting and IPR protection more realistic and supportive of local needs. However, the challenges to trade in genetically modified rice will be to related to spread of unauthorized production of modified seed that offer production advantage circumventing biosafety norms, need for labelling and certification that will increase costs of products in the markets and, possible monopoly of certain regions of the world that can develop traits combining productivity with adoption due to technological advantages.

Way Forward

With Asia in the center of debates related to rice production and consumption in the coming decades, it is important that the region realizes the potential of emerging technologies such as biotechnology in feeding its population and achieving both self-reliance and self-sufficiency in rice breeding. Regional efforts to join hands in forming a consortium to support further development and adoption of rice farming technology can be a possible option with countries like Thailand and Myanmar poised for continued expansions and increasing yields. Using integrated approaches to rice farming that include better use of water and being responsive to changing climatic conditions – both in irrigated and rainfed conditions – will be one area that will need more emphasis in the years to come. Recognising the innate genetic potential of traditional varieties that continue to grow in fragile environments and enhancing their yield are as important as supporting technological interventions in breaking potential of rice crop. Development of such varieties and recognition of such varieties through mechanisms such as farmers' rights will be critical for ensuring continued engagement of poor farmers in rice cultivation.

The International Year of Rice comes to a close in December 2004. However, the commemoration envisions rice as the focal point through which the interdependent relationships among agriculture, food security, nutrition, agro-biodiversity, the environment, culture, economics, science, gender and employment can be clearly assessed. This makes rice and its farming a challenge as well as an opportunity. Some of the challenges and opportunities include:

- **Enhancing food and nutritional security.** Although rice is a rich source of energy and protein, it has limited quantities of vitamins and other essential micronutrients. Nutrition can be improved by better rice processing and cooking techniques, the use of rice varieties with high nutritional values, and the fortification of rice with vitamins and minerals (e.g. through applying food technology). Countries should develop the infrastructure to support the responsible utilization of biotechnology and enhance support to increasing diversity in rice-based systems which greatly contribute to rural income and complete nutrition.
- **Improving the productivity of rice-based systems.** Sustainable quantitative and qualitative improvements to rice cropping requires: i) genetic improvements for higher yield potential, ii) better crop management techniques; iii) reduced post-harvest losses, and iv)development of integrated agronomic systems. To achieve these countries need capacity, through training and information exchange, and responsible ways of transferring technologies, including biotechnology.
- **Managing water resources.** There is growing concern about the sustainable availability of water that can be used for irrigation at

global level. Water scarcity can be addressed by reducing the quantity of water required (through developing new rice varieties or improved irrigation/agronomic systems) or by recycling water through multiple uses. The cultivation of rice in low-water regimes will lead to changes in water and nutrient management, cropping patterns and tillage practices. National water policies should be responsive to these issues.

- **Protecting the environment.** Environmental concerns in rice production include indiscriminate use of pesticides, inefficient use of fertilizers, and emissions of greenhouse gases. At the same time, rice-based ecosystems host a wealth of biodiversity, and the majority of the planting material used by poor farmers is derived from seeds that they produce themselves and that represent generations of local genetic resources. Traditional rice varieties and cropping systems should be integrated with modern practices to ensure rice cultivation is not only attractive to local resource poor framers but also justifies investments into continued conservation efforts.
- **Options for synergy.** The overall challenge for rice-based systems is to identify and execute synergetic solutions for rice development, and these are possible only if decision-makers, technicians, farmers and civil society are well aware of the many factors related to sustainable rice production. In addition, sound policies on rice development depend on the harmonization of diverse policy instruments, which are often under the auspices of different ministries. Synergies between instruments such as the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), CBD's Programme of Work on agrobiodiversity, the trade rules of World Trade organization (WTO), the principles of access and benefit sharing are a few of such policies that need better national integration to ensure rice cultivation remains relevant in the decades to come.

The experiences and directions provided in this special issue on 'Rice Biotechnology' offer some insights into the issues and relevance of rice to Asia. Not only the regional cooperation to conserve and utilize rice germplasm is important, but there is also need for recognition of the role of technology transfer in the region to achieve sustainable rice production systems in the years to come. What we need now is not only another revolution in increasing yields but a revolution in ensuring opportunities, awareness and information are more equitable and benefits of actions shared more equally. These need to be based on principles of support and respect to human well being and dignity so that we will have other opportunities to celebrate the role of rice in continuing human well-being.

Endnotes

[1] Janaiah and Hossain (2002).
[2] Hossain (1997) and IRRI (2004).
[3] UNDP-HDR (2001).
[4] Yu *et al.* Goff *et al.* Sasaki *et al.* and Feng *et al.* (2002).
[5] Giri and Vijaya Lakshmi (2000).
[6] Coffman *et al.* (2004).

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