

Preface

The collection, analysis and dissemination of information on rice and rice-based production systems is a major activity of the Secretariat of the International Rice Commission in its mission to promote national and international action in matters relating to the production, conservation, distribution and consumption of rice. In this regard and under the guidance of the FAO Steering Committee of the International Rice Commission, the Secretariat publishes an annual volume of the IRC Newsletter.

The International Rice Commission has 61 member countries, and English, French and Spanish are the official languages of the Commission. Until 2002, the volumes of the IRC Newsletter were published in all three official languages. From 2003 to 2005, however, the Newsletter was published in English only, in order to save the available resources for the preparation and subsequent implementation of the International Year of Rice – 2004, declared by the United Nations General Assembly (UNGA). The successful implementation of the International Year of Rice came to a conclusion in December 2005. The implementation of IYR in 2004 was reported to the Second Committee on Poverty Eradication during the 60th Session of UNGA in November 2005. In its Resolution, the Second Committee on Poverty Eradication of UNGA noted:

the important contribution that the observance of the International Year of Rice, 2004, has made in drawing world attention to the role that rice can play in providing food security and eradicating poverty in the attainment of the internationally agreed development goals, including the Millennium Development Goals.

The 21st Session of the International Rice Commission was held from 3 to 5 May 2006 in Chiclayo, Peru with the main theme of “Rice is Life – Bringing the Implementation of IYR to Farmers’ Fields”. This IRC Newsletter Volume 55 contains mainly the keynotes and papers presented during the Session in order to share the current knowledge, thoughts and visions for sustainable rice production systems.

I am pleased to announce that the FAO Steering Committee has decided to resume publication of the IRC Newsletter in all three official languages of the Commission, beginning with the present IRC Newsletter Volume 55, in order to strengthen the dissemination of information to better serve the Commission’s member countries.

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Improved rice production in a changing environment: from concept to practice

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The rice subsector has experienced three striking events since the last meeting of the International Rice Commission (IRC), held in 2002 in Bangkok, Thailand. First, the United Nations General Assembly adopted Resolution 57/162, declaring 2004 the International Year of Rice (IYR); it was the first time the UN had dedicated this honour to a single commodity. Second, in 2002 world rice production began to increase once again, following three consecutive years of declining production: world production in 2005 stood at around 614 million tonnes of paddy rice (FAOSTAT, 2005). Third, world average yield in 2005 is projected to break the 4 tonnes/ha barrier. An average yield of 4 tonnes/ha may not appear to be a major accomplishment, but considering that rice is grown on over 150 million ha under a wide variety of conditions from irrigated to dryland to floating, an average yield of 4 tonnes/ha is indeed a significant achievement.

There are, however, also negative factors that plague the rice sector. Rice production in sub-Saharan Africa continues to be outpaced by consumption; imported rice now accounts for over 50 percent of sub-Saharan Africa's rice requirement. Rice is rapidly becoming a food staple in the African diet, and low and stagnant rice production accentuates the food security problem confronting much of sub-Saharan Africa. Food shortage in Africa is becoming synonymous with rice deficit. Excessive water usage, environmental degradation due to pesticide and nutrient contamination, methane emission and ammonia volatilization are a few of the adverse affects of rice production requiring urgent attention. Land and water resources for rice production are diminishing and global climate changes may have a major effect on rice production. There are, however, a wide range of technologies available for reducing the adverse consequences of rice production, but the majority have not been extended to the rice grower. Technology adaptation and adoption remain opportunities and challenges.

In consideration of the entire spectrum of events, the 21st Session of the International Rice Commission is

being held in a much more positive environment than most recent sessions. Several of the advances in rice production have emerged from recommendations made at recent IRC sessions, in particular the promotion of improved crop management technologies. The 20th Session in Thailand, as well as the 19th Session in Egypt, made important recommendations for improving yield and bridging the yield gap in irrigated rice. The Expert Consultation on Yield Gap and Productivity Decline in Rice Production in September 2000 in Italy also identified that improved crop management and technology transfer are the principal mechanisms for enhanced yield. FAO and its partners took immediate action on the Commission's recommendations and have made major progress in this important area: there is the potential to enhance the productivity and efficiency of farmers' crop management as well as to help meet global food security requirements. This article gives primary attention to these advances and also reviews other developments that may have important effects on the global rice industry in the near future.

THE CHANGING ENVIRONMENT OF RICE PRODUCTION

Global rice production has met consumption demand during recent decades. However, this situation cannot necessarily be maintained without appropriate action in the near future. The global rice production environment is undergoing substantial changes in numerous areas that require adjustments in rice research and development to support sustainable production.

Increasing rice demand and declining resources for rice production

Worldwide, rice provides 27 percent of dietary energy supply and 20 percent of dietary protein. Rice production nearly doubled during the period from 1970 (316 million tonnes) to 2001 (592.8 million tonnes). The world's rice production, after reaching a peak in 1999, declined during

the 2000-02 period and has been increasing again since 2002 (Figure 1), closing the gap between consumption and production. However, there are still 852 million people suffering from hunger and malnutrition and, due to the steady population increase, rice demand is projected to increase from 571.9 million tonnes in 2001 to 771.1 million tonnes in 2030 (FAO, 2003a).

The world rice harvested area grew from 133 million ha in 1970 to 157 million ha in 1999 (FAOSTAT, 2005), mainly as a result of the increase in cropping intensification. In tropical climate areas with favourable temperature regimes, two or more rice crops can be grown on the same land in a year. Rice-rice and rice-other-crop-rice systems are very popular with farmers in Bangladesh, southern China, southern India, Indonesia, Myanmar, the Philippines and Viet Nam. Rice-rice systems are also widely practised in many irrigated lands in sub-Saharan Africa. Continuous rice production systems are common in much of tropical Latin America.

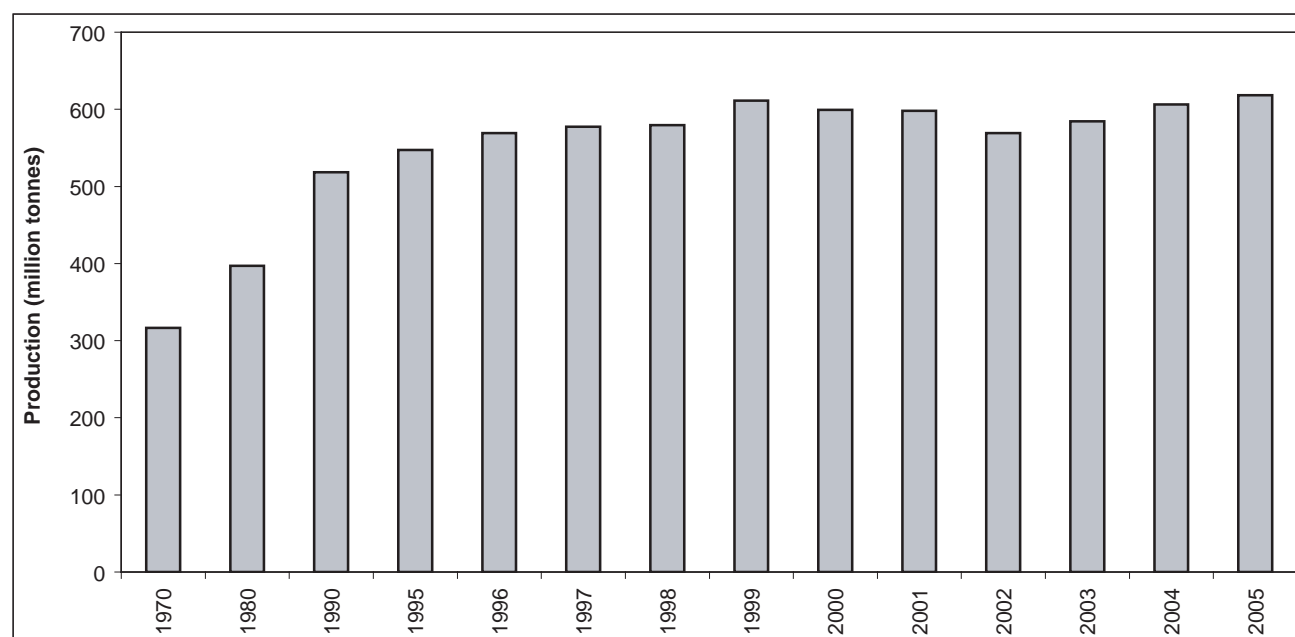
In 2005, the global rice harvested area was 153.5 million ha, i.e. a decline of 3.4 million ha since 1999 (FAOSTAT, 2005). In the near future, the possibility for expanding area under rice-based systems will be limited due to increased competition for land and water from the urban and industrial sectors in the major rice-producing countries in Asia. Outside Asia, inadequate

water supply limits rice cultivation in Spain, Portugal, Egypt and Australia (Nguyen and Ferrero, 2005). The Egyptian Government plans to limit the area under rice production due to the limited water supply. In a number of countries in sub-Saharan Africa and Latin America, there is still considerable land area suited to rice production. High development costs are a deterrent to expanding irrigated rice in Africa. Lack of capital and stable economic policies restrict long-term investment in irrigated rice in Latin America, despite the availability of vast land and water resources.

The accumulation of greenhouse gases in the atmosphere is warming the planet, resulting in changes in the global climate (IPCC, 2001). In 1992, Downing reported that the core agricultural zone in Zimbabwe would be reduced by 67 percent with a 2°C temperature increase (Downing, 1992). A later report suggested that agricultural land in low latitude tropical climate regions may be hardest hit by temperature increases (Rosenzweig and Iglesias, 1994). Recently, Darwin *et al.* (2005) estimated that the amount of land classified as “land class 6” – the primary land class for rice, maize, sugar cane and rubber in tropical areas – would decline by 18 to 51 percent in the next century as a result of global warming.

Increasing the productivity of the rice systems has proven an effective means of conserving water and of

FIGURE 1
World rice production



Source: FAOSTAT, 2005.

decreasing greenhouse gases in wetland rice systems by reducing the area under production. The large-scale adoption of hybrid rice (about 50 percent of total rice area) permitted China to increase production from 128 million tonnes in 1975 to 191 million tonnes in 1990, while reducing the rice harvested area from 36 million ha in 1975 to 33 million ha in 1990 (Nguyen, 2004). Increase in productivity has translated into a substantial reduction in the total amount of water consumed in rice production. The practice of intermittent irrigation is also expanding as a potential alternative to the relatively high rate of water consumption in fully flooded irrigated rice.

Changing policy, trade and market agreements

Historically, rice trade has accounted for only a small amount of world rice production; until recently, it was considered relatively unimportant. Rice is generally thought of as the “most protected” crop, since governments have historically intervened in pricing, input supplies, procurement and trade. However, trade in rice has grown into a major international business with the global rice trade amounting to over 26 million tonnes (milled) in 2004, and growth is projected to continue (Calpe, 2005).

Rice protection policies in both developing and developed countries are becoming contested issues in world trade negotiations. The trade liberalization policies resulting from the Uruguay Round of the GATT (General Agreement on Tariffs and Trade) conference in the late 1990s are often considered to be the driving force behind the rapid increase in rice trade. Likewise, failure to reach an agreement at the World Trade Organization (WTO) Cancun meeting was precipitated by agriculture, and rice trade was a major issue.

The questions of market access and export subsidies remain to be resolved. Domestic price support is difficult to negotiate due to the historical importance of rice as a food and a source of income in many major rice-producing countries. Although the international rice trade is still relatively small and accounts for only 7 percent of world production, trade has been shown to assist in reducing large fluctuations in national rice prices and has had a calming effect on world prices.

National rice policies are in a continuous state of evolution, and more changes are anticipated as world production and consumption equalize and other sectors of the economy become increasingly important in the major rice-producing countries. Consequently, rice is no

longer viewed as just a subsistence crop in the world market but increasingly as a tradable commodity. Recent studies reported that complete trade liberalization would increase rice trade by between 7 and 73 percent (depending on grain type), increase export prices by 2 to 91 percent, but decrease consumer prices by 18 to 27 percent. Total economic gain from complete liberalization would amount to US\$7.4 billion annually with over two-thirds of the gains going to importing countries or rice consumers (Wailes, 2004). This illustrates the potential economic gains and losses involved in rice trade agreements. Although it has not been quantified, similar reductions in government subsidies in the United States and Europe would have major impacts on world trade and rice prices.

Diminishing labour supply and increased concern for environmental conservation

Rice cultivation in many countries is labour-intensive. Labour shortages are being experienced in many rice-producing areas, especially those near urban centres, as farmers migrate to seek more lucrative employment in other sectors of the economy. The labour supply for rice production is diminishing in a number of Asian countries (Pingali, Hossain and Garpacio, 1997). Farm mechanization will be required to sustain rice production as migration from rural to urban areas increases with industrial development. There is a need to foster sustainable mechanization, which is environmentally friendly, ecologically sound and less resource demanding. Direct seeding is growing in popularity in Asia due to labour shortages for transplanting. It requires rice varieties with thicker stems and which are less susceptible to lodging, as well as better land levelling and preparation to ensure adequate plant establishment.

Environmental considerations play an increasingly important role in rice production. Contamination from pesticides and fertilizers is under close scrutiny; programmes such as integrated pest management and integrated nutrient management offer viable alternatives. Reduced subsidies for fertilizers will require greater efficiency; this in turn will bring about changes in cultural practices. In general, the major rice-producing countries have low N-use efficiency. Technology for higher N-use efficiency is available, but has not been adopted by most rice producers. New paradigms in technology transfer are required to expand the use of proven technologies in pest management, fertilizer usage and water management.

Shifting consumer preference and malnutrition in rice-consuming populations

Nutritional value is normally not considered a qualitative factor. The nutritional contribution of rice was reviewed extensively in the 2002 IRC Session (Kennedy, Burlingame and Nguyen, 2003). Essentially, rice in developing countries is an important source of:

- carbohydrates (27-50 percent of dietary energy supply);
- protein (20-50 percent of dietary protein requirements); and
- fat (3-27 percent of dietary requirements).

The variation in meeting dietary requirements is explained by the wide range of rice consumption. In countries such as China and India, rice supplies approximately 9 to 17 percent of the recommended nutrient intake (RNI) of calcium, foliate and iron and nearly 20 percent of the RNI of zinc. In general, rice contains adequate levels of B vitamins (thiamine, riboflavin and niacin) but contains little vitamin C, D or beta-carotene (vitamin A). The bran contains the highest level of dietary fibre, minerals such as Ca, K, Fe, Zn and P, as well as most of the B vitamins. Consequently, rice processing (milling and polishing) significantly reduces the nutritional quality of rice. Most high-yielding varieties contain less than 1.5 mg iron/100 g, but germplasm has been identified containing twice this quantity (Graham *et al.*, 1999; Juliano, 2003). However, iron nutrition is complex and a major problem is the low bioavailability (often only about 18 percent). In addition, there are numerous inhibitors of iron absorption, including phytic acid, polyphenols, vegetable proteins and calcium, as well as enhancers of absorption, including ascorbic acid, organic acids and animal tissues (meat, fish and poultry).

Extensive research is underway to improve the nutritional quality of rice, using both conventional breeding methods and biotechnology. Variation within the species permits the use of conventional breeding methods to improve nutritional characters, avoiding the difficulties with genetically modified organisms (GMOs) (Graham *et al.*, 1999; Kennedy, Burlingame and Nguyen, 2003). Data in Table 1 show the wide range of protein content in rice varieties around the globe. Senadhira, Gregorio and Graham (1998) also reported large variations in the zinc and iron content of different rice varieties. Attempts to improve beta-carotene content led to the "Golden Rice" phenomenon in the mid-1990s, but difficulties encountered in engineering led to delays in its commercial development. Many of these difficulties may now have been resolved and promising new research points to higher levels of beta-carotene (Beyer *et al.*, 2002). Efforts are also underway to increase iron content via several methods, including genetic modification using the ferritin gene from the common bean (Lucca *et al.*, 2000). Although work is at an advanced stage, a major limitation remains consumer acceptance of GMO rice.

Higher incomes as a result of developments in the manufacturing sector are leading to greater demand for higher quality rice. The price of aromatic rice such as Basmati and Khao Daw Mali is much higher than that of HYVs (high-yielding varieties) and the demand for aromatic, soft and long-grain rice continues to increase with improvements in the income of rice-consuming populations, especially in many European countries (Ferrero and Nguyen, 2004). Currently, high quality rice accounts for 75 percent of the international rice trade (Calpe, 2005). Rice breeders will have to be more stringent on grain quality characteristics to meet the requirements of sophisticated consumers.

TABLE 1
Protein content in grains of rice planted around the globe

Source	Sample number	Range of protein content (%)
<i>Oryza sativa</i> L.	2 674	4-14
• Asia	1 626	4-14
• Australia	24	5-10
• North America	190	4-13
• South America	301	5-13
• Europe	233	5-13
• Africa	300	5-11
<i>Oryza glaberrima</i> Steud	195	9-14

Source: Juliano and Villareal, 1993 (adapted).

Emerging partnerships in research and development

The contribution to rice producers and consumers from research conducted at the international research centres under the CG (Consultative Group [on International Agricultural Research]) system is significant and unquestionable. Both consumer and producer have benefited tremendously from the advances made in research. Further refinements in pest and disease resistance breeding and improved grain quality have added further value to the high-yielding plant types that drove the Green Revolution in the 1960s and 1970s. The worldwide benefits of the Green Revolution were seen in the yield increase of 1.7 tonnes/ha (Figure 2). Although not readily apparent, agronomic research conducted following the Green Revolution is the primary factor fuelling current yield increases.

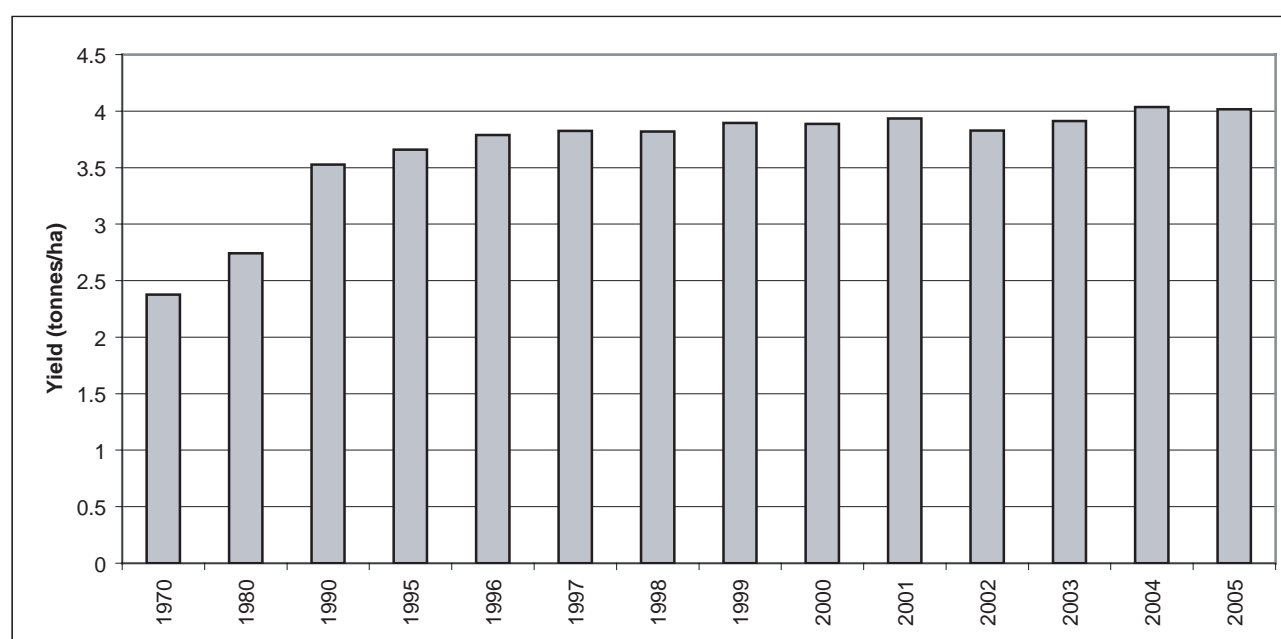
The CG centres have fostered closer collaborations with national programmes and non-traditional partners, partly as a result of the reduction in resources. The participatory approach to research has helped the centres focus more sharply their research activities. Furthermore, centre-wide initiatives were introduced to reduce duplication of efforts and more cost-effective research programmes. The CG centres have historically been the source of new technologies; current research from these centres and elsewhere will contribute to the continuing

effort to further increase rice production that is less resource demanding and less damaging to the environment.

Public sector research and extension programmes have traditionally assumed responsibility for national enhancement of rice production in many countries. In Latin America, however, the demise of the public sector efforts during the 1990s due to structural re-adjustments resulted in the surfacing of a national growers' association as a primary conduit for rice research and development. Currently, the private sector accounts for nearly 80 percent of all expenditures on rice research and development in Latin America. A similar retraction in public sector support to rice has occurred in much of Asia, but the private sector has not often assumed a stronger role in rice development. Little funding is available for laboratory-level or on-farm research activities.

The private sector is an untapped resource for rice development. Private seed companies, fertilizer suppliers, pesticide companies etc. depend on economically successful farmers to be successful themselves. The advancement of technologies that increase farmer profits also produces increased sales of essential inputs. Recently, non-governmental organizations and the private sector have begun to actively invest in rice research, especially in the field of rice biotechnology (Brookes and Barfoot, 2003).

FIGURE 2
World rice yield



Source: FAOSTAT, 2005.

Policy-makers as well as researchers and extension personnel, therefore, need to examine alternative means of support for vital rice research and development. State and district governments are assuming more of a role in several countries, NGOs are operating in all areas of development, input suppliers have a vested interest in the advancement of rice, and millers require paddy to operate. Establishing partnership linkages within the rice chain to pool revenue for research and development is feasible, since all sectors have a vested interest in the success of the crop. Promoting research and development through growers associations is an attractive alternative. For example, FLAR (Latin American Fund for Irrigation Rice) not only derives funds for rice research and development from producers and millers, but it has established agreements with commercial seed and chemical companies. Expanding and widening partnerships among the public sector, NGOs and the private sector will be a central challenge for rice research throughout the world. The FLAR model should be examined by other countries.

FROM CONCEPT TO PRACTICE: CASE STUDIES ON CLOSING THE YIELD GAP IN IRRIGATED RICE PRODUCTION

The 19th Session of the IRC in 1998 directed special attention to the yield gap in irrigated rice and noted that bridging the yield gap was the most appropriate means of increasing yield and profitability in the highly productive irrigated sector. Subsequently, in 2000, FAO organized in Rome an Expert Consultation on Bridging the Yield Gap that provided a forum for analysing the extent of the yield gap in the major rice-producing regions and developing action plans for addressing the problem. These two events, combined with the 20th Session of the IRC, provided the basis for formulating the concept of rice integrated crop management to enhance productivity in irrigated rice, which was then articulated by the Secretariat of the IRC (Nguyen, 2002; Clampett, Nguyen and Tran, 2003). After the 19th Session of the Commission, FLAR, with assistance from the Common Fund for Commodities (CFC), commenced efforts to close the yield gap in several Latin American countries. FAO has assisted Indonesia, the Philippines, Thailand and Viet Nam in initiating activities in integrated crop management and technology transfer. The International Rice Research Institute (IRRI) in collaboration with Indian institutions has also undertaken activities to address the yield gap

problem. Finally, a new “compost-based” concept for smallholders emerged from Madagascar and is referred to as the system of rice intensification (SRI). While the activities are being pursued by different organizations, often with distinct methods, they all have the common objective of increasing on-farm yields through the use of improved crop management.

Asian case studies

Improved crop management programmes are also being implemented in several Asian countries, including the Philippines, Indonesia, Viet Nam and India. The programmes are being implemented by several institutions using different technologies and methods of technology transfer. Results from several of the countries are presented in the 2005 issue of the International Rice Commission Newsletter (Vol. 54).

Indonesia

Much research, development and assessment of integrated crop management (ICM) has been carried out by numerous national institutions in Indonesia during the last 5 years (Abdulrachman, Las and Yuliardi, 2005). The programme has evolved from a discipline-oriented on-farm research programme into an active integrated extension programme that utilizes ICM as a methodology with a set of principles for guiding farmers in managing the rice crop with emphasis on the following areas:

- Selection of rice variety for high yield and use of quality seed.
- Planting of young and healthy seedlings.
- Incorporation of organic manure and basal fertilizer prior to transplanting and use of the leaf colour chart for predicting the need for nitrogen top-dressing.
- Use of intermittent irrigation.
- Frequent mechanical weeding.
- Control of pests and diseases based on regular field observations.

The rice ICM system was first evaluated in Grobogan District, Central Java in the wet season (Nov.-Feb.) of the 2000/01 cropping season. In the 2001 dry season, the assessment became part of the National Integrated Crop Management Network of the Indonesian Agency for Agricultural Research and Development (IAARD) and was conducted in seven provinces. In 2002, the Integrated Rice Development Project (P3T) was initiated and developed in 31 districts, located in 14 provinces. The

TABLE 2
Range of yield changes due to application of ICM methodology in 26 villages in Indonesia during three cropping seasons, 2001-02

Range (%) of yield change due to application of ICM	Number of villages
Increase of > 30% to < 50%	6
Increase of > 20% to < 30%	7
Increase of > 10% to < 20%	8
No increase	4
Decrease of > 3%	1
Total number of villages under observation	26

assessment of the impact of the application of the rice ICM system during 2001/02 showed that the application of ICM methodology positively increased yield in 25 villages (out of the 26 villages assessed), with yields increasing by more than 20 percent in 13 villages (Table 2). The programme found that new varieties, seed treatment and rodent control were the preferred features of the ICM programme. In contrast, use of the leaf colour chart, organic fertilizer and soil analysis to predict P and K requirements were least accepted by growers.

Philippines

The Philippine Rice Research Institute is implementing a rice integrated crop management system, referred to as PalayCheck (Cruz *et al.*, 2005; Olvida, 2005; Publico, 2005). The programme is based upon the application of key checks and is similar to the Australian RiceCheck programme. Technological interventions consist of eight checks, namely:

- use of high quality seed;
- land-levelling;
- reduced density and early transplanting;
- use of leaf colour chart for monitoring N nutrition;
- monitoring of panicle size and density;
- water management;
- control of pests, diseases, insects and weeds; and
- harvest at early maturity.

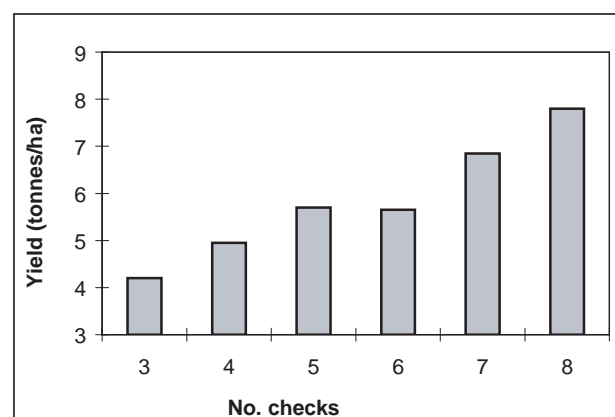
A large number of on-farm demonstration plots show that full compliance with the checks results in yields of over 8 tonnes/ha compared to an average of 4.5 tonnes/ha with conventional crop management (Figure 3). Yield is highly related to adoption of the key checks and ranges from about 4 tonnes/ha from farmers who achieved three key checks to over 8 tonnes/ha from farmers who achieved all key checks. Similarly, gross profit margins nearly doubled from US\$421/ha to US\$828/ha, due mainly to

increased yield. Although some farmers reported high yields, especially during the dry season, the overall impact was limited because the checks were only partially adopted; only 20 percent of the farmer-cooperators followed all eight recommendations. Farmers seldom adopt technologies as “packages”; they normally select component practices that they view as more important. Adoption of several practices (in this case, eight) requires time and much effort. Therefore, during the initial phase of introducing the technologies, it may be necessary to reduce the number of technological interventions resulting in a simpler technical message.

Viet Nam

Viet Nam is employing an integrated crop management programme called “3 Increases, 3 Reductions” (Pham, Trinh and Tran, 2005). The application of this programme follows a participatory approach in which the technology is introduced, tested and subsequently modified based on farmer experience. The programme has not to date resulted in substantial increases in rice yield. Yield increases ranged from 1.7 to 6.3 percent in three cropping seasons in two districts during 2002-04. However, the programme reduced production costs as a result of the decrease in the quantities of fertilizers, pesticides and seed; there were also improvements in grain quality. Rice produced with the “3 Increases, 3 Reductions” programme was cleaner (as a result of the lower incidence of disease infection), resulting in higher whole grain yield from milling. As a result, profits increased from US\$44 to US\$64/ha/season (Pham, Trinh and Tran, 2005).

FIGURE 3
Yield increase related to use of checks, Philippines



Source: Cruz *et al.*, 2005 (adapted).

India

Collaboration between IRRI and Indian scientists led to the development of an ICM programme incorporating technologies from various sources. The ICM programme is built upon five management factors (Balasubramanian *et al.*, 2005):

- early transplanting (4-leaf stage);
- one seedling per hill;
- square transplanting (0.225 × 0.225);
- early and frequent mechanical weeding; and
- intermittent irrigation.

Yield increase on research farms using the five management factors ranged from 35 to 48 percent. Removal of a single component caused the following yield depressions:

- 19 percent due to late weeding;
- 16 percent due to transplanting older seedlings;
- 14 percent due to transplanting more than one seedling per hill; and
- 10 percent due to infrequent irrigation.

On-farm demonstration plots reported yields of 6.6 tonnes/ha with ICM and 4.4 tonnes/ha with conventional management, i.e. a 50 percent yield increase. Profits increased more than threefold from US\$105/ha to US\$369/ha, due to improvements in crop management. The programme is currently developing procedures for widespread dissemination of ICM technologies.

Latin American case studies

Following the recommendations that emerged from the 19th Session of the IRC in 1998 and the Expert Consultation on Bridging the Yield Gap (FAO, Rome) in 2000, FLAR obtained assistance from the CFC to initiate

efforts to bridge the yield gap in several Latin American countries. The following is a summary of the results of this effort in southern Brazil, Venezuela (Bolivarian Republic of), Costa Rica and Nicaragua.

Brazil (Rio Grande do Sul)

Average irrigated rice yield in the state of Rio Grande do Sul in southern Brazil stagnated at 5.2 tonnes/ha in the last 15 years. In 2003/04, FLAR, in collaboration with the state rice growers' association, Rio Grande Rice Institute (IRGA), initiated activities to improve yield through the introduction and promotion of improved crop management (Pulver and Carmona, 2004). The salient features of the technical intervention focus on six strategic management practices:

- Planting date to expose the crop to high solar radiation during the reproductive period.
- Reduced seeding density to produce healthy plants that are less susceptible to lodging with less incidence of foliar diseases.
- Improved pest management based upon insecticide treated seed.
- Balanced nutrition in sufficient quantities for high yield.
- Early weed control.
- Appropriate irrigation water management.

The six practices must be applied in an integrated manner and with precision. Simply adopting one or two of the improved practices and omitting others does not result in the anticipated increase in yield. Likewise, applying the practices at an inopportune time or under inappropriate conditions does not produce the desired results.

In the first year of the project (2003/04), demonstration plots were established on 17 sites. Farmers who applied

TABLE 3

Summary of yields obtained with the most appropriate technology in demonstration plots established on farms with farmer leaders

Region	Yield (tonnes/ha)			
	District average	Farmer yield	ICM	Yield increase over district average
Fronteira Oeste Region – 7 sites	5.9	6.7	10.0	4.1
Campanha Region – 2 sites	5.5	5.5	10.0	4.5
Depressão Central Region – 5 sites	5.6	5.8	9.0	3.4
Average of all regions – 14 sites	5.7	6.2	9.7	4.0

Source: Pulver and Carmona, 2004 (adapted).

all the practices with precision obtained an average yield of 9.7 tonnes/ha, which is 4 tonnes/ha greater than the regional average and 3.5 tonnes/ha greater than the adjacent commercial fields of the participating farmer (Table 3). From the demonstration plots, established on two sites of commercial size, yields of 12 tonnes/ha were recorded. These are the highest yields that have ever been reported in the state and clearly show that very high yields are feasible even with currently available varieties when accompanied by improved crop management.

In the second year, the programme expanded to cover 52 sites. The mean yield of demonstration plots comprising over 8 000 ha was 9.1 tonnes/ha (2.3 tonnes/ha greater than commercial fields on the same farm) (Table 4). Growers who adopted all the practices but not in the degree required had an average yield of 7.8 tonnes/ha (1.6 tonnes/ha greater than the regional average during the same season). These farmers generally did not reduce the seeding density to the required level. Growers who partially adopted the improved practices obtained a yield of 7.1 tonnes/ha (1.0 tonnes/ha greater than the regional average). Finally, growers who attended only one or two field events and attempted to use the technology but in an imprecise manner reported an average yield of 6.5 tonnes/ha, representing a yield increase of only 0.8 tonnes/ha above the regional average. The varying level of success, depending upon the degree of adoption of the technology, is similar to the yield responses experienced with the adoption of “production checks”, popularized by the Australian RiceCheck programme.

In just two growing seasons, the programme incorporated 1 600 farmers over an area of approximately 200 000 ha into the improved crop management programme. The large number of participants and the rapid adoption of the technology are principally due to the

extension methodology employed, that is, the “farmer-to-farmer” method. This system is based on farmer-to-farmer exchange, resulting in the autonomous diffusion of technologies. In addition, the use of large-scale demonstration plots provides convincing evidence that the technology being transferred is relevant, easily adjusted to different conditions and simple to adopt.

Venezuela (Bolivarian Republic of)

During the last two decades, the mean rice yield in Venezuela (Bolivarian Republic of) has remained stagnant at 4 to 4.5 tonnes/ha. In the 2003 season, the CFC/FLAR project commenced, providing assistance to the national rice growers’ association (FUNDARROZ) with the objective of developing a coordinated technology transfer system (Pulver and Rodriguez, 2004 and 2005). The project collaborates with eight organizations, accounting for approximately 115 700 ha of irrigated rice (nearly 80 percent of the total rice area in the country). During the 2003/04 dry season, demonstration plots with improved management technology gave excellent yields, often exceeding 9 tonnes/ha. The agronomic practices that resulted in improved yields were based on four concepts:

- date of planting that permits the crop to receive maximum solar radiation during the reproductive phases;
- N fertilizer management resulting in high N efficiency;
- early weed control; and
- improved irrigation water management.

In the second year of the project, two additional practices were added:

- use of insecticide-treated seeds to control insect outbreaks during crop establishment; and

TABLE 4

A summary of farmer participation, adoption of improved practices and the resulting impact on yield, production and income for the 2004/05 cropping season

All regions 2004/05 season	No. farmers	Area (ha)	Yield (tonnes/ha)	Yield increase (tonnes/ha)	Production increase (tonnes)
Farmer leaders	52	8 467	9.1	2.3	19 124
Farmers with assistance	115	25 805	7.8	1.6	42 291
Farmers without assistance	268	52 107	7.1	1.0	53 154
Indirect participants	1 171	114 209	6.5	0.8	92 247
Total	1 606	200 588			206 816
Value of increased production @ US\$150/tonne					US\$31 022 400
Increased income/farmer					US\$19 317

Source: Pulver and Carmona, 2005 (adapted).

- lower planting density to reduce foliar disease and cost of treated seeds.

National yields in Venezuela (Bolivarian Republic of) are increasing at a faster rate than in any other Latin American country (FAOSTAT, 2005). The current national yield of 5.2 tonnes/ha is approximately 0.5 tonnes/ha greater than the national average prior to the CFC project. Numerous demonstration plots as well as commercial fields have demonstrated that yields of 6 to 7 tonnes/ha are readily feasible during the rainy season and yields of 8 to 10 tonnes/ha are obtainable during the dry season when solar radiation is abundant.

Costa Rica

Mean irrigated rice yields in Costa Rica have stagnated at about 4 to 4.5 tonnes/ha over the last 15 years. In the 2003/04 season, demonstration plots were established using the six strategic management practices developed for Venezuela (Bolivarian Republic of), but modified to suit local conditions. On two cooperating farms on a semi-commercial area, yields of 7.5 tonnes/ha (approximately 3.5 tonnes/ha greater than the national average yield under irrigation) were obtained (Oviedas, 2005). In the 2004/05 season, the improved practices were extended to six commercial farms and 1 500 ha were planted using the six strategic practices, resulting in an average yield of 6.5 tonnes/ha (2.3 tonnes/ha greater than the national average). In the same season, demonstration plots planted

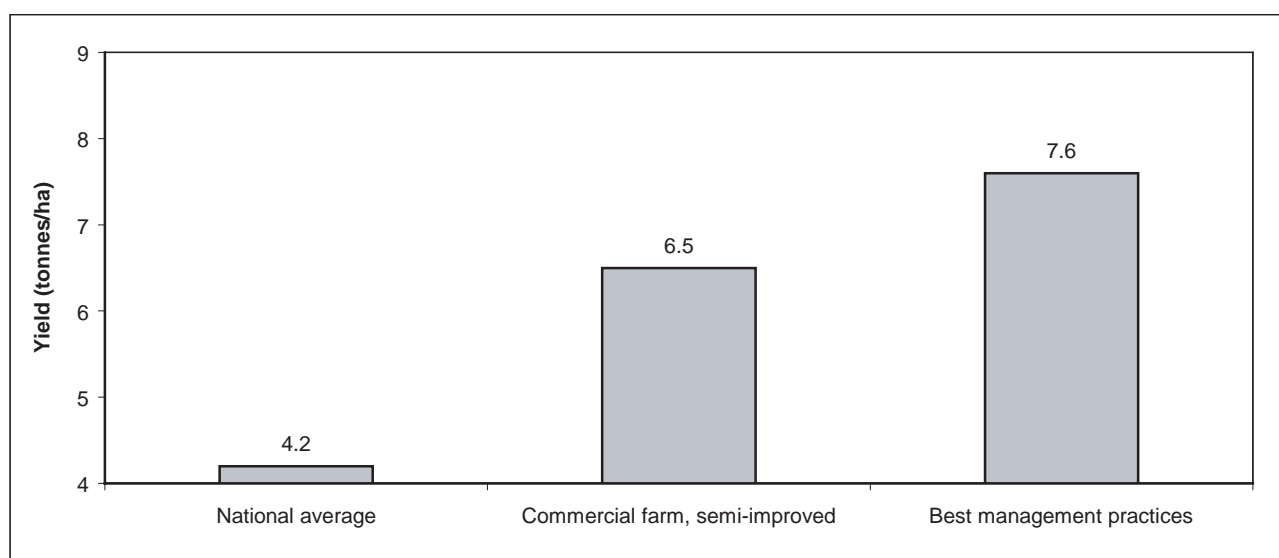
on the same farms using “best management practices” gave an average yield of 7.6 tonnes/ha over an area of 360 ha (3.4 tonnes/ha greater than the national average) (Figure 4). The “best management practices” are essentially further modifications of the six strategic practices for Costa Rican conditions.

Nicaragua

Yields obtained in the irrigated production system were approximately 4 tonnes/ha during the last decade. The last two seasons saw the FLAR/CFC project, in collaboration with the national rice growers’ association (Asociación Nicaragüense de Arroceros – ANAR), introduce improved crop management practices. The technology consisted of the same six strategic management practices described for Brazil and Venezuela (Bolivarian Republic of), but they were adjusted to the conditions of Nicaragua.

In the 2003/04 season, the technology was introduced on one commercial farm. Yield with improved management was 9.7 tonnes/ha (5.3 tonnes/ha greater than the national average under irrigated conditions). In the second season, the same technology was extended to four commercial farms. The average yield of the “best management practice” farms was 9.9 tonnes/ha (Pulver, Bejarano and Mendez, 2005). Participating farmers also began utilizing the technology and reported an average yield of 7.4 tonnes/ha. These yields are 3 to 5.5 tonnes/ha greater than the national average (Figure 5).

FIGURE 4
Yield in Costa Rica



African case study

The system of rice intensification (SRI) was developed in Madagascar in 1986 and has recently been spreading to Asia (Stoop, Uphoff and Kassam, 2002 and 2004; Stoop, 2003; Uphoff, 2005). SRI is based upon:

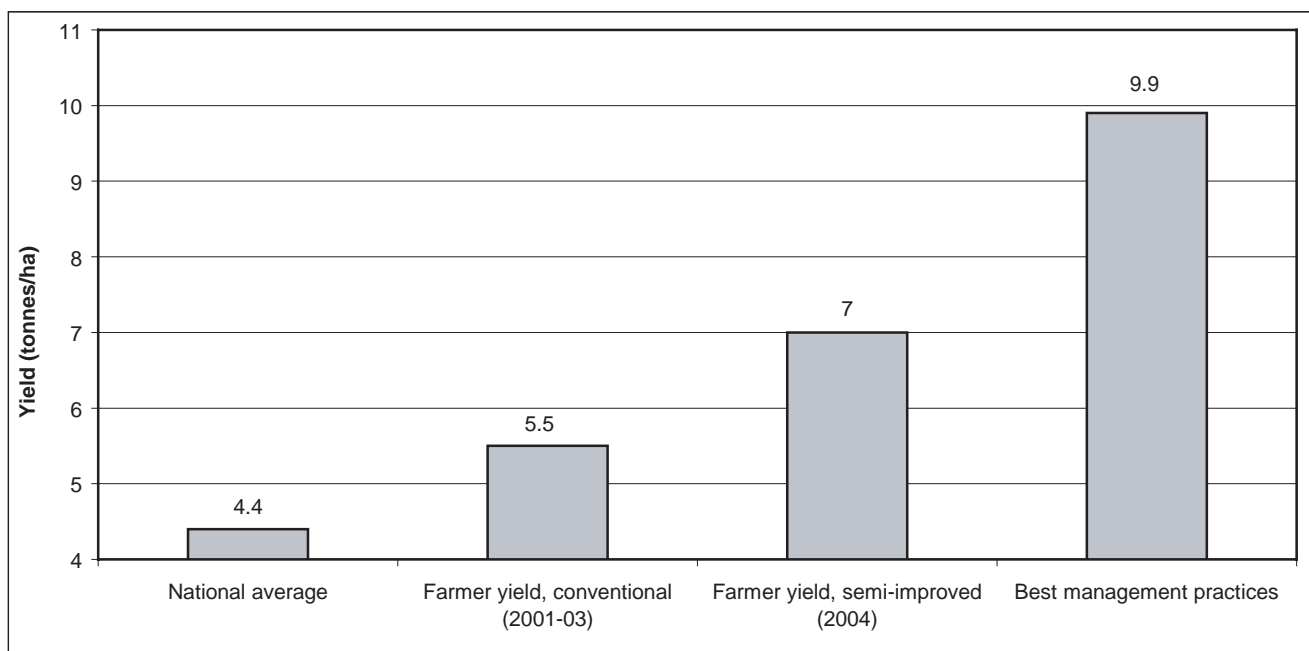
- early transplanting of clean seedlings;
- careful attention to transplanting to avoid root injury;
- transplanting at pre-determined spacing (0.25×0.25 m in unfertile soil and up to 0.50×0.50 m in fertile soil);
- frequent hand weeding before canopy closes;
- use of large amounts of compost or organic amendments; and
- intermittent irrigation to maintain the soil constantly moist during the vegetative stage followed by flooded conditions during reproduction.

The SRI system has been called unconventional, despite the fact that the technology employed has been well known for decades (Doberman, 2003; Sinclair, 1993; Sheehy *et al.*, 2004). Use of high quality seed is known to provide a yield advantage of 10 to 15 percent; transplanting before the 4-leaf stage increases yield by approximately 16 percent (Balasubramanian *et al.*, 2005); a weed-free environment is essential for high yields; and numerous sources of organic matter contain sufficient nutrients for high yields if applied in sufficient quantity.

Intermittent irrigation is feasible where it is possible to control weeds manually. It has been practised for decades in the Tolima area of Colombia and high yields are the norm, often exceeding 10 tonnes/ha. However, weed control costs often reach US\$400/ha, due to dependence on chemical weed control and the need for repeated applications in the absence of flooded conditions to provide residual weed control. This does not appear to be a limitation for small farms, which are the focus of the SRI programme and where frequent hand weeding is feasible.

Management of inorganic N fertilizer (urea) is a major problem without the water control provided by flooded conditions. Ammonia volatilization is a huge problem with surface applications of urea; it can be significantly reduced by applying urea on the dry soil surface followed by establishment of a permanent flood to prevent nitrification/denitrification. In contrast, nutrients derived from the degradation of organic compost are essentially “slow release” with minimum losses. Some composted materials contain high levels of nutrients (e.g. chicken manure), and if applied in sufficient quantity they provide adequate nutrients to support high yields. However, not all compost is rich in nutrients, especially N. Given the wide variation in nutrient content of diverse compost, the SRI programme requires a more precise definition of suitable organic compost.

FIGURE 5
Yield in Nicaragua



Summary of case studies

The case studies from several countries in Asia, Latin America and Madagascar implemented under distinct socio-economic settings, employing different technologies and methods of transfer, have several features in common:

- High yields of irrigated rice are readily obtainable with improved crop practices utilizing current varieties. Yields in on-farm demonstration plots and commercial areas in southern Brazil routinely surpass 10 tonnes/ha and yields as high as 12.3 tonnes/ha have been obtained. Yields in Venezuela (Bolivarian Republic of) in the dry season often surpass 10 tonnes/ha in large areas. In Nicaragua, yields of over 12 tonnes/ha have been recorded in on-farm demonstration plots. In the Philippines, a yield of 11 tonnes/ha was recorded in demonstration plots using the PalayCheck technologies. Similarly, high yields often exceeding 8 tonnes/ha have been reported in lowland rainfed rice in Indonesia when grown under improved management. The SRI programme has also reported exceptionally high yields. An eminent rice scientist stated that the yield increases due to improved crop management are comparable to the yield advances experienced during the Green Revolution and referred to the advances occurring in crop management as the “Agronomic Revolution” in rice (Jennings, 2004).
- Observations from Asia and Latin American countries indicate that varieties are not the only limitation to improved yield. Currently available varieties are capable of yielding over 10 tonnes/ha and farmers are exploiting less than 50 percent of the yield potential of available genetic material. The yield gap – the difference between yield potential and actual yield – is due to lack of application of improved crop management practices. New genetic material will only be beneficial if accompanied by improvements in crop management; otherwise, yield expression will be limited by deficiencies in crop management, as has been the case since the Green Revolution. On the other hand, improved crop management offers the opportunity for plant breeders to develop genetic material with higher yield potential. For example, FLAR breeders, recognizing the yield limit of current varieties, have adjusted their breeding programme to focus on identifying genetic material with higher yield potential to link to improved crop management.
- High yields are more feasible in more favoured ecologies. Irrigated areas are easier to impact than less favoured ecologies; nevertheless, advances have also been reported in the lowland rainfed ecology. Within the irrigated sector, high yields are dependent upon adequate solar radiation. Yield advances are more frequently recorded during the dry season in the tropics or in temperate environments, where solar radiation is not a yield-limiting factor. Yield during the wet season in the tropics is limited, most probably due to low levels of solar radiation. All high-yielding environments, such as California, Australia, Egypt, coastal Peru and the southern cone of South America, also exhibit high levels of solar radiation. Under tropical conditions, adjusting the planting date to encounter high solar radiation during the critical phase of panicle initiation to flowering is one of the primary factors resulting in high yields reported in the case studies in Latin America.
- Focusing production during the dry season and under irrigation presents opportunities for alternative uses of land resources during the wet season and in less productive ecologies. At current rice prices, production during the low-yielding wet season and in stressed ecologies may often not be economically viable. Rice prices have been declining for decades and as production and consumption equalize, there will be more pressure for lower paddy prices (Dawe, 2004). The low level of return on labour in rice production often confines farmers to poverty. Use of simple water harvesting techniques permits production during the high solar radiation dry season. Alternative land use and income-generating practices are also required. Fish production may provide more income than rice during the wet season. Livestock rotated with rice is an attractive alternative in many areas and is already widely practised in the temperate regions of Latin America. In Asia, traditional thinking encourages rice production during the monsoon season since rice can tolerate excessive water.

However, further yield improvement during the wet season may be limited due to the low level of solar radiation. More thought is required to identify alternatives to rice farming during the solar-radiation-limiting wet season and other less favoured ecologies.

- To date, the efforts in integrated crop management have been carried out mainly by FAO and some government institutions in four Asian countries, by IRRI and institutions in India, and by FLAR in Latin America (as well as growers' associations in a number of countries). The transfer of SRI was carried out by conservation groups and NGOs. Traditionally, technological developments in rice were derived primarily from research activities at the CGIAR centres. The CG system may have over-emphasized variety development at the expense of crop management following the success of the Green Revolution, resulting in a missed opportunity and decades of yield stagnation, especially in the high-yield-potential irrigated system (Jennings, 2004).

Variety improvement merits sustained attention in order to address the yield potential barriers. Varieties with higher yield potential will be essential for a sustainable increase in rice production under conditions of diminishing land and water resources and taking into account the potential impacts of climate changes, such as high temperature regimes and increased area under tidal influence due to the rising sea level. The achievement of mapping the rice genome in 2002 creates new opportunities for the application of genetic resources in rice variety improvement by allowing scientists to identify and functionally characterize the genes and biochemical pathways that are responsible for agronomic performance, resistance to biotic and abiotic stress and consumer quality (Khush, 2004).

Outstanding issues in extension of crop management practices

Efficient and effective technology transfer programmes

The case studies provide convincing evidence that there are major differences between the transfer of improved crop management practices and simply introducing new varieties. Seed-based technologies are relatively easy to introduce and expand due to farmer-to-farmer exchange

of seed. In contrast, improved crop management is “knowledge-based” and considerable effort is required to educate growers. Farmer-to-farmer exchange is often important but must be accompanied by a continuing educational process. Agronomic practices are not “fixed” like genetic traits and must be modified for different environments and frequently refined for distinct conditions within a particular farm. This requires in-depth knowledge of crop management by the farmer. How to teach millions of farmers with varying degrees of education remains a major challenge facing the rice sector.

Attention and resources have been directed towards the spread of high-yielding varieties. International germplasm testing programmes have been operative for decades. In contrast, there has been little attention to crop management and the identification of effective and efficient technology transfer programmes. The rice sector has limited knowledge of the farmer decision-making process, methods of educating growers, and means of sustaining extension activities, with the result that there is much “trial and error” in technology transfer. There are several examples of successful technology transfer programmes that are suitable for particular socio-economic settings, but it would be naïve to assume that systems developed in one particular country will function similarly in other countries with distinct socio-economic conditions. However, even with these limitations, there are concepts that may be applicable to successful technology transfer programmes. These universal concepts need to be more clearly identified, adjusted to particular socio-economic conditions and assembled into a structured extension service. It is recommended that the International Rice Commission and its partners take a lead role in defining more efficient and effective technology transfer programmes to extend the use of improved crop management practices.

Improved N management

N fertilizer is an essential ingredient for high yields in rice production. Increased costs for N-based fertilizer present a serious problem for advocating adequate N rates for high yields, and the environmental consequences of inefficient use are also a major concern. The problems associated with low N efficiency were highlighted at the 20th Session of the Commission. In Asia, FAO, IRRI and some member countries have promoted the use of the leaf colour chart for N top-dressing. Programmes in Latin America have incorporated practices to enhance high N

fertilizer efficiency in the technology transfer efforts. SRI also places emphasis on more efficient N management through the use of organic compost. Technologies for N efficiency are available and need to be a component of all technology transfer programmes. In many African countries, high fertilizer prices make highly efficient management practices essential in order to compete with imported rice.

Research in crop management

Research in agronomy has not received the attention required; there is an imbalance in resource allocation which favours genetic improvement. This appears to be a consequence of the success of the Green Revolution, but the substantial decline in the growth rate of rice yield indicates that factors other than varieties are limiting yield. A host of factors require further research, for example, nutrient management for high yield, the role of climatic factors, date of planting, irrigation water management, and pest and disease control. Research on identifying improved crop management practices is out of date or lacking at both international and national level. Agronomic constraints to improved production are often erroneously thought to be “site specific”, precluding a concerted research effort at the international research centres. However, recent efforts show that the major constraints to improved crop management are widespread and it is inefficient to address the factors on a country-by-country basis without networking and sharing experiences.

TECHNICAL OPPORTUNITIES FOR SUSTAINABLE RICE PRODUCTION IN THE MEDIUM TERM (2006-10)

The current challenge is to find ways to continue increasing yields without putting pressure on the environment. Farmers who adopted high-yielding rice varieties obtained a major increase in yield but it was a one-time event; that is, once the new varieties were adopted, there was no subsequent yield increase.

The spread of rice cultivation into new areas, such as sub-Saharan Africa, presents yet another challenge to the scientific community. Even with the increased amount of land dedicated to rice, production has not kept pace with demand. This is further complicated by the low-input production systems in sub-Saharan Africa. Low input results in low yield and subsequently high-cost-per-unit output. With this scenario it is difficult for small, poor

farmers to compete in the market place against cheaper imported rice. Some low-lying areas in Asian countries with monsoon rainfall patterns are not suited for growing anything but rice in the rainy season. Trends certainly indicate that the demand for rice will continue to grow, but the issue is how to maintain small farmers in rice production if yields are so low that they cannot compete in an open market situation.

Improved field management can result in significant yield increases, comparable to the advances witnessed during the Green Revolution. However, in order to improve management, farmers must be exposed to the new crop management technology and this implies considerable resources for extension and farmer training. In addition to the closing of the yield gap with efficient transfer of improved crop management practices, as discussed above, there are also readily available technical options for assisting rice farmers. The most prominent are described below.

Hybrid rice

Hybrid rice was first cultivated commercially in China in 1976 and yielded approximately 15 percent more than high-yielding varieties. Most recently, “super hybrids” have been developed that further increase yield by 20 percent. Hybrid rice increased annual production in China from about 128 million tonnes in 1975 to 191 million tonnes in 1990 (i.e. an increase of more than 60 million tonnes), while during the same period, the rice harvested area was reduced from 36 to 33 million ha. In 2004, more than 15 million ha in China and 1.5 million ha in other areas of Asia were planted with hybrid varieties. The area planted to hybrid rice in Asian countries outside China, however, represents only a small fraction of the total rice area (Table 5), indicating the major potential for adoption of hybrid rice to increase rice production.

Outside Asia, hybrid rice varieties have also been successfully developed and used in the United States (Way, 2004). Recently, hybrid rice varieties suitable for a subtropical climate have been successfully developed in Egypt (FAO, 2003b). However, the high price of F_1 seeds due to limited production remains a serious limitation to the widespread use of hybrids. Genetic uniformity and vulnerability remain a concern with current hybrids due to a common source of cytoplasmic male sterility.

New Rice for Africa (NERICA)

NERICA rice was developed by plant breeders at the Africa Rice Center (WARDA), combining African rice varieties already adapted to the local environment with Asian varieties that have high yield potential. NERICA is drought-tolerant and can increase yield by 30 percent over traditional African varieties (Jones and Wopereis-Pura, 2001; Defoer *et al.*, 2004). Its short growing season (approximately 15 days shorter than that of other varieties) is especially important in sub-Saharan Africa where farmers can schedule their planting and harvesting to take advantage of the short rainy season in drought-prone areas. This also allows farmers to grow a second crop (e.g. legumes) that, when alternated with rice, helps maintain soil fertility. Although developed mainly for the rainfed uplands, researchers hope to develop other varieties of NERICA for irrigated and lowland systems. West and Central Africa boast some 20 million ha of inland valley swamps which are well suited for rice production, but less than 20 percent is used at present.

With the initial support of the United Nations Development Programme (UNDP), WARDA and FAO, the governments in sub-Saharan Africa established the African Rice Initiative (ARI) in 2002 to promote the dissemination of NERICA rice. Recently the African Development Bank approved a US\$35 million multinational project for NERICA dissemination in sub-Saharan Africa (Akintayo, 2005). Also, the Government of Japan has approved funding support for FAO projects on the dissemination of NERICA and improved rice technologies in Ghana, Sierra Leone and Uganda.

Progress in advanced breeding and rice biotechnology

Advances in rice research and biotechnology are crucial for raising the yield potential of rice. The development of new plant type (NPT) and C-4 rice aims to increase the yield potential of tropical rice to about 12 to 13 tonnes/ha. Recent efforts have resulted in only limited success (Khush, 2004). FLAR breeders are now also developing new plant types with higher yield potential to respond to the advances in agronomy. These new types are based upon large panicles. Wide crosses involving wild relatives of *Oryza* offer promise for incorporating traits not found in *Oryza sativa* and perhaps increased yield potential (Khush, 2004). Recurrent selection strategies have also been used by a number of countries in Latin America and the Caribbean (LAC) for improving traits, such as cold tolerance, grain quality, disease resistance and yield potential. More than 20 broad genetic base populations with different characteristics have been created by national programmes; in 2002, Brazil released the first irrigated rice variety (SCSBRS 113-Tio Taka) out of a population breeding strategy, and in 2005, Bolivia released the second one. Breeding programmes in France and China already have population improvement as part of their breeding portfolio (Guimaraes, 2005).

The entire genome of rice has been sequenced and this has allowed the identification of thousands of DNA markers that are simple-sequence repeat (SSR), best known as microsatellite markers. Since the introduction of the modern high-yielding varieties, many breeding programmes have employed a genetically narrow gene pool. There are SSR markers available for many other

TABLE 5

General situation of the commercial hybrid rice cultivation in Asian countries outside China, 2002-04

	Hybrid rice area (ha)			National rice area (million ha)	% national area covered by hybrid rice
	2002	2003	2004	2004	2004
Viet Nam	500 000	600 000	650 000	7.40	8.8
India	200 000	290 000	560 000	42.50	1.3
Philippines	27 943	-	192 000	4.00	4.8
Myanmar	1 294	54 656	54 656	6.00	0.9
Bangladesh	-	-	40 000	11.00	0.4
Indonesia	-	-	875	11.70	n.a.
Sri Lanka	-	-	15	0.75	n.a.
Total	-	-	1 497 546		

Source: Nguyen, 2005.

traits, and there are numerous research programmes working to discover the function of rice genes. This type of information will allow the widespread development of single nucleotide polymorphisms (SNPs) – highly specific markers that are amenable to very high-throughput analysis.

Marker aided selection (MAS) is amenable to high-throughput analysis and sufficient polymorphism can be found for the parents of most crosses, enabling breeding to expand the genetic base (Coffman, McCouch and Herdt, 2004). Several molecular markers for disease and pest resistance are available, including markers for both major and minor resistance genes for rice blast, rice bacterial blight (*Xanthamonas oryzae*) and planthopper. Rice hoja blanca is an important disease in LAC and is costly to screen in the field. Already one potential marker has been identified for resistance to this disease. The MAS technologies are being used in only a few advanced laboratories. As more information on resistance to biotic and abiotic stresses (as well as on important agronomic characteristics) emerges, the use of MAS will become more compelling. The question is not will MAS become an important standard activity in rice breeding programmes, but when will it be economical to employ the technology in high-volume rice breeding programmes?

Rice does not normally produce vitamin A and “Golden Rice” was developed to alleviate vitamin-A deficiency. It was developed by inserting two daffodil genes and one bacterial gene into the rice genome. This allows the production of beta-carotene in rice grain. The resulting plants are normal except that their grain is a golden-yellow colour due to the presence of provitamin A (Potrykus, 2003).

Rice hoja blanca virus (RHBV) is a major viral disease of economic importance affecting rice in northern South America, Central America and the Caribbean. Transgenic plants with the RHBV nucleoprotein viral gene are available and have been crossed with the commercial variety, Fedearroz 50 (Lentini *et al.*, 2003). Field evaluations indicated that six fixed, transgenic lines were more resistant than Fedearroz 2000, the most RHBV-resistant commercial variety. The transgenic lines express low levels of RNA, which is detectable only by RT-PCR, and the RHBV nucleoprotein is not expressed in these plants, thus suggesting a very low risk, if any, for environmental and food safety concerns.

While the deployment of transgenic rice varieties for commercial production is still limited, there are many

field experiments throughout the world. Herbicide resistance and stem borer resistance (Bt) are widely deployed in commercial cotton, maize and soybean. Herbicide resistance using mutants which are not transgenic is currently used on a wide scale in southern Brazil, the United States and parts of Colombia and Costa Rica. Mutant herbicide resistance offers the opportunity to effectively control red rice, a major problem throughout LAC. New herbicide resistance based upon transgenic technology will soon be available, but commercialization remains a question. Resistance to abiotic and biotic stresses using genetic transformations continues to be pursued by several laboratories.

Commercial use of the new technology is complicated by:

- issues of intellectual property rights;
- public acceptance of GMOs; and
- difficulties involving the trade of transgenic material.

The technology is much more advanced than is public acceptance and perception; advanced breeding and biotechnology methods are available. However, the results of an FAO study show the need for urgent capacity building in developing countries, if full advantage is to be taken of the new technologies.

THE WAY FORWARD

The advances in crop management and corresponding large yield increases reported by various organizations in different countries and continents present new opportunities, especially in the irrigated sector. Technological factors and methods per se do not appear to be the primary factor limiting production increases but deficiencies in application of technology transfer hinder the spread of known technologies to large numbers of farmers. There are diverse methods of technology transfer. Several programmes are operative using different methodologies and strategies and involving a range of institutions/agencies. New partnerships are evolving that offer unique opportunities. Development of appropriate technology transfer systems for distinct socio-economic settings involving a range of actors represents the next challenge in the rice sector.

Higher yields and lower production costs with minimum harmful effects on the environment are imperative for more competitive production in a global market that is increasingly environmentally sensitive.

Improved crop management can result in significant yield and production increases on less land and with less water. This offers the opportunity for diversification of rice-based systems, for example, rotation of rice with fish, rice with livestock, rice with a range of other crops in order to spread risk but also to increase income and to improve human nutrition. New paradigms are emerging that require innovative ideas in technology transfer, more efficient use of resources and alliances with new partners.

As the yield gap in rice production is narrowing with improved crop management, a new generation of rice varieties will be needed for sustainable rice production. The progress in plant breeding and rice biotechnology should be harnessed for generating rice varieties with not only high yield potential but also good taste, eating quality and added nutrients. This will require a broad and strengthened partnership among international institutions, public institutions, the private sector and non-governmental organizations.

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Amélioration de la production rizicole dans un contexte en évolution: de la théorie à la pratique

Depuis la dernière réunion de la Commission internationale du riz, qui s'est tenue en 2002 à Bangkok (Thaïlande), plusieurs faits marquants ont été enregistrés dans le sous-secteur du riz: l'Assemblée générale des Nations Unies a adopté la Résolution 57/162 proclamant 2004 l'Année internationale du riz; en 2002 la production mondiale de riz a commencé à nouveau à progresser après trois années consécutives de recul; enfin en 2005, le rendement mondial moyen a dépassé le seuil des 4 tonnes à l'hectare. On relève aussi des facteurs négatifs. La production rizicole en Afrique subsaharienne continue à être inférieure à la consommation. Une utilisation excessive de l'eau, une dégradation environnementale due à la contamination par les pesticides et les éléments nutritifs, les émissions de méthane et la volatilisation de l'ammoniaque sont parmi les risques liés à la production de riz qu'il convient de traiter d'urgence. Les ressources en terre et en eau nécessaires à la production rizicole diminuent et les changements climatiques mondiaux peuvent avoir des répercussions importantes sur la production de riz.

Plusieurs recommandations ont été formulées aux dernières sessions de la Commission internationale du riz, notamment pour ce qui est de la promotion des techniques améliorées de cultures lors de la vingtième

session (en Thaïlande) et de la Consultation d'experts sur les écarts de rendements et la chute de la productivité dans la production de riz (Italie, septembre 2000). Les études de cas relatives à plusieurs pays d'Asie et d'Amérique latine ainsi qu'à Madagascar, effectuées dans divers contextes socio-économiques et en utilisant des techniques et des méthodes de transfert différentes, ont montré qu'il est facile d'obtenir des rendements élevés pour le riz irrigué en utilisant des pratiques culturales améliorées appliquées aux variétés courantes. Les pratiques de culture améliorées ont permis d'obtenir des rendements plus élevés et une réduction des coûts de production, tout en limitant les effets néfastes pour l'environnement, ce qui est essentiel pour stimuler la compétitivité sur un marché mondial de plus en plus sensible aux questions liées à l'environnement. Toutefois, afin d'améliorer la gestion, les agriculteurs doivent connaître les nouvelles technologies de gestion ce qui nécessite des ressources considérables destinées à la vulgarisation et à la formation des agriculteurs.

Les agriculteurs peuvent avoir facilement accès au riz hybride et aux variétés NERICA. Le riz hybride a été cultivé pour la première fois en Chine, en 1976, et a permis d'obtenir un rendement supérieur d'environ 15 pour cent à celui des variétés à

haut rendement. En 2004, les variétés hybrides ont été cultivées sur plus de 15 millions d'hectares en Chine et sur 1,5 million d'hectares dans d'autres régions d'Asie.

Le riz NERICA a été obtenu par l'Association pour le développement de la riziculture en Afrique de l'Ouest (ADRAO) en associant des variétés de riz africain déjà adapté à l'environnement local à des variétés asiatiques dont le rendement potentiel est élevé. Le riz NERICA résiste à la sécheresse et sa période de croissance est courte (environ 15 jours de moins que les autres variétés) caractéristique très importante en Afrique subsaharienne, car les agriculteurs peuvent ainsi planifier les semis et la récolte pour tirer parti de la brève saison des pluies dans les zones exposées à la sécheresse.

Comme l'écart de rendement dans la production de riz diminue avec une meilleure gestion des cultures, il est nécessaire d'obtenir de nouvelles variétés permettant une production de riz durable. Les progrès accomplis par la sélection végétale et les biotechnologies appliquées au riz devraient permettre de créer des variétés dotées non seulement de rendements potentiels élevés aussi de qualités gustatives et nutritionnelles. À cet effet, il sera nécessaire d'élargir et de renforcer les partenariats entre les institutions internationales, les institutions publiques, le secteur privé et les organisations non-gouvernementales.

Mejorar la producción del arroz en un entorno cambiante: del concepto a la práctica

Desde la última reunión de la Comisión Internacional del Arroz, celebrada en Bangkok (Tailandia) en 2002, se han producido acontecimientos notables en el subsector del arroz. La Asamblea General de las Naciones Unidas aprobó la Resolución 57/162, en la que se declaró el año 2004 como Año Internacional del Arroz. La producción mundial de arroz comenzó a aumentar nuevamente en 2002 después de tres años consecutivos de descenso y en 2005 el rendimiento medio mundial se sitúa por encima de la barrera de las 4 toneladas/ha. Sin embargo, el sector del arroz también se ve aquejado por factores negativos. En el África subsahariana, el consumo de arroz sigue superando la producción. El uso excesivo de agua, el deterioro ambiental debido a la contaminación por plaguicidas y nutrientes, las emisiones de gas metano y la volatilización del amoníaco son algunos de los efectos perjudiciales de la producción del arroz que requieren atención urgente. Los recursos de tierras y aguas para la producción del arroz disminuyen y los cambios climáticos mundiales podrían tener efectos de gran alcance en esta producción.

En las últimas reuniones de la Comisión Internacional del Arroz (CIA) se formularon varias recomendaciones, en especial la relativa al fomento de tecnologías mejoradas de gestión de cultivos, formulada en la 20ª reunión,

celebrada en Tailandia, y en la Consulta de expertos sobre el déficit de rendimientos y el descenso de la productividad en el sector arrocero, celebrada en Italia en septiembre de 2000. Los estudios monográficos de varios países de Asia, América Latina y Madagascar, realizados en diferentes entornos socioeconómicos y empleando técnicas y métodos de transferencia distintos, han señalado que pueden obtenerse fácilmente rendimientos elevados del arroz de riego con prácticas de cultivo mejoradas que utilizan las variedades actuales. La mejora de las prácticas de gestión de los cultivos se tradujo en un aumento de los rendimientos y en la reducción de los costos de producción con unos efectos perjudiciales mínimos en el ambiente, lo cual resulta obligatorio para conseguir una producción más competitiva en un mercado mundial cada vez más sensibilizado con el medio ambiente. No obstante, para mejorar la gestión es necesario que los agricultores se familiaricen con la nueva tecnología de gestión de cultivos, lo cual conlleva dedicar una cantidad importante de recursos a la extensión y la capacitación de los agricultores.

Para ayudar a los agricultores de arroz, también son fácilmente asequibles las variedades de arroz híbrido y de NERICA. El arroz híbrido se cultivó por vez primera para su comercialización en China en 1976 y sus rendimientos fueron casi un 15 % mayores que los obtenidos

con variedades de alto rendimiento. En 2004, se plantaron variedades híbridas en más de 15 millones de hectáreas en China y en 1,5 millones de hectáreas de otras zonas de Asia.

Fitogenetistas del Centro Africano del Arroz (ADRAO) obtuvieron la variedad NERICA combinando variedades de arroz africanas ya adaptadas al entorno local con variedades asiáticas de elevado rendimiento potencial. La variedad NERICA tolera la sequía y su breve período de crecimiento, unos 15 días menos que el de otras variedades, reviste especial importancia en el África subsahariana, donde los agricultores pueden programar su plantación y cosecha para aprovechar la estación de las lluvias cortas en zonas propensas a la sequía.

Dado que la mejora de la gestión de cultivos reduce la brecha de rendimientos en la producción del arroz, es preciso obtener una nueva generación de variedades de arroz a fin de conseguir la producción sostenible del arroz. Los avances logrados en el fitomejoramiento y la biotecnología del arroz deberían aprovecharse para generar variedades de arroz que no sólo tengan un elevado rendimiento potencial, sino también buen gusto, calidad alimentaria y nutrientes añadidos. Para ello será necesario que instituciones internacionales, instituciones públicas, el sector privado y organizaciones no gubernamentales amplíen y refuercen su colaboración.

Rice contribution to food outlook¹

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PRODUCTION

Outlook for global paddy production in 2006 positive, but falling profitability could dampen rate of expansion of the sector

The 2006 paddy season started on the trail of an excellent 2005 season, which saw paddy production rise by more than 3 percent to an all-time high of 631 million tonnes (421 million tonnes, milled basis). This outcome reflected the favourable growing conditions in most parts of the world, but also the generally attractive price conditions that prevailed in 2004 and which prompted a general expansion of planting. In addition, governments in several countries continued to provide support to the sector with the objective of achieving self-sufficiency in the medium term.

The 2006 paddy season is already well advanced south of or along the equator where, by May, many countries are already harvesting their main paddy crop. In the Northern Hemisphere, the main 2006 crops are still at the development stage in parts of Asia, Africa, Europe

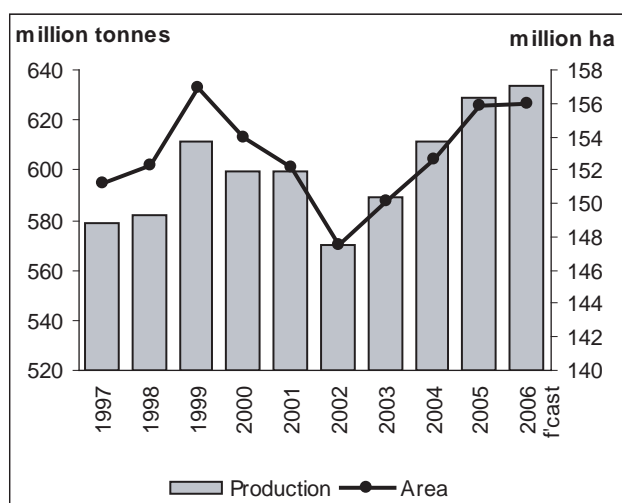
and North America, while they are not even in the ground in countries such as India or the Philippines, where the opening of the season coincides with the arrival of the southwest monsoon around June. This represents a major element of uncertainty for the 2006 production outlook – uncertainty that will persist until at least August, when more will be known about the timing and distribution pattern of the monsoon rains.

Although still tentative, the FAO forecast for global paddy production in 2006 currently stands at 635 million tonnes (only 0.8 percent, or 4 million tonnes, more than last season). This rather subdued outlook reflects the concerns over rising production costs and uncertain price prospects.

In the Southern Hemisphere (where the 2006 season is fairly advanced), production is estimated to increase in Argentina, Australia, Indonesia, Madagascar and Ecuador, while the outlook is negative for Brazil, Peru, Uruguay and Sri Lanka. However, most of the expected growth in global production is likely to originate in the major producing countries situated north of the equator, in particular Bangladesh and China. In Bangladesh, strong domestic demand for rice and the maintenance of high subsidies on petroleum prices are likely to sustain growth, while in China, relatively attractive market prices (especially for high quality rice) and continued government support are expected to sustain the recovery of the sector initiated in 2004.

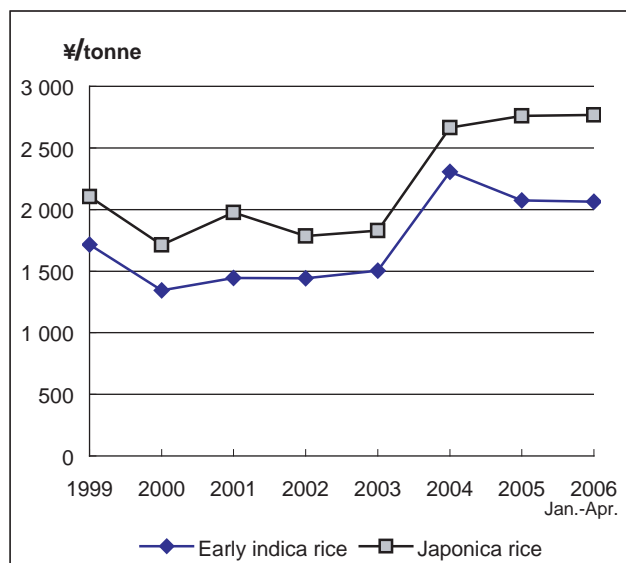
Assuming a normal monsoon, an increase in production is forecast in India and the Philippines; however, this outlook is surrounded with uncertainty. Production prospects are positive in Thailand and Viet Nam (the two major rice-exporting countries) and also in Nigeria (a major importer), where the government is actively promoting expansion of the sector. In contrast, production is forecast to fall in Japan, where exceptionally favourable conditions boosted yields in 2005 and thwarted government efforts to cut excess supplies. The outlook is negative also in Pakistan, where insufficient rainfall and water shortages at sowing time delayed plantings. Similarly, the USDA (United States Department of

FIGURE 1
Global rice paddy production and area



¹ The information contained in this article is of June 2006.

FIGURE 2
Rice market prices (China)



Agriculture) forecast points to a reduced crop in the United States, especially for long-grain, *indica* rice varieties, reflecting a marked reduction in the area prompted by high fuel prices and damage from hurricanes in 2005.

INTERNATIONAL TRADE

Following record high in 2005, international trade in rice may decline in 2006, still striking second best performance on record

In 2005, rising import demand from countries in Africa and Asia provided a major stimulus to the rice trade, which rose to an all-time high of 29.4 million tonnes. The expansion took place in spite of a reduction in exports from Thailand and China, the shortfalls of which were more than compensated for by a surge of shipments from India, Pakistan and Viet Nam.

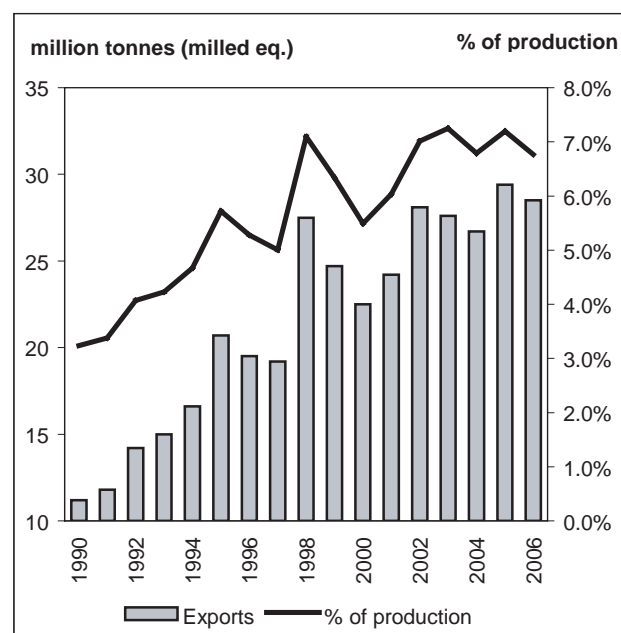
FAO currently anticipates a 2.5 percent reduction in the world rice trade in 2006 to 28.6 million tonnes – nevertheless the second highest level on record. Following the exceptional 2005 trade performance, the drop is anticipated as a result of the general reduction in import demand by African countries, where good crops were harvested in 2005. Much of the reduction is on account of Nigeria, where shipments are forecast to drop from 2.0 to 1.6 million tonnes, reflecting the imposition of a ban on milled rice imports since the beginning of 2006. Though falling, shipments to Côte d'Ivoire, Senegal and South Africa are likely to remain large (in the order of

800 000 tonnes), with imports from all African countries expected to reach some 9.2 million tonnes (32 percent of the world total), down from 10.1 million tonnes in 2005.

Deliveries to Asian countries are forecast to remain very close to last year's level of 13.4 million tonnes, despite smaller anticipated deliveries to Bangladesh, the Democratic People's Republic of Korea and the Philippines, where record crops were harvested in 2005. Purchases by the Islamic Republic of Iran, on the other hand, are anticipated to surge: given the tensions on the international front, the country is increasing imports in an attempt to build up reserves. Purchases by China are also likely to rise, following trade agreements signed in 2005 with several exporting countries and given the growing domestic demand for quality rice. Iraq, the Republic of Korea, Saudi Arabia and Turkey are also expected to import more this year. In Indonesia (one of the major traditional rice markets), government restrictions currently extended until June 2006 are likely to keep imports in 2006 at around the 2005 level of 600 000 tonnes.

Overall, shipments to countries in Latin America and the Caribbean are expected to rise slightly compared with 2005, reflecting a recovery in imports by Brazil as a result of this season's production shortfall. In contrast, imports by Peru may fall, while little change is expected in imports

FIGURE 3
World rice trade (in volume and as share of global production)



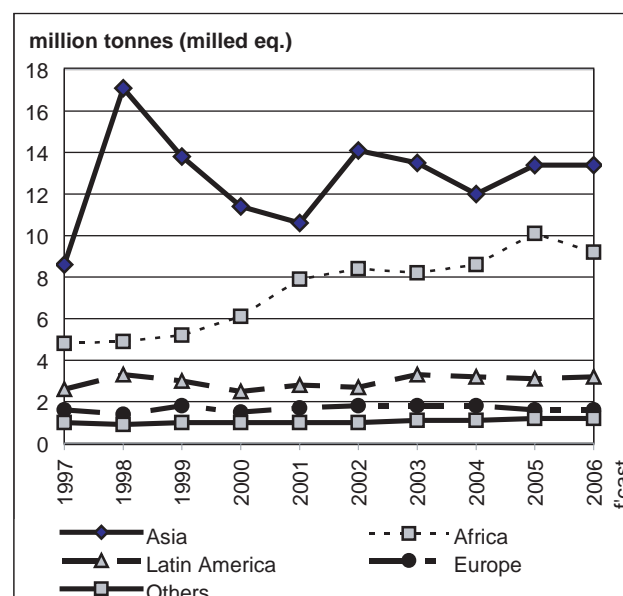
directed to the other countries in the region. On the policy front, it is worth noting the implementation in 2006 of the free trade agreement (FTA) signed between the United States and six countries in Central America and the Caribbean (Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras and Nicaragua). The FTA granted rice long transition periods of between 18 and 20 years for the complete elimination of border tariffs; therefore, no major immediate impact on the volume of imports of the member countries is expected, but traditional suppliers may be displaced as the United States gain access thanks to the duty-free quota (Table 1).

FTAs were also signed earlier this year between the United States and Colombia and between the United States and Peru, but they have not yet been ratified by the countries' parliaments.

In the rest of the world, imports by the United States are officially forecast to rise strongly. In the European Union (EU), the reform of the rice import system – with a marked reduction in duties on husked rice and milled rice imports – may result in a higher level of rice deliveries to the EU in 2006. Under the new regime, milled rice will be subject to duty of either 145 or 175 euros per tonne and husked rice to duty of 30, 42.5 or 65 euros per tonne, depending on the actual level of imports. In contrast, purchases by the Russian Federation might fall, following the bumper crop harvested last season.

In terms of exports, the expected fall in international trade in 2006 will be due to smaller shipments from those countries that witnessed a surge in 2005, in particular India, which shipped an estimated 5.3 million tonnes last year, second only to Thailand. In 2006, India's rice sales are forecast to be much smaller – in the order of 4.4 million tonnes – as large government procurement purchases are reported to have lifted prices of rice (with the exception of parboiled rice) above other competitors' levels. Exports from Egypt, Pakistan, the United States

FIGURE 4
Rice imports, by region



and Uruguay may also decline, as the four countries face tightening of supplies in 2006. Thailand's competitiveness has been eroded since April: the strength of the Baht relative to the US dollar, combined with the government rice-pledging scheme, has contributed to a rise in export quotations, resulting in a 4 percent reduction in shipments in the first quarter of 2006. However, strong sales to the Islamic Republic of Iran and Iraq and government-to-government deals are likely to enable the country to maintain exports at around last year's volume of 7.5 million tonnes. Viet Nam's shipments are currently forecast to remain in the order of 5.2 million tonnes (the government's set target), especially as availability from the 2005 season will be less – a factor which may prompt the government to impose intermittent restrictions on exports again in 2006. On the other hand, shipments from China, which remain under government control, may

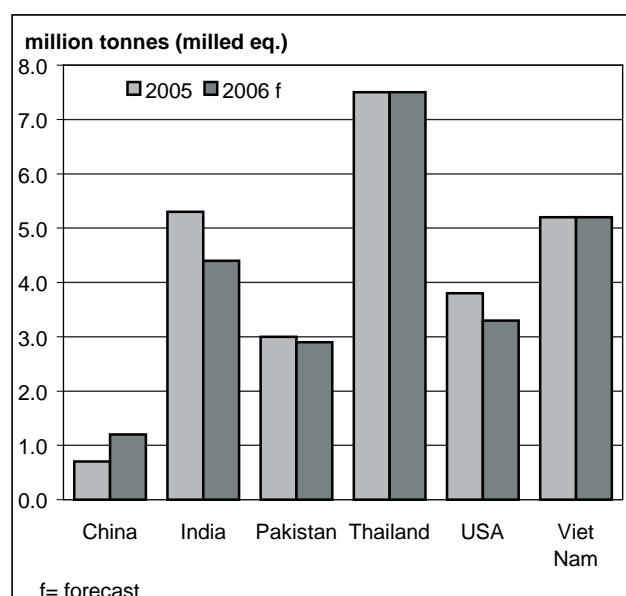
TABLE 1
Rice duty-free quota to the United States (first year of implementation, 2006)

	Costa Rica	El Salvador	Guatemala	Honduras	Nicaragua	Dominican Republic	Total
Paddy rice	51 000	62 220	54 600	91 800	92 700	2 140	354 460
Milled rice	5 250	5 625	10 500	8 925	13 650	8 560	52 510
Total rice quota (milled rice equivalent^a)	38 400	46 068	45 990	68 595	73 905	9 951	282 909

^a Paddy rice converted into milled rice by applying a standard multiplying factor of 0.65.

Source: CAFTA, FAO.

FIGURE 5
Rice exports by the major exporters



rebound somewhat. Similarly, the end of the drought and the ensuing production recovery in 2006 should enable Australia to recapture some of the markets lost over the past 4 years. In Latin America and the Caribbean, sales by Argentina are expected to rise, especially in view of an expected rebounding of imports by Brazil and higher prices from the United States, a major competitor in the region.

GLOBAL RICE UTILIZATION

Under current prospects for modest growth in global production in 2006, rice utilization in 2006/07 not sufficient to prevent per caput consumption from falling
Given the relatively high costs of production, rice remains essentially a food commodity, with only a small share of supply destined for feed, except on farms. Large gains in production in the 2005 season are estimated to have boosted global rice utilization, even allowing a small increase in per caput rice consumption from 56.9 kg in 2004/05 to 57.1 kg in 2005/06. However, this gain was mainly concentrated in developed countries, where per caput demand has been following a marked upward trend in recent years. Per caput rice availability remained unchanged (at around 68.7 kg) for developing countries as a whole and even declined for low-income food-deficit countries (LIFDCs).

Tentative forecasts indicate that world rice utilization will increase marginally in 2006/07, on the basis that

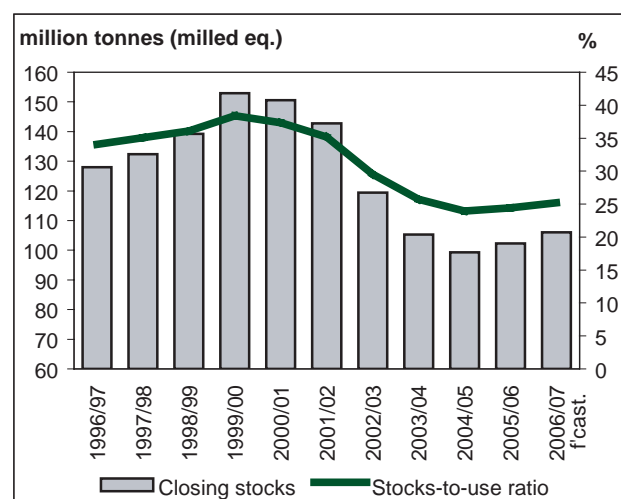
limited gains in production are expected in 2006. Availability of rice for food consumption will be lower with a fall in average per caput availability to 56.9 kg. All country groupings, including LIFDCs, would be affected.

CLOSING RICE INVENTORIES

Rebuilding of global rice inventories initiated in 2005 likely to progress in 2006

World rice inventories at the close of the 2005/06 marketing season are estimated to reach 102 million tonnes (up from 99 million tonnes in the previous year). Production in the 2005 season would thus be sufficient to meet consumption needs at a slightly higher average per caput level and global rice reserves (falling since 2000) could be rebuilt. Stocks in China – the country that has driven much of the recent downscaling of global rice inventories – ended higher, reflecting growth in production and a lingering tendency for per caput rice demand to weaken. Production increases in 2005 also facilitated a rebuilding of inventories in Bangladesh, Cambodia, the Islamic Republic of Iran, Myanmar and Thailand. On the other hand, carryovers are estimated to have fallen below their opening level in Indonesia and Viet Nam. In Africa, the anticipated drop in imports in 2006 contributed to a fall in end-of-season stocks in most countries. This was the case in Egypt, where reserves were consumed in order to meet the strong domestic and export demand. The larger crops harvested in 2005 in South America allowed some rebuilding of rice reserves

FIGURE 6
Global rice closing stocks and stocks-to-use ratio



in the subregion, in particular, in Brazil and Peru. Among developed countries, inventories increased in Japan and the United States.

Preliminary forecasts for closing rice inventories at the end of the 2006/07 marketing season point to a continuation of the stock rebuilding process initiated in 2005, with global rice inventories expected to rise to 106 million tonnes. Most of the increase, however, is likely to be concentrated in China, with larger reserves of rice also foreseen in Thailand. Stocks in most of the other countries could end lower, including those held by major rice exporters, in particular India and the United States.

INTERNATIONAL PRICES

Buoyant international rice prices in the first months of 2006

International prices in the first 4 months of 2006 were remarkably buoyant. The FAO rice price index, which had been stable at 101 from June to December 2005, rose to 103 in January 2006, to 105 in February and to 106 in both March and April 2006. Prices remained high in the first 2 weeks of May, when the index reached 107.

Ordinary and parboiled *indica* had particularly good prices, thanks to large purchases by countries in Asia, notably Iraq, the Islamic Republic of Iran and the

Philippines. The launching of import tenders by Japan and the Republic of Korea also tended to lift *japonica* rice quotations. On the other hand, quotations of lower quality *indica* tended to weaken compared with the end of 2005, to some extent reflecting the retrenchment of African buyers. The general strengthening of international rice prices in the first quarter of the year also reflected the effects of government procurement programmes with relatively high prices in Thailand and India and a tightening of export availability in some major exporting countries, including Pakistan, the United States and Viet Nam. In addition, the strengthening of the Thai Baht relative to the US dollar (in which export prices are expressed) further contributed to the buoyancy of price quotations since April.

World rice prices in the next few months are expected to remain firm, although much will depend on the policies of the major international trade players, in both export and import. Given the prevailing stance of governments in Thailand and Viet Nam to keep prices from falling and limited export from alternative sources (including Australia, India, Pakistan and the United States), rice quotations are expected to make further gains at least until August/September when several Northern Hemisphere countries will start harvesting their main 2006 crops.

Contribution relative au riz parue dans les perspectives de l'alimentation

Les perspectives actuelles concernant la production de paddy de 2006 font état d'une croissance modeste du fait des préoccupations liées aux coûts de production croissants et à la moindre rentabilité. Toutefois, ces indications ont un caractère provisoire, du moins jusqu'en août, époque où l'on en saura plus sur le comportement des pluies de mousson en Asie. Après

avoir atteint un volume record en 2005, les échanges de riz pourraient se contracter pendant l'année en cours, car les importations à destination des pays africains – principal moteur de croissance au cours de la décennie passée – devraient reculer. La reconstitution des stocks de clôture, qui s'est amorcée en 2005-06, devrait se poursuivre pendant la campagne en

cours, processus qui concerne essentiellement la Chine.

Les gains de production devant être limités, la disponibilité par habitant de riz destinée à la consommation devrait reculer en 2006/2007. Les cours mondiaux du riz, qui ont été particulièrement florissants au cours du premier trimestre de 2006, devraient rester fermes ces prochains mois.

La aportación del arroz a las perspectivas alimentarias

Debido a las inquietudes que suscitan el aumento de los costos de producción y la disminución de la rentabilidad, las perspectivas actuales para la producción de arroz en 2006 no apuntan sino a un crecimiento moderado. No obstante, se trata de perspectivas que han de considerarse provisionales al menos hasta agosto, cuando se tengan más datos sobre las modalidades de las lluvias monzónicas en Asia. Tras el

nivel sin precedentes alcanzado en 2005, el comercio del arroz podría debilitarse durante el año, al disminuir las importaciones de los países africanos, que en el decenio pasado constituyeron el motor principal de su crecimiento. Es probable que en la campaña actual prosiga la reposición de las existencias arroceras iniciada en 2005/06 y concentrada principalmente en China.

Dadas las expectativas de que se produzca un aumento moderado de la producción y de la reposición de las existencias arroceras, es posible que en 2006/07 disminuya la disponibilidad per cápita del arroz destinado al consumo humano. Los precios internacionales del arroz, que en el primer trimestre de 2006 eran particularmente firmes, deberían mantenerse estables en los meses venideros.

Summary report of the 21st Session of the International Rice Commission

N.V. Nguyen

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The FAO Conference, at its Fourth Session in 1948, established the International Rice Commission (IRC), with the objective of promoting national and international action in matters relating to the production, conservation, distribution and consumption of rice. The Commission's Constitution went into force in 1949. Its member countries have since grown from 15 in 1949 to 61 at present. Every 4 years, the IRC organizes a session to review the emerging issues and recent achievements in scientific, technical and socio-economic matters relating to sustainable rice production. Furthermore, it assists member countries in orienting strategies for their national rice development programmes while encouraging extensive interaction among national, regional and international institutions.

The 20th Session of the IRC was convened in Bangkok, Thailand, in 2002. The 21st Session of the IRC was convened at the Gran Chiclayo Hotel, Chiclayo, Peru, from 3 to 5 May 2006 by the Ministry of Agriculture of Peru and FAO. The main theme was "Rice is Life – Bringing the Implementation of IYR to Farmers' Fields". It was attended by 90 delegates and participants from member countries and partner institutions. There were five sub-sessions, a poster session and a field visit.

MAIN OBSERVATIONS

The Commission *noted* the following:

- In December 2002, the United Nations General Assembly (UNGA) at its 57th Session, noting that rice is the staple food of more than half of the world's population and reaffirming the need to focus world attention on the role that rice can play in providing food security and eradicating poverty, declared 2004 the International Year of Rice (IYR).
- The Second Committee of the 60th Session of the UNGA in November 2005 recognized the success and the contribution of the implementation of the International Year of Rice in 2004 in effectively raising awareness of the role that rice plays in reducing hunger and poverty and the support of all stakeholders for sustainable rice production.
- Rice supplies consumers with more calories than other staple crops, particularly in the diets of very poor people whose food purchases account for more than half of all expenditures. Women and children in sub-Saharan Africa, South and Southeast Asia, and Latin America and the Caribbean are especially susceptible to deficiencies in micronutrients, in particular vitamin A, iron and zinc.
- For the third consecutive year, global paddy production experienced a brisk expansion in 2005, lifting total production to a record 629 million tonnes. However, the increase in global production in 2005-06 will be only just sufficient to cover utilization.
- Rice production in sub-Saharan Africa continues to be outpaced by consumption, while food insecurity and poverty are extensive in rainfed rice ecosystems in Asia where the demand for food has been growing fast.
- The world population continues to increase steadily, while land and water resources for rice production are diminishing due to competition from other sectors of the economy and the growing population. Moreover, the environment and natural resource bases of rice production are being degraded due to pesticide and nutrient contamination.
- The increased temperature, rising seas and erratic rainfall distribution under global climate change have potentially large negative impacts on the productivity of rice farming.
- Pilot tests conducted by FAO, member countries and partner institutions have demonstrated the effectiveness of rice integrated crop management (RICM) systems in closing the rice yield gap (i.e. the difference between the yield potential of existing varieties and the yields which are actually obtained by farmers), increasing farmers' profits and minimizing damage to the environment.

- After the development of high-yielding varieties, hybrid rice and NERICA (New Rice for Africa) rice are the two major achievements in the field of rice breeding. In 2004, about 1.5 million ha of hybrid rice were planted in a number of Asian countries, in addition to about 15 million ha of hybrid rice in China. In sub-Saharan Africa, NERICA rice is being adopted by farmers.

MAIN RECOMMENDATIONS

The Commission *recommended* the following:

- Member countries, funding donors, FAO, partner institutions and all stakeholders should increase collaborative efforts and funding support to activities aimed at full implementation of the Commission's recommendations for the sustainable increase in rice production to reduce hunger and poverty.
- The partnership in rice research and development between national and international institutions, as well as NGOs (non-governmental organizations) and the private sector, should be strengthened and broadened for effective contribution to the sustainable increase in rice production in member countries.
- Rice production systems should be viewed in an integrated way, from seed selection to food on the table, taking into account the interaction and relationships among rice plants and other organisms in the rice ecosystems, in order to maximize income and nutrition enhancement and to conserve natural resources for future production.
- Strategies and policies for sustainable rice production should aim to build the capacity of rice farmers in precision management in order to: improve the efficiency of resource utilization (especially water), reduce environmental damage and enhance the economic competitiveness of rice production systems. Guidelines and criteria for monitoring the sustainability of rice production systems should therefore be developed for each of the rice agro-ecologies in order to facilitate farmer training.
- Efforts to improve human nutrition should include initiatives to: promote the development, dissemination and adoption of rice varieties with a high content of iron, zinc and vitamin A; raise consumer awareness; and obtain support from industry.
- Variety development should focus not only on high yield, but also on increased nutritional value and improved tolerance to salinity, high temperature, drought and flood stress.
- Small and medium-size enterprises that harness technologies for transforming the whole rice grain – including milled rice, rice bran and rice husks – into value-added products should be promoted in order to increase the returns from rice production and to open up employment opportunities.
- The Secretariat of the Commission should organize a Global Expert Consultation, between the 21st (2006) and 22nd (2010) Sessions, in order to review progress and identify suitable strategies for upscaling the transfer of rice integrated crop management systems for closing the yield gap, increasing profit and reducing environmental degradation in rice production under different agro-socio-economic set-ups.

DATE AND PLACE OF THE NEXT SESSION

The Commission expressed appreciation for the invitation extended by the delegation of France to host the 22nd Session in 2010. The final decision as to the exact date and place shall be made by the Director-General of FAO, in consultation with the Government of the member country concerned.

Résumé du rapport de la vingt et unième session de la Commission internationale du riz

La Conférence de la FAO, à sa quatrième session en 1948, a établi la Commission internationale du riz (CIR), dont l'objectif est de promouvoir les initiatives nationales et internationales visant la production, la conservation, la distribution et la consommation de riz. L'acte constitutif de la Commission est entré en vigueur en 1949. Ses États membres sont passés de 15 en 1949 à 61 à l'heure actuelle. Tous les quatre ans, la Commission organise une session pour examiner les nouveaux développements et les réalisations récentes dans les domaines scientifique, technique et socio-économique pour ce qui est de la production durable. En outre, elle aide les États membres en orientant les stratégies de leurs programmes nationaux de mise en valeur du riz tout en encourageant une interaction massive entre les instituts nationaux, régionaux et internationaux. La vingtième session de la Commission s'est tenue à Bangkok (Thaïlande) en 2002. La vingt et unième session de la CIR a été organisée au Gran Chiclayo Hotel à Chiclayo (Pérou), du 3 au 5 mai 2006 par le Ministère de l'agriculture du Pérou et la FAO, autour d'un thème central: "Le riz c'est la vie - Mettre en œuvre les apports de l'Année internationale du riz dans les petites exploitations". Quatre-vingt dix délégués et participants provenant des États membres et des institutions partenaires étaient présents. Ils ont assisté à cinq sous-sessions, à une séance de démonstration et à une visite de terrain.

Principales observations

La Commission a *noté* les points suivants :

- En décembre 2002, l'Assemblée générale des Nations Unies, à sa cinquante-septième session, notant que le riz est l'aliment de base de plus de la moitié de la population mondiale et réaffirmant la nécessité d'appeler l'attention mondiale sur le rôle que peut jouer le riz dans la sécurité alimentaire et la réduction de la pauvreté, a déclaré 2004 Année internationale du riz.
- Le deuxième comité de la soixantième session de l'Assemblée générale des Nations Unies, en novembre 2005, a reconnu le succès de l'Année internationale du riz en 2004, la contribution que son application a apporté à l'amélioration effective de la prise de conscience du rôle joué par le riz pour réduire la faim et la pauvreté ainsi que le soutien de toutes les parties prenantes en vue d'une production rizicole durable.
- Le riz offre aux consommateurs davantage de calories que d'autres aliments de base, notamment dans l'alimentation des couches très pauvres de la population qui consacrent plus de la moitié de leurs revenus à l'achat de leur nourriture. Les femmes et les enfants, en Afrique subsaharienne, en Asie du Sud et du Sud-Est, en Amérique latine et aux Caraïbes sont particulièrement exposés aux carences en micronutriments (surtout en vitamine A, en fer et en zinc).
- Pour la troisième année consécutive, la production

mondiale de riz paddy a enregistré une nette expansion en 2005, atteignant le niveau record de 629 millions de tonnes. Cela dit l'accroissement de la production mondiale en 2005-06 permettra à peine de couvrir l'utilisation.

- La production de riz en Afrique subsaharienne est encore insuffisante par rapport à la consommation, alors que l'insécurité alimentaire et la pauvreté sévissent dans les systèmes rizicoles de culture pluviale en Asie où la demande de nourriture a progressé rapidement.
- La population mondiale continue à augmenter rapidement, alors que les ressources en terres et en eaux pour la production rizicole diminuent du fait de la concurrence exercée par d'autres secteurs de l'économie et par l'accroissement de la population mondiale. Qui plus est, l'environnement et les ressources naturelles nécessaires à la production rizicole sont dégradés du fait de la contamination liée aux pesticides et aux fertilisants.
- La hausse des températures et du niveau des mers et les précipitations irrégulières dues aux modifications des conditions climatiques mondiales peuvent se répercuter de manière négative sur la productivité des cultures de riz.
- Des tests pilotes conduits par la FAO, les États Membres et les institutions partenaires ont montré l'efficacité des pratiques de gestion intégrée des cultures rizicoles pour réduire l'écart de rendement (c'est-à-dire la différence entre le rendement potentiel des variétés existantes et les résultats

effectivement obtenus par les agriculteurs), relever les profits des agriculteurs et réduire les dommages à l'environnement.

- Outre la mise au point de variétés à haut rendement, le riz hybride et le riz NERICA sont les deux principaux résultats obtenus dans le domaine de l'amélioration du riz. En 2004, environ 1,5 million d'hectares ont étéensemencés en riz hybride dans divers pays d'Asie, outre environ 15 millions d'hectares en Chine. Dans les pays d'Afrique subsaharienne les agriculteurs sont en train d'adopter le riz NERICA.

Principales recommandations

La Commission a *recommandé* les mesures suivantes:

- Les États membres, les bailleurs de fonds, la FAO, les institutions partenaires et toutes les parties prenantes devraient renforcer les efforts de collaboration et le soutien financier aux activités intéressant la mise en œuvre complète des recommandations en vue d'un accroissement durable de la production rizicole pour réduire la faim et la pauvreté.
- Les partenariats dans le domaine de la recherche rizicole et du développement, entre les institutions nationales et internationales, ainsi qu'entre les ONG (organisations non gouvernementales) et le secteur privé devraient être renforcés et élargis pour une contribution réelle à l'accroissement durable de la production rizicole dans les États Membres.

- Les systèmes de production rizicole devraient être appréhendés de manière globale, de la sélection des semences à la consommation, en tenant compte des interactions et des relations entre les plants de riz et les autres organismes des écosystèmes rizicoles, en vue d'accroître les revenus, d'améliorer la nutrition et de conserver les ressources naturelles nécessaires à la production pour l'avenir.
- Les stratégies et les politiques relatives à la production durable de riz devraient viser à renforcer la capacité des riziculteurs dans la gestion de précision afin d'améliorer l'efficacité de l'utilisation des ressources (surtout l'eau), réduire les dommages à l'environnement et renforcer la compétitivité économique des systèmes de production rizicole. Les directives et les critères de suivi pour la durabilité des systèmes de production rizicole devraient donc être élaborés pour chacune des agroécologies rizicoles en vue de favoriser la formation des agriculteurs.
- Les efforts pour améliorer la nutrition humaine devraient prévoir des initiatives visant à promouvoir le développement, la diffusion et l'adoption de variétés de riz à fort contenu en fer, en zinc et en vitamine A ainsi que renforcer la prise de conscience des consommateurs et obtenir le soutien de l'industrie.
- L'élaboration de variété ne devrait pas seulement tenir compte des rendements, mais aussi de

l'accroissement de la valeur nutritionnelle et de la tolérance accrue à la salinité, aux températures élevées, à la sécheresse et aux inondations.

- Les petites et moyennes entreprises qui utilisent les technologies pour transformer le riz entier – y compris le riz usiné, le son de riz et les balles de riz - en produits à valeur ajoutée devraient être encouragées à accroître les revenus dérivés de la production de riz et développer les possibilités d'emploi.
- Le Secrétariat de la Commission devrait organiser une Consultation mondiale d'experts, entre la vingt et unième (2006) et la vingt-deuxième (2010) session, afin d'étudier les progrès accomplis et déterminer les stratégies à adopter pour élargir le transfert de la gestion intégrée des cultures rizicoles, pour combler l'écart de rendement, augmenter les profits et réduire la dégradation de l'environnement dans les systèmes rizicoles importants.

Date et lieu de la prochaine session

La Commission a exprimé son appréciation pour l'invitation faite par la délégation française d'accueillir la vingt-deuxième session en 2010. La décision finale relative à la date exacte et au lieu précis sera prise par le Directeur général de la FAO en consultation avec le gouvernement de l'État membre concerné.

Resumen del informe de la 21ª reunión de la Comisión Internacional del Arroz

La Conferencia de la FAO, en su cuarto período de sesiones celebrado en 1948, estableció la Comisión Internacional del Arroz (CIA) con el objetivo de fomentar la adopción de medidas nacionales e internacionales relativas a la producción, conservación, distribución y consumo de arroz. La Constitución de la Comisión entró en vigor en 1949. El número de sus Estados Miembros se ha elevado de 15 en 1949 a 61 en la actualidad. Cada cuatro años la CIA organiza una reunión con objeto de examinar los nuevos problemas y los progresos recientes en ámbitos científicos, técnicos y socioeconómicos relacionados con la producción arroceras sostenible y los sistemas agrícolas basados en el arroz. Además, ayuda a los Estados Miembros a orientar sus estrategias para llevar adelante sus programas nacionales de fomento del arroz, a la vez que impulsa una amplia interacción entre las instituciones nacionales, regionales e internacionales.

La 20ª reunión de la CIA se celebró en Bangkok (Tailandia) en el año 2002. El Ministerio de Agricultura del Perú y la FAO convocaron la 21ª reunión de la CIA, que tuvo lugar en el Hotel Gran Chiclayo, en Chiclayo (Perú), del 3 al 5 de mayo de 2006. El tema principal fue “El arroz es vida: Llevar la aplicación del AIA a los campos de los agricultores”. Asistieron 90 delegados y participantes de Estados Miembros e instituciones colaboradoras. Hubo cinco subsesiones, una exposición visual y una visita de campo.

Observaciones principales

La Comisión *señaló* lo siguiente:

- En diciembre de 2002, la Asamblea General de las Naciones Unidas en su 57º período de sesiones, observando que el arroz es el alimento básico de más de la mitad de la población del mundo y reafirmando la necesidad de concentrar la atención mundial en la función que puede desempeñar el arroz en la consecución de la seguridad alimentaria y la erradicación de la pobreza, proclamó el año 2004 Año Internacional del Arroz.
- El Segundo Comité del 60º período de sesiones de la Asamblea General de las Naciones Unidas, celebrado en noviembre de 2005, reconoció los buenos resultados de la observancia del Año Internacional del Arroz en 2004 y su contribución a la sensibilización sobre la función que desempeña el arroz en la reducción del hambre y la pobreza, así como el apoyo de todas las partes interesadas a la producción sostenible del arroz.
- El arroz aporta a los consumidores más calorías que otros productos básicos, sobre todo en la alimentación de las personas muy pobres, para las cuales la compra de alimentos constituye más de la mitad del total de los gastos. Las mujeres y niños del África subsahariana, el sur y sudeste de Asia, y América Latina y el Caribe son especialmente susceptibles a las deficiencias de micronutrientes, sobre todo vitamina A, hierro y cinc.
- Por tercer año consecutivo, la producción mundial de arroz registró un fuerte crecimiento en 2005, lo que elevó la producción total hasta un nivel sin precedentes correspondiente a 629 millones de toneladas. Sin embargo, el incremento de la producción mundial en 2005-06 sólo alcanzará para cubrir la utilización.
- La producción de arroz en el África subsahariana sigue viéndose superada por el consumo, en tanto que la inseguridad alimentaria y la pobreza se generalizan en los ecosistemas de arroz de secano en Asia, donde la demanda de alimentos ha estado creciendo con rapidez.
- La población mundial sigue aumentando de manera constante, mientras que los recursos de tierras y aguas para la producción de arroz disminuyen debido a la competencia de otros sectores de la economía y al aumento de la población. Además, el medio ambiente y las bases de recursos naturales para la producción de arroz están deteriorándose a causa de la contaminación por plaguicidas y nutrientes.
- El aumento de las temperaturas, la subida del nivel del mar y la distribución de lluvias irregulares a tenor del cambio climático mundial podrían tener amplias repercusiones negativas en la productividad del cultivo de arroz.
- Ensayos experimentales realizados por la FAO, Estados Miembros e instituciones colaboradoras han demostrado la eficacia de los

- sistemas de gestión integrada de los cultivos del arroz para cerrar la brecha de rendimientos de este cultivo (esto es, la diferencia entre el rendimiento potencial de las variedades actuales y los rendimientos que obtienen realmente los agricultores), aumentar los beneficios de los agricultores y reducir al mínimo los daños causados al medio ambiente.
- Tras obtener variedades de alto rendimiento, el arroz híbrido y el arroz NERICA constituyen los dos logros principales en el campo del mejoramiento del arroz. En 2004, se plantaron en torno a 1,5 millones de hectáreas de arroz híbrido en varios países asiáticos, además de los casi 15 millones de hectáreas plantadas en China. En el África subsahariana, los agricultores están adoptando la variedad de arroz NERICA.

Recomendaciones principales

La Comisión *recomendó* lo siguiente:

- Los Estados Miembros, donantes fundadores, la FAO, instituciones colaboradoras y todas las partes interesadas deberían aumentar su colaboración y apoyo financiero a actividades encaminadas a lograr la plena aplicación de las recomendaciones de la Comisión para aumentar de forma sostenible la producción de arroz a fin de reducir el hambre y la pobreza.
- Debería reforzarse y ampliarse la colaboración en la investigación y fomento del arroz entre instituciones nacionales e internacionales, así como ONG (organizaciones no gubernamentales) y el sector privado, para contribuir eficazmente a incrementar de manera sostenible la producción del arroz en los Estados Miembros.
- Los sistemas de producción del arroz deberían contemplarse de forma integrada, desde la selección de semillas hasta los alimentos en la mesa, teniendo en cuenta la interacción y las asociaciones entre las plantas de arroz y otros organismos de los ecosistemas arroceros, a fin de elevar al máximo los ingresos y la mejora de la nutrición y conservar los recursos naturales para la producción futura.
- Las estrategias y políticas relativas a la producción sostenible del arroz deberían procurar fortalecer la capacidad de los agricultores de arroz en la agricultura de precisión a fin de: mejorar la eficiencia de la utilización de recursos (en especial el agua), reducir los daños ambientales y favorecer la competitividad económica de los sistemas de producción del arroz. Por consiguiente, deberían elaborarse directrices y criterios para llevar a cabo un seguimiento de la sostenibilidad de los sistemas de producción del arroz para los distintos contextos agroecológicos de este producto a fin de posibilitar la capacitación de los agricultores.
- Entre las actividades para mejorar la nutrición humana deberían figurar iniciativas destinadas a: promover la obtención, distribución y adopción de variedades de arroz con un contenido elevado de hierro, zinc y vitamina A, sensibilizar a los consumidores y obtener el apoyo de la industria.
- La obtención de variedades debería centrarse no sólo en las variedades de alto rendimiento sino también en variedades con un valor nutritivo más elevado y una mayor tolerancia a la salinidad, las elevadas temperaturas, la sequía y el estrés por inundaciones.
- Deberían fomentarse las pequeñas y medianas empresas que emplean tecnologías para transformar el grano entero de arroz (incluido el arroz elaborado, el salvado de arroz y las cascarillas de arroz) en productos de valor añadido con objeto de aumentar la rentabilidad obtenida de la producción de arroz y crear oportunidades de empleo.
- La Secretaría de la Comisión debería organizar una consulta de expertos mundial, entre la 21ª reunión (2006) y la 22ª reunión (2010), en la que se examinarán los progresos realizados y se identificarán las estrategias convenientes para mejorar la transferencia de sistemas de gestión integrada de cultivos del arroz a fin de cerrar la brecha de rendimientos, aumentar los beneficios y reducir el deterioro ambiental en los sistemas importantes de producción basados en el arroz.

Fecha y lugar de la próxima reunión

La Comisión manifestó su agradecimiento por la invitación de la delegación de Francia para albergar la 22ª reunión, que tendrá lugar en el año 2010. El Director General de la FAO, en consulta con el gobierno del Estado Miembro en cuestión, tomará la decisión final sobre la fecha y el lugar exactos de celebración.