Rice production in Latin America at critical crossroads

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RICE TRENDS IN LAC

In the twentieth century, per caput rice consumption in Latin America and the Caribbean (LAC) increased from 10 to 30 kg. Rice now supplies more calories to the diet than wheat, maize, cassava or potatoes and it is especially important in the diets of the poor. Rice is a versatile crop, and it is grown in a wide range of climates, soils and moisture conditions. About 55 percent of the crop (3.6 million ha) is grown with irrigation or in wetlands. About 45 percent (3.0 million ha) is grown under rainfed conditions.

Twenty-six countries in the LAC region grow rice, and annual production in 2004 was estimated at 25.8 million tonnes of paddy. This means that LAC accounts for about 4.2 percent of world rice production (estimated at 605 million tonnes of paddy), increasing from the average production in 2002-03 of 22 million tonnes. During this period, yields saw an increase from an average of 3.5 to over 4.0 tonnes/ha, while the area under production decreased, mainly as a result of the low world prices. In 2004, as prices recovered, the area under production increased to the same area as in 2000. This is indication that rice production in LAC is sensitive to world rice prices.

The semitropical or temperate zones of southern Brazil, Uruguay and Argentina are dominated by irrigated rice and they are net exporters. This is in contrast with Central America and Mexico, where rice is grown in both irrigated and upland conditions and rice production is less than half the level of rice consumption. In southern Brazil and Uruguay, both the public and private sectors have strong rice programmes. In the smaller countries of Central America, on the other hand, the national programmes tend to involve few people in rice research and the private sector is often dominated by smaller regional companies.

CURRENT POLICIES OF NATIONAL GOVERNMENTS TO SUPPORT RICE PRODUCTION

NAFTA and its effect on rice production in Mexico

The United States accounts for approximately 12 percent of global rice exports. The largest market for United States rice is Latin America. Mexico is part of the North American Free Trade Agreement (NAFTA) that came into effect in 1994. Although the first few years were difficult and there was a severe devaluation of the currency in 1994, Mexico has gained many benefits from NAFTA and per caput income has doubled in the last decade. The rice sector in Mexico has not been so fortunate. While the United States spends over US$1 billion a year to subsidize rice, the Mexican Government has done little to support rice production in Mexico.

Under the agreement, the United States phased out its tariffs on rice imports from Mexico over a 10-year period. Mexico also phased out its tariffs (10 percent for United States paddy rice and 20 percent for United States refined rice) over a 10-year period. No quantitative restrictions affect United States and Mexican trade in rice.

The effect of the agreement has been an increase in rice imports to Mexico from the United States. This increase was affected by world rice prices and subsidies to United States farmers. As rice became cheaper, it was hard for the Mexican farmers to compete, and imports began to increase sharply in 1999. There is high demand among Mexican consumers for a short-grain rice that is not commonly produced in the United States; this demand prevented the reduction in production from being even greater.

The Mexican rice sector is becoming more organized, and the Consejo Mexicano del Arroz is promoting both rice production and consumption, with financial assistance from the Mexican Government. In 2004, it became a member of FLAR (Latin American Fund for

Irrigated Rice) with the aim of increasing activities in rice breeding and crop management. Yields in Mexico average slightly over 4 tonnes/ha and the rice sector must increase yields significantly and reduce production costs if it is to become competitive in an arena without protection.

CAFTA and its effect on the rice sector

The United States, El Salvador, Guatemala, Honduras and Nicaragua have ratified the CAFTA (Central American Trade Agreement) treaty. Ratification of the treaty by Costa Rica is pending, and Panama is not included in the treaty. Central American countries are the second largest importer of rice from the United States, importing a combined total of about 550 000 tonnes per year. The CAFTA treaty imposes a complex mixture of tariff rate quotas (TRQs). During the first year of CAFTA, the TRQs are 343 000 tonnes of paddy and 44 000 tonnes of milled rice. Paddy rice will be charged a tariff of 5 percent and milled rice a tariff of 10 percent. Any additional imported rice will be charged tariffs ranging from 20 to 35 percent on paddy rice and from 30 to 45 percent on milled rice, depending on the importing country. The quantity of rice imported under the quota will increase by 5 percent a year for milled rice, and by 2 percent a year in Costa Rica, El Salvador and Honduras, 3 percent in Nicaragua, and 5 percent in Guatemala. Duties on all types of rice will be phased out over the next 18 to 20 years. The reduction in quotas applies only to the CAFTA countries, and they are expected to manage the TRQs in a manner that encourages the quotas to be filled.

The only country that agreed to a quota higher than current imports is Guatemala. Per caput consumption in Guatemala is only 8 kg per person. This means that local producers will begin competing directly with United States rice in the first year of the CAFTA treaty. The Guatemalan Rice Association (ARROZGUA) promotes both rice consumption and production. Central American countries only produce about half of the rice they consume; most of the remainder is imported from the United States. Therefore, the other countries have time to increase the efficiency of their rice production before having to compete directly with imported rice. As for Mexico, meeting this challenge will require better organization both in the development of new varieties and in the management of the crop. As the rice sector employs 1.2 million people, it must become competitive and contribute to lowering the rates of poverty in this region.

POTENTIAL FOR RICE PRODUCTION

Rice is a crop that depends on water and most rice production depends on irrigation. Latin America is a region that still has ample water and land; the only other continent with a comparable abundance of water is North America. In contrast, water is a relatively scarce resource for Asia, Africa and Europe.

Given the consistent rainfall in many regions, about 40 percent of rice production in Latin America is upland or non-irrigated rice. Although yields tend to be lower, it is economical to produce upland rice because the cost of production is significantly less than the cost associated with irrigated production. There are major areas of upland rice in Brazil and Bolivia.

Rice production is very dependent on water and the most consistent and highest yields occur in irrigated systems. Most irrigated rice is in flooded fields. However, it is easier to control weeds, pests and diseases if irrigation can take place during the drier times of the year. In the desert coastal areas of Peru, rice is irrigated by mountain water and yields are often above 12 tonnes/ha. There are many areas of Latin America that can potentially produce large quantities of rice, but they lack the infrastructure to do so.

For rice production to substantially increase, it must be able to compete in the export market. Given the estimated US$25 billion of subsidies for United States rice production, it is difficult for LAC to compete. Nevertheless countries like Uruguay are competing and exporting most of the rice that they produce. Latin American rice producers need to support the development of modern varieties with multiple stress resistance, adopt effective integrated crop management strategies, and develop post-harvest processing systems that will help to stabilize the local rice prices. Latin America has the potential to fill the increasing demand for rice that is occurring with the increase in population.

In most LAC countries, the internal price of rice is higher than the border price for imported rice. While subsidies play a role in this discrepancy, it is also the result of a combination of high costs and low yields, which result in relatively high unit costs for rice. As a rule of thumb, countries should have a target of US$1 000 per hectare costs, with yields of at least 7 tonnes/ha to be able to supply rice at a competitive price. While this is feasible, it is not the norm. In the temperate regions, these targets have been reached by many farmers. Rice-pasture rotation helps on both fronts: lower costs and higher yields. In the tropics, low luminosity during the rainy season becomes a hindrance for low cost and high yield. To move away from that condition, water harvesting programmes will have to be implemented to allow farmers to produce in the dry season, with high luminosity and favourable conditions for pest and disease control.

RICE BREEDING PROGRAMMES

Rice production has been quite dynamic in this region. Following the late 1960s, over 300 new varieties were released and production tripled with 80 percent of this increase due to higher yields. The main beneficiaries of the process are consumers, as real rice prices dropped by over 40 percent in the same period (Sanint, 1992).

Conventional rice breeding

Rice programmes vary – from well-financed multi-disciplinary teams to poorly funded groups with activities in rice breeding. They include national programmes, state programmes, and programmes run by rice federations, universities and private companies. The capacity ranges from developing and testing crosses, to simply evaluating a limited number of fixed lines. To be effective, smaller programmes must be associated with organizations that develop fixed lines. Two such organizations, the FLAR and GRUMEGA (Working Group on Advanced Rice Breeding) networks, currently support activities in irrigated and upland rice. Rice programmes in both the public and the private sector are facing more open markets; they are collaborating more closely and understand the need for this trend to continue. The International Network for Genetic Evaluation of Rice (INGER) in LAC has been relatively inactive during the last few years. CIAT, FLAR and IRRI understand that there is an urgent need to revitalize this mechanism for germplasm evaluation and distribution. Some of the major activities and trends in rice breeding for LAC are described below.

FLAR breeding activities

FLAR was created in 1995 in response to decreasing budgets at CIAT for rice research. Its main focus was to maintain the flow of elite lines to and from the region and the generation of new lines with enhanced characteristics that are the basis for the efficiency and competitiveness of the sector. FLAR currently has 14 member countries, i.e. the majority of countries with an important rice sector.

The FLAR breeding programme is mainly a varietal development effort shared by its members to achieve economies of scale and avoid duplication of efforts in a carefully crafted process that takes advantage of the division and specialization of labour. The programme has two main domains in terms of the varieties being developed: temperate and tropical. FLAR delivers segregating lines to its partners, which, in turn, finish the selection process to identify those that are released as new varieties. Representatives in each member country are responsible for the protection of the varieties and for collecting fees to keep the model financially healthy and operational.

Recurrent selection

Population breeding by recurrent selection is efficient for trait improvement showing low heritability. Through short cycles of selection and recombination, linkage blocks are broken down and favourable genes are accumulated. This is a smooth process of continuous improvement. The methodology applied to rice and implemented by the project was described in a handbook by Châtel and Guimarães (1998).

Basic composite populations are enhanced using two recurrent selection-breeding methods: mass and S_2 progenies evaluation. At each step of enhancement, fertile plants are selected for the development of segregating lines and progeny selection using the conventional pedigree method. One major advantage of this method is that populations are started with many parents, and more than 20 parents are often used to develop the basic composite populations. These populations can target specific ecosystems or complex traits, such as drought tolerance, through the selection of the founding parents.

The CIRAD (International Cooperation Centre of Agricultural Research for Development)/CIAT rice collaborative project concentrates on broadening the genetic base of rice through composite population improvement using the recurrent selection method combined with conventional breeding methods. Guimarães (2005) documents many of the advances that have been made using recurrent selection in rice breeding throughout LAC.

Both populations and advanced upland lines are locally screened and selected. The most promising lines are evaluated at regional yield trials. In Chile, the population-breeding project uses site-specific populations developed from the introgression of local adapted material into the population GPIRAT-10. The Chilean populations are enhanced for cold tolerance and other agronomic traits. During the enhancement process, segregating lines are developed and advanced lines are already in yield trials. A promising line could be released next year if its behaviour is confirmed. In Venezuela (Bolivarian Republic of), in the Fundación DANAC rice breeding project, 43 percent of the advanced lines come from selections made in different introduced and site-specific composite populations, and a line from the population PCT-16 was identified as a candidate cultivar for launching as a commercial variety in 2007. In Argentina, the population-breeding project was started in late 1996 with the introduction of populations from Colombia. From the best-adapted germplasm (PCT-8), a site-specific population was set up (PARG-3) and characterized for different traits. About 150 breeding lines are in the pipeline for fixed line development.

The first irrigated variety in LAC that was developed using recurrent selection was released by EPAGRI (Empresa Catarinense de Pesquisa Agropecuária), Santa Catarina, Brazil in 2003, and it was named in honour of the retiring rice breeder, Tio Taka. The first upland variety selected from the composite population PCT-4 was officially launched as a variety in January 2006. The variety is adapted to upland traditional and mechanized rice systems. For small farmers, the advantages of this variety include earliness and drought tolerance, as well as good yield potential. Earliness is a very important trait, because farmers can put rice on the market early in the season and get good prices. It also gives farmers time to plant a second higher value crop which is important for income generation.

Recurrent selection helps increase variety diversity and also the probability of selecting for complex traits such as drought stress. As with all breeding activities, a long time is required. Only after 10 years of using this method are varieties starting to be released. There are more than ten breeding programmes that use recurrent selection and they are associated in GRUMEGA. This network helps build regional relations between breeding programmes through LAC, and conducts workshops where advanced materials are available for selection. These workshops are important for the larger breeding programmes and essential for the smaller ones. They have also been an effective forum for promoting the innovative breeding method of recurrent selection.

MINING THE WILD RICE SPECIES

The genus *Oryza* consists of 21 wild rice and two cultivated species. After 6 000 years of continuous selection by man and intensive breeding efforts during the last 100 years, the genetic base of the crop is narrower than ever. The modern high-yielding rice varieties that ushered in the Green Revolution brought about dramatic increases in rice production worldwide, but a narrower genetic base. The *Oryza* wild species represent a potential source of new alleles for improving the yield, quality and stress resistance of cultivated rice.

The wild relatives of rice are resistant to many pests and diseases for which there is not sufficient genetic resistance in rice. There are even components in the wild species that can increase the yield potential of rice. Advanced lines from the cross Lemont/*O. barthii* mature early with good yields and excellent grain quality. Interspecific crosses are being made for many traits, including *O. rufipogon* as a source aluminium tolerance and vigorous root growth. High levels of resistance to the rice stripe necrosis virus were found in *O. glaberrima*, and this resistance has been transferred through interspecific crosses to Bg90-2 and Caiapo. The results for disease resistance are also impressive. Using high disease pressure, advanced breeding lines with resistance to *Rhizoctonia solani* were derived from the interspecific crosses of Oryzica3/*O. rufipogon*.

The diversity of the parents makes these interspecific crosses ideal in studies to develop molecular markers. By using a set of chromosome introgressed substition lines (CISL), the genomic region of the interspecific species can rapidly be identified. Already, they have been used to mark regions of the chromosome of *O. glaberrima* for important traits. Varieties with more diversity, that yield well in environments with low inputs, use water more efficiently and are more nutritious, will be easier to develop if the genetics and molecular basis for these traits are understood.

The future for marker-assisted selection

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 use a genetically narrow gene pool, and marker-assisted selection (MAS) is amenable to high-throughput analysis, and sufficient polymorphism can be found for the parents of most crosses (McCouch *et al*., 1997).

To increase the efficiency of developing hybrid rice, IRRI uses DNA MAS for the WA cytoplasm restoration ability and thermosensitive genetic male sterility. Markers for quality traits were developed at Texas A&M. Many disease markers are available, including markers for both major and minor resistance genes for rice blast, for rice bacterial blight (*Xanthamonas oryzae*) and planthopper resistance. Rice hoja blanca virus (RHBV) is an important disease in LAC and is costly to screen in the field. One potential marker has already been identified for resistance to this disease.

There are SSR markers available for many other traits, and there are many research programmes working to discover the function of rice genes. At the Fifth International Rice Genetic Congress, it was proposed that the function of all the rice genes should be determined by 2015, and some indicated that it might be possible to achieve this goal as early as 2010. This type of information will allow the widespread development of single nucleotide polymorphisms (SNPs, pronounced "snips") – highly specific markers that are amenable to very high-throughput analysis.

The MAS technologies are being used at a few advanced laboratories, but are still not widely used. As more information is obtained on resistance to biotic and abiotic stresses as well as important agronomic characteristics, 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 start using this technology?

Potential of transgenic rice

While there are no transgenic rice varieties grown commercially, there are many field experiments throughout the world. Herbicide resistance and stem borer resistance (Bt) is widely deployed in commercial cotton, maize and soybeans. Herbicide resistance would be effective for controlling red rice which is a major problem throughout LAC. Herbicide-resistant rice has been developed but is not available in commercial varieties.

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 were 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, 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.

Rice does not normally produce vitamin A and "Golden Rice" was developed to alleviate vitamin-A deficiency. It was made 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 (Ye *et al.*, 2000).

One reason that transgenic rice has not been commercialized is that there are several biosafety issues. One of these issues is the gene flow from rice to red rice. In contrast to temperate regions, where weedy rice is mainly composed of *Oryza sativa f. spontanea* (red rice), in tropical America, the weedy rice complex is diverse and composed of numerous *Oryza* species. The preliminary results demonstrate that there is a natural gene flow rate from transgenic/non-transgenic rice to weedy rice of between 0.0 and 0.3 percent in the field, but no differences were found in the hybridization rates between weedy rice and transgenic or non-transgenic rice. If herbicide resistance is the transgenic trait, there should be few red rice in the field and outcross should be a rare event. However, if transgenic rice becomes commercialized, the post-harvest management of the field will be important for reducing the transfer of transgenic characteristics to weed populations.

The principal reason for which transgenic rice has not been commercialized is related to the politics of transgenic crops. The United States does not wish to jeopardize the European or Japanese export markets, and other countries are also hesitant to be the first to deploy transgenic rice. It is expected that China will be the first country to actually deploy commercial transgenic rice. Given the acceptance of transgenic soybean, maize and cotton in several LAC countries, and taking into consideration the limited amounts of exports, the release of commercial transgenic rice could bring benefits to several countries in the region.

INCREASING PRODUCTIVITY THROUGH INTEGRATED CROP MANAGEMENT

Most countries in LAC do not reach the yield potential of their germplasm, mainly as a result of deficiencies in crop management. Most countries are now quite active in terms of identifying constraints and tackling them jointly – FLAR has focused on agronomy in the past 5 years, thanks to a project supported by FAO and the Common Fund for Commodities (CFC). CIAT also accompanies these regional efforts.

Integrated production and pest management

There are several proposed systems of integrated production and pest management (IPPM). They are all knowledge intensive and depend on the development of a set of best management practices. An example of IPPM is the RiceCheck system – described in detail by Clampett, Nguyen and Tran (2003). Another example is the Management Program for the High Production of Rice, described by Dr Edward Pulver during this IRC meeting.

IPPM systems involve proper fertilization, water and weed management, timing and density of planting, monitoring for pests and diseases, and the judicious use of inputs. These practices are based on a knowledge-based system with intensive management. It is important to know the principal varieties and their behaviour within the context of the local agro-ecosystem. Proper crop management is essential if Latin America's rice farmers wish to be competitive.

PRINCIPAL PEST PROBLEMS IN LATIN AMERICA

The mite complex: a new challenge

During the mid-1990s, a new pest complex caused economic damage in Cuba. There were severe outbreaks of *Sadocladium*, which is normally a minor problem. There were also an unusually high number of sterile spikes. The mite *Stenopheles spinki* – principally a pest in Asia – was found in high numbers in the affected field. It was also found in Haiti and the Dominican Republic. For the following decade, this pest was thought to be localized in these islands. The Cuban rice research programme developed mutants of a couple of popular varieties and started selection of new varieties with resistance to the mite.

In 2004, there was a major outbreak of grain discolourization. This was discovered to be a complex between *S. spinki* and bacteria. Higher levels of *Sadocladium* were also reported in some areas. Countries started monitoring activities for *S. spinki* which was found in Nicaragua, Panama and Colombia. In Panama, it is associated with outbreaks of bacteria. In Colombia, the region of Casanare had multiple disease problems and it is suspected that *S. spinki* was part of the complex.

Varietal resistance exists for this mite and many commercial varieties have been classified as susceptible or tolerant. Tolerance to *S. spinki* is to be added as one of the breeding goals in many of the breeding programmes in the affected region.

Crop management is the most important way to control the pest and disease complex associated with *S. spinki*. Farmers need to resist indiscriminate spraying for the mite. The insecticides that are effective also eliminate the beneficial spiders that are biological control agents for the rice crop. Before any application of pesticides, one needs to monitor the field and determine the level of infestation. Given that *S. spinki* colonizes the interior of the leaf sheath, monitoring is not as easy as for other insects. Protocols for determining the level of infestation were developed and are available on several Web sites and in pamphlets. The best management practices in IPPM tend to produce rice plants that are hardier. These plants are also more resistant to damage from *S. spinki*. These management practices also encourage the build-up of natural enemies of the mite. In areas where the mite is a problem, a variety that is moderately tolerant to the mite should be selected and IPPM should be used.

Rice blast: a continuing challenge

Most commercial varieties remain resistant to rice blast (*Mangaphora gresia*) for only 1 to 3 years. There is a tug of war between the pathogen and the host. While a host may be resistant to many of the rice blast isolates, there always seems to be a subset of the population that is not recognized by the plant's defences and it soon becomes predominant. The resistance is then broken and the new variety becomes susceptible to rice blast. Hot spot selection under high disease pressure and pathogen diversity has been the principal method for breeding rice-blast-resistant lines and varieties. For example, the variety, Fedearroz 50, is widely grown in Colombia and has remained highly resistant to rice blast since its introduction in 1998. This contrasts with most new varieties that start to have problems 1 to 2 years after release.

Much work remains before it can be declared that there are the knowledge and methods to consistently develop rice with durable resistance, but there is evidence that, step-by-step, progress is being made. Oryzica Llanos 5 is a variety that was developed through hot spot breeding; it is exceptional because it has remained resistant to rice blast for more than 15 years. The genome of Oryzica Llanos 5 is being analysed and contains several major resistance genes as well as a group of minor resistance genes.

This is part of a greater effort to catalogue both the resistance genes in the plant and the virulence genes in the fungus. The fungal isolates can be characterized using near isogenic lines carrying individual resistant genes. This can identify the most common rice blast linages in an area. On the plant side, the rate of discovery of rice blast resistance gene is one of the benefits of knowing the entire rice genome sequence. Testing of resistant gene combinations that confer durable resistance is being done and this knowledge leads to designer varieties with better resistance to rice blast.

Rice hoja blanca virus

Since the mid-1950s, the development of rice varieties with resistance to rice hoja blanca virus (RHBV) has been a breeding objective. The virus is transmitted by the planthopper *Tagasodes orizicolus*. For many years, only one source of resistance was widely used in breeding programmes, and there was only marginal progress. Most commercial varieties are still not resistant to hoja blanca disease. In the mid-1990s, when it appeared that a new epidemic was imminent, CIAT – with the collaboration of FEDARROZ in Colombia and DANAC in Venezuela (Bolivarian Republic of) – started working intensively on developing resistant varieties. In addition to the mass screen method that has been in place since the mid-1980s, an evaluation scheme using different levels and timing of disease pressure in randomized block design was introduced. These efforts led to the development of five varieties with resistance to hoja blanca disease. Two varieties, Fedearroz 2000 and Fedearroz Victoria 1, have resistance that is superior to any of their parents. Because most breeding programmes do not have capacity to screen for RHBV, most commercial varieties are not resistant to RHBV.

Progress is being made in understanding the genetics and in developing markers for resistance to both the virus and its vector. There are more breeding programmes which have access to laboratories with the capability to implement MAS than to viruliferous colonies of *T. orizicolus*. This use of MAS for RHBV should lead to the development of more commercial varieties with resistance to this disease.

Reaching the small rice farmers

One of the most innovative activities in terms of meeting the needs of small rice farmers is the CIRAD/CIAT rice participatory breeding project. Since 2003, upland composite populations and advanced and segregating lines developed by CIRAD/CIAT have been evaluated in Nicaragua. While some of the evaluation has been done in a traditional manner with the National Agricultural Research Institute, many of the materials were evaluated using participatory variety selection (PVS). Composite populations are also being evaluated using participatory plant breeding (PPB). The organization of the groups, the involvement of the farmers, the exchange of local and technical information are all important benefits of this method. By having more access to information and the ability to function as a group, the small farmers are empowered to develop solutions to their critical needs. Activities focus on selecting rice varieties adapted to the needs of the small farmer; the outcome is social benefits to the small farmers and their communities.

CONCLUSIONS

About 4.2 percent of total global rice production is harvested in Latin America and the Caribbean and this percentage has been increasing in recent years. Net consumption is nearly equal to production with the southern cone countries, where a surplus is produced; Central America, Mexico and the Caribbean region are net importers. Both the major exporters of the southern cone and the net importers of Central America and the Caribbean are facing a similar challenge. In order to increase production, their rice farmers must produce rice that competes with rice in the export markets.

In order to effectively compete, rice yields must continue to increase while the costs associated with production are reduced. The new varieties must be of excellent grain quality, have multiple stress resistances and high yield potential. Yield potentials needs to be exploited by making investments in the land and water resources. Good agronomic practices include: effective fertilization; water and weed management; lower plant densities; and growing rice during the seasons of highest solar radiation.

Both government and the private sector must be committed to:

- supporting the development of varieties;
- creating access to certified seed, extension and other information services; and
- providing a system of credit and crop insurance.

The universities – which are very important in the United States for both research and extension activities – are very limited in LAC. This type of support is not a subsidy and the countries of LAC need to increase their investments in these institutions for the whole agricultural sector.

Finally, as long as the rice sector in LAC remains divided and continues to compete with other national organizations, the sector remains in jeopardy. The different actors need to work together to influence government policy and strengthen investment in rice farming. Availability of water, land and human resources is not a problem. With the new trade agreements and the region reaching self-sufficiency in rice production, LAC is at a crossroads. Will there be enough unity in the rice sector to influence policy and attract local investment or will it remain a sector with many small and somewhat conflicting voices that lacks the clout to influence governments or attract investment from the private sector. Organizations, such as FLAR and FEDARROZ, are a sign that the rice sector understands the challenge and wants to develop strategies to become more productive. To achieve this, governments and the private sector need to help strengthen the public sector, including the international centres, national and state programmes, and universities. The rice sector may then continue to evolve and prosper.

REFERENCES

Châtel, M. & Guimarães, E.P. 1998. *Selección Recurrente con Androesterilidad en Arroz.* CIAT Publication No. 246.

Clampett, W.S., Nguyen, V.N. & Tran, D.V. 2003. The development and use of Integrated Crop Management for rice production. In *Proc. 20th Session of the International Rice Commission*, Bangkok, Thailand, 23-26 July 2002. FAO.

Guimarães, E.P. (ed.). 2005. *Population improvement: A way of exploiting the rice genetic resources of Latin America*, p. 1-350. Rome, FAO.

Lentini, Z., Lozano, I., Tabares, E., Fory, L., Domínguez, J., Cuervo, M. & Calvert, L. 2003. Expression and inheritance of hypersensitive resistance to rice hoja blanca virus mediated by the viral nucleocapsid protein gene in transgenic rice. *Theor. Appl. Genetics*, 106: 1018-1026.

McCouch, S.R., Chen, X., Panaud, O., Temnykh, S., Xu, Y., Cho, Y.G., Huang, N., Ishii, T. & Blair, M. 1997. Microsatellite marker development, mapping and application in rice genetics and breeding. *Plant Mol. Biol.*, 35: 89-99.

Sanint, L.R. 1992. New rice technologies for Latin America: social benefits, past reminiscences and issues for the future. In *Trends in CIAT commodities*, Working Document 111. Palmira, Colombia, CIAT.

Ye, X., Al-Babili, S., Klöti, A., Zhang, J., Lucca, P., Beyer, P. & Potrykus, I. 2000. Engineering the provitamin A (-carotene) biosynthetic pathway into (carotenoid-free) rice endosperm. *Science*, 287: 303-305.

La production de riz en Amérique latine: une étape décisive

Relativement bon marché, le riz est devenu un bien de consommation courante en Amérique latine et dans les Caraïbes. Il occupe une place toute particulière dans l'alimentation des pauvres. Alors que la production et la consommation de riz sont en équilibre si l'on considère l'ensemble de la région, on relève un déficit en Amérique centrale et dans les Caraïbes et un excédent dans le cône austral.

Les accords de libre-échange ont actuellement des répercussions négatives sur la production au Mexique et affecteront bientôt la production en Amérique centrale. La production du cône austral doit être rentable pour permettre la compétitivité sur le marché international du riz. La solution a consisté à augmenter le soutien aux riziculteurs ce qui a permis d'accroître les rendements au cours des cinq dernières années. Si cette tendance se confirme, des progrès devront être accomplis dans le développement des variétés et la gestion des cultures.

Le présent article décrit l'orientation actuelle, le potentiel de production du riz et certaines des activités axées sur l'augmentation de la compétitivité de la culture du riz en Amérique latine et dans les Caraïbes.

La producción de arroz en América Latina en una difícil situación

Dado que el arroz es relativamente barato, se ha convertido en uno de los alimentos básicos principales de América Latina y el Caribe, con especial importancia en la alimentación de las personas pobres. Aunque la producción y el consumo de arroz en la región muestran en general un equilibrio, la región de América Central y el Caribe presenta un déficit frente al superávit que se registra en la región del Cono Sur.

Los acuerdos de libre comercio están afectando de forma negativa a la producción en México y pronto comenzarán a afectar a la producción de América Central. El Cono Sur tiene que resultar rentable para que los productores compitan en los mercados de arroz internacionales. La reacción ha sido aumentar el apoyo a los cultivadores de arroz, y en los últimos 5 años los rendimientos se han incrementado considerablemente. Si se mantiene esta tendencia, será necesario realizar nuevos avances tanto en la obtención de variedades como en la gestión de cultivos.

En este artículo se describen las tendencias actuales, el potencial de producción de arroz y algunas de las actividades que pretenden aumentar la competitividad del cultivo de arroz en América Latina y el Caribe.

Challenges and opportunities for sustainable increase of rice production in the Near East region

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Rice is the third largest crop in the Near East region in terms of area sown after wheat and cotton; Egypt, Pakistan, Iran (Islamic Republic of), Morocco, Iraq, Turkey, Mauritania and Sudan are the main producing countries. Rice occupies about 3.9 million ha annually, playing a significant role in the strategy to overcome food shortages. Total production is about 17.9 million tonnes with an average productivity of 4.6 tonnes/ha. With the exception of Egypt and Pakistan, which had an exportable surplus in 2004 of about 1.0 and 1.8 million tonnes, respectively, the countries in the region are net rice importers. It is estimated that approximately half of the rice consumed in Near East countries is imported every year (FAO, 2003). In 2004, the total amount of milled rice exported from rice-producing countries in the Near East region was only 2.8 million tonnes, while the imported amounts were about 1.1 million tonnes.

The irrigated agro-ecology is the most favourable for very high yields. However, high variability in rice yield exists among the countries in the region. The average national yield is 9.83 tonnes/ha in Egypt, compared to only 4.53 tonnes/ha in Mauritania. This type of yield gap is due mainly to socio-economic factors (e.g. crop management and access to knowledge and technologies), and to a lesser extent to biophysical factors (e.g. climate, length of growing season, soil, water and pest pressure). The low rate of adoption of productive varieties and improved crop management technologies as a result of weak research and extension systems is apparent for the low yields achieved in many of the region's rice-producing countries.

PRODUCTION AND CONSUMPTION

Rice (*Oryza sativa*) is not only the staple food in many countries of the Near East region, but a key source of employment and income for rural people in rice-producing countries. It is the most widely grown crop under irrigation. Rice is grown in 16 countries in the region. Rice production in Pakistan, Egypt and Iran (Islamic Republic of) accounts for 92 percent of the region's rice production. Data in Table 1 show the evolution in the harvested area, yield and total production in some of the region's rice-producing countries in the past 42 years. Since 2000, paddy output in the region has rebounded strongly in countries that were affected by drought in the late 1990s, reflecting heavy precipitation that helped to reconstitute water reserves. This and other incentives are expected to boost rice production in the main rice-producing countries. In 2004, 2.67 percent of the rice harvested area was located in the Near East region (Table 2).

In Egypt and Pakistan, rice is considered one of the potential export crops capable of providing foreign exchange to the country. It also has an important socio-economic impact, due to the fact that a large number of the labour force is employed in the rice sector. Total consumption in Egypt for 2002 was estimated at about 3.3 million tonnes. In countries such as Morocco and Turkey, rice consumption is very low. Morocco is one of the lowest-consuming countries in the world (less than 1 kg of rice per caput per year) – clearly a major constraint to the development of rice production in the country.

Table 3 shows the level of rice consumption in some of the rice-producing countries in the Near East. During recent decades, there have been consistent increases in demand for rice, and its growing importance is evident in the strategic food security planning policies of many countries. With the exception of a small number of countries that have attained self-sufficiency in rice production, rice demand exceeds production and large quantities of rice are imported to meet demand at a huge cost in hard currency.

TABLE 1
Rice-producing countries and production in the Near East

Paddy rice	Harvested area (*ha*)			Yield (*tonnes/ha*)		Production (*tonnes*)		
	1961-2002[a]	2002	2004	2002	2004	1961-2002[a]	2002	2004
Afghanistan	187 088	135 000	-	2.87	-	367 900	388 000	-
Algeria	805	200	200	1.50	1.50	2 361	300	300
Azerbaijan	2 469	3 407	2 573	4.88	3.98	10 063	16 640	10 243
Egypt	464 119	612 616	645 930	9.14	9.80	3 038 389	5 600 000	6 352 375
Iran (Islamic Republic of)	456 995	550 000	630 000	3.85	5.40	1 597 116	2 115 000	3 400 000
Iraq	78 199	100 000	-	0.90	-	187 996	90 000	-
Kazakhstan	85 039	65 733	76 300	3.03	3.60	260 591	199 089	275 849
Kyrgyzstan	4 798	6 008	6 104	3.17	3.00	10 797	19 029	18 344
Mauritania	7 581	16 975	17 000	4.00	4.50	27 741	67 900	77 000
Morocco	5 343	5 100	2 300	3.29	7.30	23 785	16 780	16 900
Pakistan	1 861 799	2 201 000	2 519 500	2.88	2.99	4 459 130	6 343 000	7 537 100
Somalia	2 258	2 500	-	1.60	-	5 775	4 000	-
Sudan	4 101	4 762	4 800	3.31	3.28	4 283	15 748	15 748
Tajikistan	13 728	10 000	10 501	2.90	4.90	35 475	29 000	51 445
Turkey	58 105	85 000	70 000	4.71	7.00	268 583	400 000	490 000
Turkmenistan	35 782	42 000	60 000	1.07	1.83	49 848	45 000	110 000
Near East (total)	**3 161 206**	**3 840 301**	**4 045 208**	**4.00 (mean)**	**5.90 (mean)**	**10 071 217**	**15 349 486**	**18 355 302**
World (total)	**140 300 516**	**147 144 157**	**151 027 926**	**3.92 (mean)**	**4.00 (mean)**	**419 192 917**	**576 280 153**	**606 648 911**
Near East/world	**2.25%**	**2.61%**	**2.67%**	**-**	**-**	**2.40%**	**2.66%**	**3%**

[a] Mean for period 1961-2002.
Source: FAOSTAT, 2005.

TABLE 2
Rice area, yield, production, import and export for Near East countries, 2004

Paddy rice	Rice area ('*000 ha*)	Yield (*tonnes/ha*)	Production ('*000 tonnes*)	Imports ('*000 tonnes*)	Exports ('*000 tonnes*)
Egypt	645.9	9.83	6 352.0	2.0	1 000.00
Iran (Islamic Republic of)	630.0	5.4	3 400.0	972.8	0.18
Mauritania	17.0	4.53	77.0	19.6	0.00
Morocco	2.3	7.3	16.9	1.5	0.00
Pakistan	2 519.0	2.99	7 537.0	0.4	1 817.00
Sudan	4.8	3.20	15.7	49.0	0.00
Turkey	70.0	7.0	490.0	103.9	0.47
Total	**3 889.0**	**4.6**	**17 888.6**	**1 149.0**	**2 818.00**

Source: FAOSTAT, 2005.

TABLE 3
Rice consumption in some Near East rice-producing countries, 2002

Country	Population (*millions*)	Total milled rice consumption ('*000 tonnes*)	Domestic milled rice production ('*000 tonnes*)	Milled rice imports ('*000 tonnes*)	Milled rice exports ('*000 tonnes*)	Rice consumption per caput (*kg/person*)
Egypt	70.5	3 283.0	3 735.0	1.7	1 065.0	46.50
Morocco	30.0	14.0	11.2	2.9	-	0.46
Turkey	70.3	583.0	240.0	344.9	2.2	8.29
Pakistan	149.9	2 815.0	4 481.0	14.2	1 680.0	18.00
Iran (Islamic Republic of)	68.0	2 844.0	1 926.0	919.5	1.4	41.00
Mauritania	2.8	92.6	51.6	40.9	-	33.00
Sudan	32.8	41.4	10.5	30.9	-	1.26
Total	**424.3**	**9 673.0**	**10 455.3**	**1 355.0**	**2 748.6**	**22.80**

Source: FAOSTAT, 2005.

PRODUCTION STATUS IN MAJOR RICE-PRODUCING COUNTRIES OF THE NEAR EAST

Egypt

Rice is one of the major field crops in Egypt. It occupies about 0.65 million ha, produces approximately 6.4 million tonnes of rough rice annually (RRTC, 2005) and contributes about 20 percent to per caput cereal consumption. The country has several production zones and ranks as one of the highest in the world in terms of productivity per unit area. Rice area has significantly increased from 464 000 ha (average for 1961-2000) to about 646 000 ha in 2004, with the total increase estimated at about 39 percent. Oad and Rajab (2002) put this expansion down to:

- the removal of government regulations on crop choices by farmers in the mid-1980s;
- the relative profitability of rice on local and international markets;
- the food security associated with rice as a home-consumption crop; and
- the government support of rice prices relative to cotton through import tariffs.

Generally speaking, there is limited potential for further increase of the rice area in Egypt, due to the limited supply of irrigation water. A number of other factors, such as soil type and climate, also determine suitable areas. Economic factors, such as yield, cost, farmgate price and net return, affect a farmer's decision on whether to cultivate rice or not.

Iran (Islamic Republic of)

Rice is the second main crop consumed in Iran (Islamic Republic of), after wheat. Production of paddy rice is currently around 3.4 million tonnes from a cropped area of 630 000 ha, all of which is irrigated. Production units are essentially small with 70 percent having less than 1 ha. Yields from traditional rice genotypes are 2 to 4 tonnes/ha, in comparison with 5 to 7 tonnes/ha for high-yielding genotypes. About 75 genotypes are grown in the country. The major rice-producing region (in Gilan and Mazandaran provinces north of the country) is located between the Alborz Mountains and the Caspian Sea. This humid region – with its suitable soils and heavy rainfall – accounts for 73 percent of the country's total rice production. Increased production of rice in Iran (Islamic Republic of) is due not only to such conditions and increased land utilization, but to mechanization, use of chemical fertilizers and insecticides, improved seeds and the introduction of high-yielding genotypes. The main factors preventing fundamental development of the agricultural sector, including rice production, are:

- lack of water resources;
- soil conditions;
- mode of land ownership;
- seed quality; and
- production technology and management.

The rice production season in Gilan and Mazandaran begins in May and the planting period lasts slightly more than 6 weeks. Harvest starts between September and October, with some areas harvested in late October due to the cooler weather and lower rainfall (Shariati, 2003).

Pakistan

Pakistan produced 7.5 million tonnes in 2004, corresponding to average paddy yields of 2.99 tonnes/ha. Rice cultivation is concentrated mainly in Punjab (59.5 percent) but it is not the only production area (Ahmed, 2003). Much of the growth in irrigated area in Asia since 1980 is the result of tubewells. In Pakistan, the canal-irrigated area declined in absolute terms between 1982 and 1995, while tubewell irrigation – either by itself or in conjunction with canals – increased; consequently, total irrigated area increased by over 100 percent during this period. However, the increase in rice productivity in the late 1990s was due to the introduction of short-cycle genotypes, improved water management, the application of fertilizers and improved plant protection. The country's rice area increased threefold over 54 years: from approximately 0.8 million ha to about 2.4 million ha (Ahmed, 2003).

Turkey

The rice area in Turkey is approximately 70 000 ha (compared to 9.3 million ha of wheat and 3.6 million ha of barley in 2004). The rice area varies between 40 000 ha (1991) and 70 000 ha (2004), depending on water availability and government policies. In 2002, it was a total of 60 426 ha distributed over six major rice-producing zones, of which the Marmara region alone accounted for approximately 62 percent of the country's total harvested area and produced nearly 50 percent of the country's total production.

Annual milled rice production ranges between 150 000 and 240 000 tonnes, which is not sufficient for domestic consumption. This deficit is covered by imports, which reached 103 900 tonnes in 2004 (i.e. more than total domestic production). Rice imports have since continued to increase. Productivity is also increasing progressively (reaching 7.0 tonnes/ha in 2004), as is the harvest area (70 000 ha) and production (490 000 tonnes).

GERMPLASM AVAILABILITY AND VARIETAL DEVELOPMENT

Varietal development is ongoing in many rice-producing countries in the region, with research institutes focusing on market-oriented germplasm. Planted varieties in Near East countries include *japonica*, *indica* and aromatic; however, the majority are short-grain *japonica*. Aromatic rice varieties are found in Pakistan and Iran (Islamic Republic of).

In Egypt, there was great progress in rice yield during the period from 1990 to 2004 (Table 4). This progress was mostly due to the development and release of new improved short-duration varieties with high yield potential, early maturity and good resistance to blast. These varieties are widely accepted by farmers and consumers. Precise actions were taken to achieve the high yields of the Egyptian varieties:

- Release and spread of new short-duration high-yielding varieties: Giza177, Giza178, Sakha101, Sakha102, Sakha103, Sakha104, Giza182 and Egyptian Jasmine.
- Transfer of appropriate technology to the farming community in order to improve crop management.
- Monitoring of production constraints and farmers' problems during the season with prompt follow-up action by various agencies under the umbrella of the National Rice Campaign.

In Morocco, several Italian, French and Egyptian varieties have been introduced or produced locally (Table 5). In Turkey, numerous *japonica* varieties have been introduced and released for production in the different regions of Turkey: Ribe, Rocca, Baldo and Veneria from Italy; Plovdiv, Rodina and Ranballi from Bulgaria; and Krasnodarsky-424 from Russia. There are a further 500 to 600 lines from the national crossing programme. Local and introduced materials from the European rice-growing countries are also stored in the national gene bank of Turkey (Table 6).

In Pakistan, four main types of germplasm are commonly grown. The fine types are Basmati super, Basmati 385 and Basmati 2000, while IR 6 is a coarse type and a common variety. Varietal development is a continuous programme and research institutes are focusing on the market-oriented germplasm. Efforts are being made to introduce hybrid rice; in this regard, research work is under way in the public and private sectors with the collaboration of Chinese scientists.

In Iran (Islamic Republic of), the most popularly grown local varieties are Hassan Sarai, Domsiah, Binam, Hassani, Salari, Anbarbo and Sang Tarom (Table 7). Despite the low yields of these local varieties (averaging 2.5-3.5 tonnes/ha), they have excellent quality traits

TABLE 4
Yield and ancillary traits of the new released rice varieties in Egypt

Variety	Yield (*tonnes/ha*)	Duration (*days*)	Height (*cm*)	Blast		Grain type	Milling (*%*)
				L	N		
Improved varieties							
Giza 177	10.7	125	100.0	3	R	Jap. (Sh)	73
Giza 178	12.1	135	100.0	2	R	Jap. (Sh)	71
Sakha 101	11.5	140	90.0	2	R	Jap. (Sh)	72
Sakha 102	10.8	125	105.0	2	R	Jap. (Sh)	72
Sakha 103	10.9	120	99.0	2	R	Jap. (Sh)	72
Sakha 104	11.4	132	105.0	2	R	Jap. (Sh)	71
Giza 182	11.7	129	94.0	2	R	Ind. (L)	70
Egyptian Jasmine [a]	9.5	150	95.0	1	R	Ind. (L)	65
Average	**11.1**	**135**	**98.5**	**1-3**	**R**	**Sh-L**	**65-73**
Old varieties							
Giza 171	7.3	160	140.0	7	S	Jap. (Sh)	72
Giza 176	8.7	150	100.0	5	S	Jap. (Sh)	69
Giza 181	9.1	150	95.0	2	R	Ind. (L)	68
Average	**8.4**	**153**	**112.0**	**2-7**	**R-S**	**Sh-L**	**68-72**

[a] Aromatic rice.

(aroma and moderate amylose content [Ac], preferred by consumers). More than 70 percent of the total rice area in Iran (Islamic Republic of) is under these varieties, characterized by tall stature (125-135 cm) and sensitivity to lodging. They have a long slender grain, head rice recovery of 60 to 63 percent, intermediate Ac, aroma and elongation qualities. They are also susceptible to blast and stem borer.

In Mauritania, through collaboration with international institutes of research and the Africa Rice Center

TABLE 5
Varieties inscribed in the national official catalogue in Morocco

Variety	Yield (*tonnes/ha*)	Duration (*days*)	Lodging	Blast	Grain type
Triomphe	6.6	143	R	S	Jap. (Sh)
446	6.2	118	PR	S	Ind. (L)
Dinar	6.5	139	PR	PS	Jap. (Sh)
Hayat	6.8	129	R	PS	Jap. (Sh)
Kanz	6.6	129	R	PS	Jap. (Sh)
Samar	7.0	135	R	PS	Jap. (Sh)
Maghreb	7.1	118	R	T	Ind. (L)
Bahja	7.13	118	R	T	Ind. (L)
Nachat	7.29	118	R	T	Ind. (L)
Farah	10.0	135	R	R	Ind. (L)
Oumnia	9.0	130	R	T	Ind. (L)
Gharbia	9.5	130	R	T	Ind. (L)
Zena	7.9	114	R	T	Ind. (L)
Riva	8.0	116	R	T	Ind. (L)

Note: R = Resistant; PR = less resistant; S = sensitive; PS = less sensitive, T = tolerant.

TABLE 6
Some developed rice varieties in Turkey

Variety	Grain yield potential (*tonnes/ha*)	Duration (*days*)	Plant height (*cm*)	Grain type
Trakya	8.5	128	113	Jap. (Sh)
Ergene	7.0	117	100	Jap. (Sh)
Meriç	8.2	125	110	Jap. (Sh)
İpsala	8.2	125	110	Jap. (Sh)
Altınyazı	7.5	127	112	Jap. (Sh)
Sürek-95	8-10	130	100	Jap. (Sh)
Osmancık-97	8-10	130	95	Jap. (Sh)
Kıral	9-10	125	90	Jap. (Sh)
Demir	10-12	135	85	Jap. (Sh)
Yavuz	8-9	130	100	Jap. (Sh)
Neğış	7-8	126	106	Jap. (Sh)
Gönen	7-8	126	108	Jap. (Sh)
Kargı	8.0	125	110	Jap. (Sh)

TABLE 7
Local rice varieties under cultivation by Iranian rice farmers

Variety	Yield (*tonnes/ha*)	Growth duration (*days*)	Plant height (*cm*)	Amylose content	Grain length	Grain type
Hassan sarai	3.5-4	120-125	135	20	Very long	Indica
Domsiah	3.5-4	130-135	130	20	Very long	Aromatic
Binam	3.5-4	120-125	135	21	Medium	Aromatic
Hassani	3-3.5	105-110	115	22	Short	Japonica
Salarie	3-3.5	125-130	140	23	Very long	Indica
Anbarbo	2.5-3	120-125	130	19	Medium	Japonica
Sang tarom	3-3.5	115-120	125	20	Long	Aromatic

(WARDA), researchers have developed new high-yielding varieties adapted to the country's agro-ecological conditions. The national requirement for certified rice seeds is about 1 500 to 2 000 tonnes per year, while national seed production is between 900 and 1 300 tonnes. The deficit is filled each year by importation from Senegal: 200 tonnes in 1998, 400 tonnes in 1999 and 800 tonnes in 2000. The following varieties perform well in Mauritania:

- Short-day varieties (e.g. Sahel 108, IR 1561 and IR 64): yields can reach 10 tonnes/ha in research stations.
- Long-day varieties (e.g. Sahel 202 and Sahel 201): yields can reach 11 tonnes/ha.

GENERAL CONSTRAINTS CONCERNING RICE PRODUCTION

Climatic constraints

- Low temperature: A major constraint, especially for late-sowing varieties.
- High temperature: At anther development stage, strong heat causes a high percentage of sterility, reaching 100 percent at temperatures of 39°C in the dry season.
- Dry and hot winds: During flowering, dry hot winds dry up panicles and can cause sterility of spikelets.

Soil and water constraints

- Salinity: An important constraint in many countries in the Near East; the use of improper irrigation without drainage can encourage waterlogging, resulting in salinity build-up and other mineral toxicities.
- Irrigation water: Causes soil degradation because of high charges of sodium bicarbonates, which lead to a long-term phenomenon of iodination, which may destroy the superficial layer of soil and organic matter and help the pH to rise.

Biological constraints

- Weeds: Reduce rice yields by competing for space, nutrients, light and water and by serving as hosts for pests and diseases. Under farmers' conditions, weed control is not usually done properly or timely, resulting in severe yield reduction. Weeds spread due to bad land-levelling, improper irrigation methods and inappropriate agricultural techniques (seeds mixed with weeds, bad soil-tilling, inappropriate methods of sowing, and no application of crop rotation). Various weed control methods, including complementary practices, hand weeding, mechanical weeding, chemical weeding and integrated approaches, may be used.
- Birds: In dry seasons, bird proliferation is a major constraint. Many farmers do not want to cultivate their crop during dry periods because of the risk of bird damage.
- Field rats: In some places, they can be harmful and may devastate farms.
- Diseases: Rice can be host to numerous diseases and insect pests. The major diseases causing economic losses in any rice-growing country in the region are: blast, bacterial blight, bacterial leaf streak and bacterial sheath rot. Many virus diseases of rice have also been identified.

Socio-economic constraints

- Supply of goods and agricultural equipment: Fertilizers are very expensive and not always available. There is an insufficient quantity of certified seeds, obliging some producers to buy bad quality seeds.
- Rehabilitation of agricultural perimeters: Perimeters are poorly constructed and not long-lasting, because of the absence of norms of construction.
- Agricultural credit: Problems include: late credit grants, poor capacity for financing agricultural campaigns, complicated procedures for obtaining loans, difficulties related to credit recovery, and weak credit capacity to purchase agricultural equipment.

CHALLENGES AND OPPORTUNITIES FOR A SUSTAINABLE RICE-BASED PRODUCTION SYSTEM

In the Near East and associated countries, rice is grown mostly under irrigated conditions. The stagnation in the expansion of rice harvested area in most of the countries observed from 1990 to 2004 suggests that this trend is not likely to change substantially in the near future. Also, the expansion of rice area in Egypt is not sustainable in the long term due to the country's limited water resources and the increased demand for water from other sectors of the national economy. Therefore, the substantial and sustainable increase in rice production in the Near East region depends greatly on the increase in productivity of rice production systems or on yield increase.

In selected locations, such as Egypt, Iran (Islamic Republic of) and Mauritania, data reveal that climatic conditions are favourable for high crop yield. The Egyptian rice yield in 2005 was the highest not only in the region, but in the world, comparable to the Australian rice yield. This yield of 9 tonnes/ha, however, is still below the yield potential of improved *japonica* varieties. The highest recorded yield of *japonica* rice was 14.7 tonnes/ha, produced by the variety, YRL, in Riverina, Australia in 1992 (Kropff *et al*., 1994). Therefore, there are still large yield gaps in rice production in the Near East and associated countries. The narrowing of the yield gap could substantially increase the productivity of the rice production systems in the region. According to Duwayri, Tran and Nguyen (1999), the rice yield gap has three components:

A. The difference between the potential yield of existing varieties and the theoretical maximum yield. Known also as the "potential yield gap", it could be narrowed with the development of rice varieties with higher-yielding potential.
B. Differences in non-transferable factors, such as environmental conditions and built-in component technologies available at research stations. This gap, therefore, cannot be narrowed or is not exploitable.
C. Differences in management practices. Known also as the "yield gap at field level", it is the result of suboptimal crop management practices, and could be closed by adoption of improved crop management practices and systems.

In summary, the development and use of a new generation of rice varieties in order to narrow gap "A", and the development and use of improved crop management systems in order to narrow gap "C" are the technical opportunities for increasing the productivity of rice production systems in the Near East and associated countries.

TECHNOLOGIES FOR INCREASING RICE YIELD

In Pakistan and Iran (Islamic Republic of), the most popular or dominant rice varieties are *indica* and aromatic types. In Egypt, Morocco and Turkey, the dominant rice varieties are *japonica*, while in Mauritania, Iraq and Sudan, *indica* varieties are popular. When implementing a strategy to narrow the yield gap in the Near East region and associated countries, these factors must be taken into account.

New generation of rice varieties

A series of improved or high-yielding rice varieties have been developed and released for cultivation by national and international breeding programmes since the early 1970s. Wide adoption of these varieties would increase productivity. Scientists at the International Rice Research Institute (IRRI) have continued working to increase the genetic yield potential of tropical rice through the concept of new plant types (NPTs), which have the potential to bring yield to between 12 and 15 tonnes/ha by 2002 (Peng, Khush and Cassman, 1994). Progress with NPTs, however, has been slow. Scientists from several research centres are working on modifying the photosynthetic pathway of the rice plant from C3 to C4 – as in maize plants – to achieve more efficient use of sunlight energy. To date, biotechnological tools have been used mainly for the breeding of transgenic varieties with better resistance to insects, diseases and herbicides, and with a higher concentration of vitamin A in the rice grain (Khush and Brar, 2002). Recently, it was announced that scientists could develop transgenic rice with better tolerance to drought and salinity.

At present, hybrid rice is the only readily available advanced breeding material for increasing productivity over improved or high-yielding varieties. The national rice programme in Egypt, with assistance from the FAO project, TCP//EGY/2801, recently developed two hybrid combinations: SK 2034H and SK 2046H. Under normal soil conditions, SK 2034H outyielded Giza 178 by 29.9 percent, while under saline soils, it outyielded Giza 178 by 31.7 percent. Similarly, SK 2046H outyielded Giza 181 by more than 25 percent. This is indication that the development and use of hybrid rice is a viable option for increasing the productivity of the rice production systems in the region and narrowing the potential yield gap.

Integrated crop management

The yield gap due to differences in management practices results mainly from numerous deficiencies arising from inadequate crop management practices. During the 1970s and 1980s, technology production packages were formulated and transferred to farmers for the cultivation of high-yielding rice varieties under different ecosystems in different places. The application of these packages has helped to increase rice yield, but it has also produced negative effects on sustainable rice production – for example, new pest biotypes and increased nutrient deficiency of phosphorus, potassium, zinc and other nutrient elements (Tran and Ton That, 1994). Integrated pest management (IPM) and integrated nutrient management (INM) systems were developed and transferred to rice farmers. IPM systems are economically advantageous and also environmentally friendly, as they help to minimize the harmful effects of pesticides on the environment and human health (Kenmore, Gallagher and Ooi, 1995), while INM systems promote the balanced application of fertilizers and the integration of organic fertilizer (green manure, composts etc.) into the provision of nutrients to the rice crops (Shastry *et al*., 1996). The application of rice integrated crop management (RICM) systems increases rice yield and reduces costs and environmental degradation through more efficient application of inputs.

The application of RICM systems therefore offers great potential in terms of narrowing the yield gap at field level, and the development and use of RICM systems is another technological option for increasing the productivity of rice production systems in the region. The experience gained through the development and application of crop management systems in rice production (in particular, IPM and INM) points towards the development of productive and environmentally friendly RICM systems.

Integrated nutrient management

Nitrogen is the nutrient most frequently responsible for limited rice production in sandy soils. There should be approaches to regulate the timing of N application (based on the needs of the rice plant) to increase the efficiency of the plant's use of applied nitrogen. Many rice farmers use very small amounts for various reasons:

- Lack of availability
- Shortage of cash
- Poor yield response
- High risk involved in application

In addition to chemical fertilizers, there are good opportunities for applying organic manure to rice fields.

Efficient water use in irrigated agriculture

In the arid regions of western Asia and North Africa, irrigation development has been very limited in recent years: the accessible water sources have already been tapped and the remaining sources are expensive to develop. At present, about 22 million ha of irrigated land are located in western Asia and North Africa. There is no doubt that the spread of irrigation has made a major contribution to the remarkable increases in agricultural output in the tropics.

There is nevertheless widespread dissatisfaction with the performance of irrigation projects, whether performance is measured in terms of achieving planned targets or in terms of the production potential created by physical works. Furthermore, suboptimal performance is observed in irrigation systems of all types and sizes, including the small farmer-managed systems in Pakistan. According to a recent report, irrigation efficiency is as low as 50 percent in Pakistan (ADB, 1991). The inefficiencies are described below:

- Actual irrigated area is often much less than the area commanded.
- Water deliveries rarely correspond in quantity and timing to crop requirements, resulting in low cropping intensity and low productivity.
- Sharp inequities frequently exist in water supplies to farmers in the head reaches of the irrigation system and those located downstream.
- Lack of maintenance causes many systems to fall into disrepair, further inhibiting performance. As a result, over time, distribution channels fill up with silt, increasing the likelihood of breaching, damaging outlets and leading to salt build-up in the soil.

These trends underlie major concerns about the sustainability of irrigation. Indeed, worldwide, an estimated 150 million ha – about 65 percent of the world's total irrigated area – need some form of upgrading to remain productive.

Excessive irrigation and poor drainage raise the water table, bring soluble salts to the surface and may adversely affect yields on irrigated land. Most irrigation systems are created for a primary public health objective: to improve human nutrition. Their success in attaining this objective is sometimes reduced by negative impacts on health.

The major challenges in irrigation for rice cultivation are:

- development of farm-water reservoirs for water harvesting;
- selection of drought-tolerant varieties; and
- increased water-use efficiency (good land-levelling and subsoiling – requisites for proper irrigation scheduling).

Generally speaking, for sustainable increase in rice production in the Near East region, strategies must focus on:

- formulation of appropriate government policies to support the development of rice production programmes;
- increase in rice yield through development and dissemination of hybrid rice and rice integrated crop management systems;
- improvement of post-harvest technology through research and extension; and
- provision of infrastructure and accessibility to inputs.

UTILIZATION OF RICE BIOMASS TO INCREASE EMPLOYMENT AND INCOME WHILE REDUCING POLLUTION

Agricultural residues are used in a broad sense to include waste from agriculture and agro-industries. They consist of unused excess residues from growing and processing raw agricultural products, such as fruits, vegetables, poultry, fish, trees and rice straw. Residues are end-products of production and consumption that have not been used or recycled. They are none-product flows of material and energy whose economic value, at the present level of knowledge, is less than the cost of collection and transformation for use; they are therefore discarded as waste. The volume of composition of residues could be reduced by converting them into a usable product – if the value of that product exceeds the costs of conversion. This could help solve the unemployment problem through the establishment of small projects for converting agricultural waste.

If residues can be used for human benefit, they are no longer “waste”, but a new “resource”. By using all or a part of the waste, disposal becomes beneficial; furthermore, it would reduce pollution caused by waste disposal. The success of residue utilization depends on:

- the beneficial use;
- adequate markets;
- the availability of suitable technology to process the residue under different conditions; and
- an overall enterprise that is socially and economically feasible.

The generation of residue (in terms of quantity and quality) from agriculture and the agro-industry is dependent on a range of factors:

- type of raw materials;
- production processes;
- price of inputs and products;
- regulations affecting product quality and use; and
- constraints imposed upon disposal of residues.

Efforts are needed to develop technologies and institutional arrangements to optimize the use of residues from agricultural production. Residues must be considered as a potential resource rather than undesirable waste.

CONCLUSIONS

Rice is one of the most rapidly expanding sources of food in several Near East countries; it has a strategic role in the food security of the region. In addition, increases in rice production and support to the diversification of the rice-based system, including the utilization of by-products in the rice ecosystem, are required to meet demand and enhance the income of small farmers. It will not be possible to do this by extending the crop into newer areas, because of the scarcity of irrigation water. A number of technical and social constraints also apply.

Various factors currently affect rice production and contribute to the yield gap in some countries of the Near East region. Recognized constraints to rice-based production systems include:

- limitation of water supply and inadequate water management, resulting in low efficiency of water use;
- inefficient drainage systems, resulting in extensive soil salinity/alkalinity problems;
- declining soil fertility (insufficient supplies of fertilizer) and improper land management;
- insect pests and diseases (lack of pesticides);
- poor quality seed (short supply of improved and quality seed);
- high post-harvest losses; and
- lack of specific and encouraging policies supporting rice farmers.

REFERENCES

Ahmed, S. 2003. *Rice irrigation in Pakistan*. FAO Regional Office for the Near East.

ADB (Asian Development Bank). 1991. *The state of irrigated agriculture. 25 years of improvement. Part III.* Consultative Group on International Agricultural Research (CGIAR), 1971-1996.

Duwayri, M., Tran, D.V. & Nguyen, V.N. 1999. Reflections on yield gaps in rice production. *IRC Newsl.*, 48: 13-26.

FAO. 2003. *Food Outlook 2003*.

FAOSTAT. 2005. Statistical Database (available at www.fao.org/faostat/).

Kenmore, P.E., Gallagher, K.D. & Ooi, P.A. 1995. Empowering farmers: Experience with integrated pest management. *Entwicklung + landicher raum*, 1(95): 27-28.

Khush, G.V. & Brar, D.S. 2002. Biotechnology for rice breeding: progress and potential impact. Paper presented at the 20th Session of the International Rice Commission, Bangkok, Thailand, 23-26 July 2002.

Kropff, M.J., Williams, R.L., Horie, T., Angus, J.F., Centeno, H.G. & Cassman, K.G. 1994. Predicting yield potential of rice in different environments. In *Proc. First Temperate rice Conference*, Yanco, NSW, Australia, 21-24 February 1994, p. 657-663.

Oad, R. & Rajab, A. 2002. Irrigation policy reforms for rice cultivation in Egypt. *Irrigation and Drainage Systems*, 16: 15-31.

Peng, S.B., Khush, G.S. & Cassman, K.C. 1994. Evolution of the new plant ideotype for increased yield potential. *In* K.G. Casmann, ed. *Breaking the yield barrier*. Proc. Workshop on Rice Yield Potential in Favorable Environments. Los Baños, Philippines, IRRI.

RRTC (Rice Research and Training Center). 2005. *Annual Report*, Sakha, Kafr El-Sheikh, Egypt.

Shariati, M.R. 2003. *Rice irrigation in Iran*. FAO Regional Office for the Near East.

Shastry, S.V., Tran, D.V., Nguyen, V.N. & Nanda, J.S. 1996 Sustainable integrated rice production. *In* D.V. Tran, ed. *Proc. 18th Session of the International Rice Commission*, Rome, Italy, 5-9 Sept. 1994, p. 45-58. Rome, FAO.

Tran, D.V. & Ton That, T. 1994. Second generation problems of high yielding varieties. *IRC Newsl.*, 39: 127-132.

Difficultés et perspectives liées à un accroissement durable de la production rizicole au Proche-Orient

Au Proche-Orient, le riz occupe la troisième place (après le blé et le coton) pour ce qui est de la superficie cultivée. Il joue un rôle important dans la stratégie engagée en vue de lutter contre les pénuries alimentaires, et tous les ans environ 3,9 millions d'hectares sont affectés à cette culture. La production totale atteint environ 17,9 millions de tonnes, la moyenne sous-régionale de productivité étant de 4,6 tonnes à l'hectare.

Les zones irriguées de la région sont propices aux rendements très élevés. Toutefois, les rendements varient considérablement d'un pays à l'autre. Cette variabilité est due aux différentes conditions socio-économiques (gestion des cultures, accès aux connaissances et aux technologies agricoles) et dans une moindre mesure aux facteurs biophysiques (climat, durée de la période de croissance, sols, ressources en eau, pressions exercées par les ennemis des cultures, etc.)

On note un faible taux d'adoption des variétés productives et des technologies d'amélioration de la gestion des cultures, que l'on peut attribuer aux faiblesses de la recherche et des systèmes de vulgarisation. Les rendements sont donc faibles dans de nombreux pays producteurs de riz. L'élaboration de nouvelles variétés est en cours dans de nombreux pays producteurs, les instituts de recherche s'orientant surtout sur un matériel génétique destiné au marché.

La superficie cultivée est demeurée inchangée dans la plupart des pays, au cours de la période 1990-2004, ce qui laisse penser que dans un proche avenir cette tendance pourrait évoluer. Ainsi, à l'avenir, un accroissement substantiel et durable de la production au Proche-Orient sera fortement tributaire d'une productivité accrue des systèmes de production du riz ou de rendements plus élevés.

Le présent document fournit des recommandations relatives à certaines mesures efficaces pour accroître la productivité du riz et réduire l'écart des rendements au Proche-Orient afin de satisfaire la demande de cette céréale dans la région

Retos y oportunidades en relación con el aumento sostenible de la producción del arroz en la región del Cercano Oriente

El arroz constituye el tercer cultivo en orden de importancia, después del trigo y el algodón, en la región del Cercano Oriente por lo que se refiere a superficie sembrada. Desempeña una función trascendental en la estrategia para remediar las escaseces alimentarias, ocupando en torno a 3,9 millones de hectáreas al año. El total de la producción asciende a unos 17,9 millones de toneladas de arroz con una productividad media subregional de 4,6 toneladas/ha.

La agroecología de riego en la región favorece la obtención de rendimientos muy elevados, pero existen grandes variaciones en los rendimientos del arroz entre los distintos países. Esta variabilidad se debe a las diferencias derivadas principalmente de factores socioeconómicos (gestión de cultivos, acceso y utilización de conocimientos y tecnologías) y, en menor medida, de factores biofísicos (clima, duración de la temporada de cultivo, el suelo, el agua y la presión de las plagas).

Debido a los deficientes sistemas de investigación y extensión, la adopción de variedades productivas y tecnologías mejoradas de gestión de cultivos es escasa y, como resultado, muchos países productores de arroz registran bajos rendimientos. Hay en marcha proyectos para la obtención de variedades en muchos países productores de arroz, donde los institutos de investigación centran mayormente su atención en el germoplasma orientado al mercado.

El estancamiento de la expansión de la superficie cultivada de arroz registrado en la mayoría de países durante el período de 1990-2004 apunta a que en un futuro próximo esta tendencia podría cambiar. Por ello, en el futuro, conseguir aumentar de forma importante y sostenible la producción de arroz en la región del Cercano Oriente dependerá en gran medida del incremento de la productividad de los sistemas de producción del arroz o del aumento de los rendimientos.

En este documento se exponen recomendaciones sobre algunas de las medidas eficaces que pueden adoptarse para incrementar la productividad del arroz y disminuir la brecha de rendimientos en el Cercano Oriente con objeto de satisfacer la demanda regional de este cultivo.

Sustainable rice production in Europe

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CURRENT SITUATION OF RICE PRODUCTION IN THE EUROPEAN REGION

Paddy rice production in the European region, including the Commonwealth of Independent States (CIS), amounts to around 4.3 million tonnes, i.e. less than 1 percent of world production. Of the region's 45 member countries, 17 are rice-producing countries. Rice is not a major crop in European agriculture; nevertheless, it has become a traditional part of agriculture in some specific locations of (mainly) southern Europe since its introduction in the fifteenth century. Rice production is usually located along river valleys and deltas or lakes: the Tejo and Mondego valleys in Portugal; the Guadalquivir valley, Albufera lake, the Aragon area and the Ebro delta in Spain; the Rhône delta in France; the Po valley in Italy; the Thessalonica area in Greece; around Plovdiv and Haskovo along the Maritsa river in Bulgaria; the Danube valley in southern Romania; Edirne, Samsun, Sinop, Çorum, Diyarbakir and Balikesir provinces in Turkey; and the Kuban valley in the Russian Federation.

In 2005, rice production in the European region was characterized by the impact of the drought that occurred in the Mediterranean Basin. This reduced the rice cultivated area, yields and production in European Union (EU) member countries,[1] and in countries of southeast Europe.[2] In contrast, rice production in the Russian Federation and Ukraine continued to increase. Italy remains the most important rice producer (over 1.3 million tonnes) in the EU, followed by Spain (approx. 850 000 tonnes) (Table 1).

In Turkey, rice production continues to expand. Producers benefit from a government scheme whereby import licences for traders are dependent on the purchase of locally produced rice.

In the central Asian subregion,[3] harvested rice area continues to decline (with the exception of Turkmenistan), but yields improve; consequently, production remains at the level of recent years.

In general, rice yields in Western Europe are much higher than in Eastern Europe and the CIS. Within the EU, yields are highest in Greece and Spain, while in the rest of the European region yields are highest in Turkey and in The former Yugoslav Republic of Macedonia.

Average rice yield in the EU increased steadily from below 6.0 tonnes/ha in the early 1990s to about 6.6 tonnes/ha in 2004. In Eastern Europe, average rice yield in many cases remained below 3.0 tonnes/ha until 1997/98. Average rice yield has since increased and now stands at around 4.0 tonnes/ha.

Although rice is not a staple food crop in Europe, demand for human consumption continues to increase and imports of rice remain high. Rice consumption in the region increases steadily: from around 3.4 million tonnes in 1994 to 4.7 million tonnes in 2003. In the same period, average annual per caput rice consumption increased from 3.5 to 5.3 kg. Rice consumption in EU member countries currently stands at 2.4 million tonnes, and FAO estimates that the EU (25) will import around 1 million tonnes of milled rice in 2006. In 2003, CIS countries consumed about 1.4 million tonnes of milled rice, half of which in the Russian Federation.

The consumption of long-grain *indica* rice has surpassed the consumption of round- to medium-grain *japonica* rice, which is traditionally produced and consumed in the Mediterranean region. Demand in north European countries is almost entirely for *indica* type grains. Furthermore, consumption patterns are changing, with growing interest in special rice varieties, such as aromatic rice (jasmine and basmati), wild rice and coloured rice.

CONSTRAINTS TO SUSTAINABLE RICE PRODUCTION IN EUROPE

European rice production is concentrated in areas with a temperate-continental climate or Mediterranean climate, with warm and dry summer, preceded and followed by periods of low temperature. Main rainfall occurs during the first stages of crop development (April-June) and in the harvesting period (September-October). The

[1] France, Greece, Hungary (since 2004), Italy, Portugal, Spain.
[2] Bulgaria, The former Yugoslav Republic of Macedonia, Romania.
[3] Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan.

TABLE 1

Rice (paddy) harvested area, yield and production in the European region

	Area harvested (*ha*)		Yield (*kg/ha*)		Production (*tonnes*)	
	2002-04	2005	2002-04	2005	2002-04	2005
EU:						
France	19 230	18 000	5 669	5 722	109 020	103 000
Greece	23 045	24 000	7 207	7 250	166 000	174 000
Hungary	2 288	3 000	4 520	3 333	10 321	10 000
Italy	222 359	222 000	6 410	6 171	1 425 715	1 370 000
Portugal	25 487	25 000	5 793	4 800	147 654	120 000
Spain	117 489	117 000	7 302	7 230	858 107	845 900
Subtotal (EU)	**409 898**	**409 000**	**6 635**	**6 413**	**2 716 817**	**2 622 900**
CIS:						
Azerbaijan	3 159	2 313	4 446	5 267	14 178	12 183
Kazakhstan	75 178	75 000	3 306	4 133	249 426	310 000
Kyrgyzstan	6 285	6 500	3 047	3 077	19 166	20 000
Russian Federation	132 700	125 000	3 563	3 920	470 630	490 000
Tajikistan	11 302	10 000	4 764	3 200	53 687	32 000
Turkmenistan	48 000	60 000	2 115	2 000	99 833	120 000
Ukraine	20 767	21 000	3 856	4 286	79 933	90 000
Uzbekistan	83 837	36 500	2 739	2 740	230 010	100 000
Subtotal (CIS)	**381 227**	**336 313**	**3 261**	**3 491**	**1 216 863**	**1 174 183**
Turkey	**65 000**	**80 000**	**6 241**	**6 563**	**407 333**	**525 000**
Others:						
Bulgaria	5 156	4 683	4 490	3 203	23 243	15 000
Macedonia (The former Yugoslav Republic of)	2 592	2 566	4 720	5 066	12 193	13 000
Romania	597	3 000	2 597	1 667	1 939	5 000
Subtotal (others)	**8 345**	**10 249**	**3 936**	**3 312**	**37 375**	**33 000**
Total	**864 470**	**835 562**	**5 065**	**5 212**	**4 378 388**	**4 355 083**

Note: For 2002-04, the figure is the average.
Source: FAOSTAT, 2006.

prevailing agro-ecological and climatic conditions in these areas pose major constraints to sustainable rice production: most importantly, low temperature, but also water scarcity and biotic stresses caused by diseases, pests and competition from weeds. In some cases, rice cultivation faces problems arising from soil salinity in marshlands and coastal lagoons, or deteriorated irrigation schemes.

Temperature

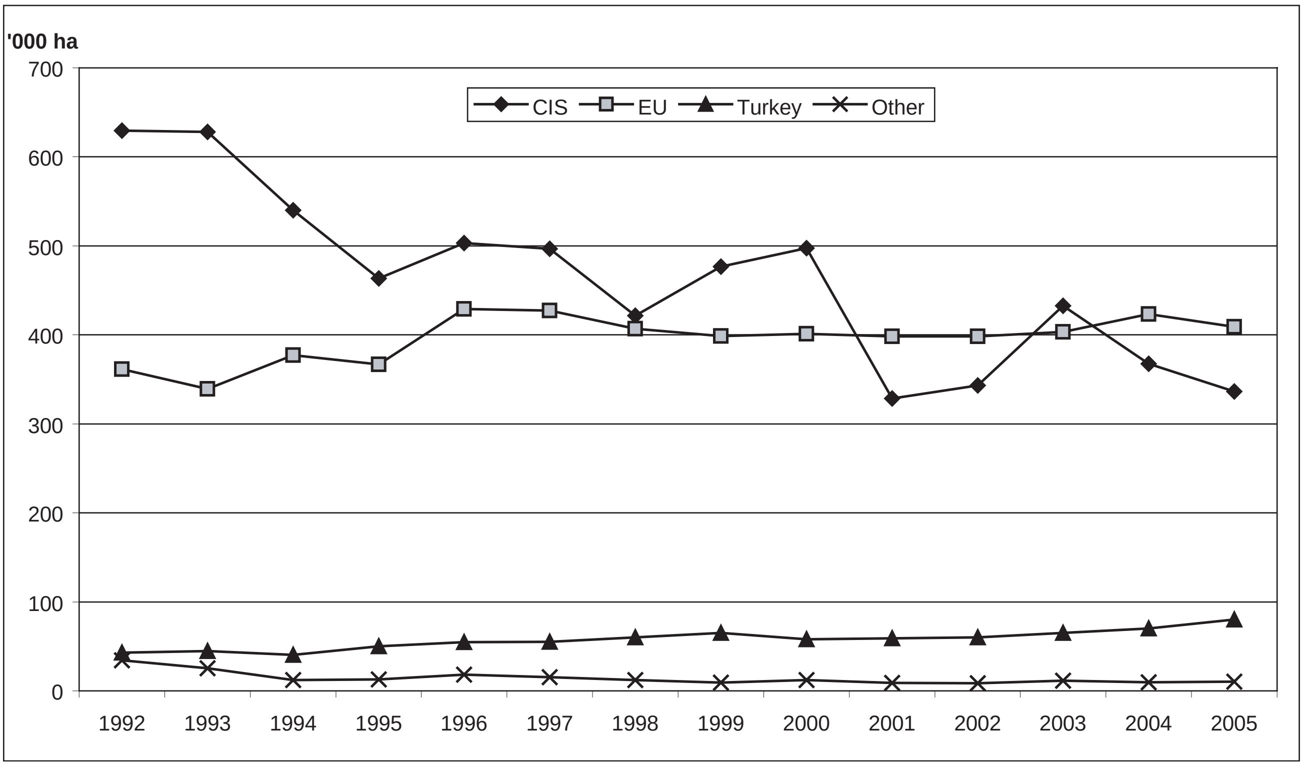
Rice plants are very sensitive to low temperature at any growth stage, in particular during seed emergence and stand establishment. In many temperate areas, such as the Mediterranean, cool weather at the beginning of the rice cropping season leads to poor stand establishment, and emergence rate may not exceed 30 to 40 percent of planted seeds. Low emergence rate is mainly due to the anaerobic conditions in paddy fields that occur at low temperatures. Farmers attempt to avoid low temperatures at the beginning of the season by delaying planting, and they compensate for stand losses with increased seed rates. However, a delay in the cropping season increases the risk of low temperatures during the reproductive stages of rice, when the death of pollen cells at meiosis stage causes grain sterility and sometimes severe damage to grain development and rice yield.

Water

Water consumption in agriculture represents about 40 percent of total water consumption in Europe, and rice is more water consuming than many other crops: in continuous flooding cultivation, it takes about six times the amount of water required by wheat. Demand for water for industrial activities, households and safe drinking water is set to increase. Governments will be obliged to place more limitations on the use of water resources, particularly in agriculture.

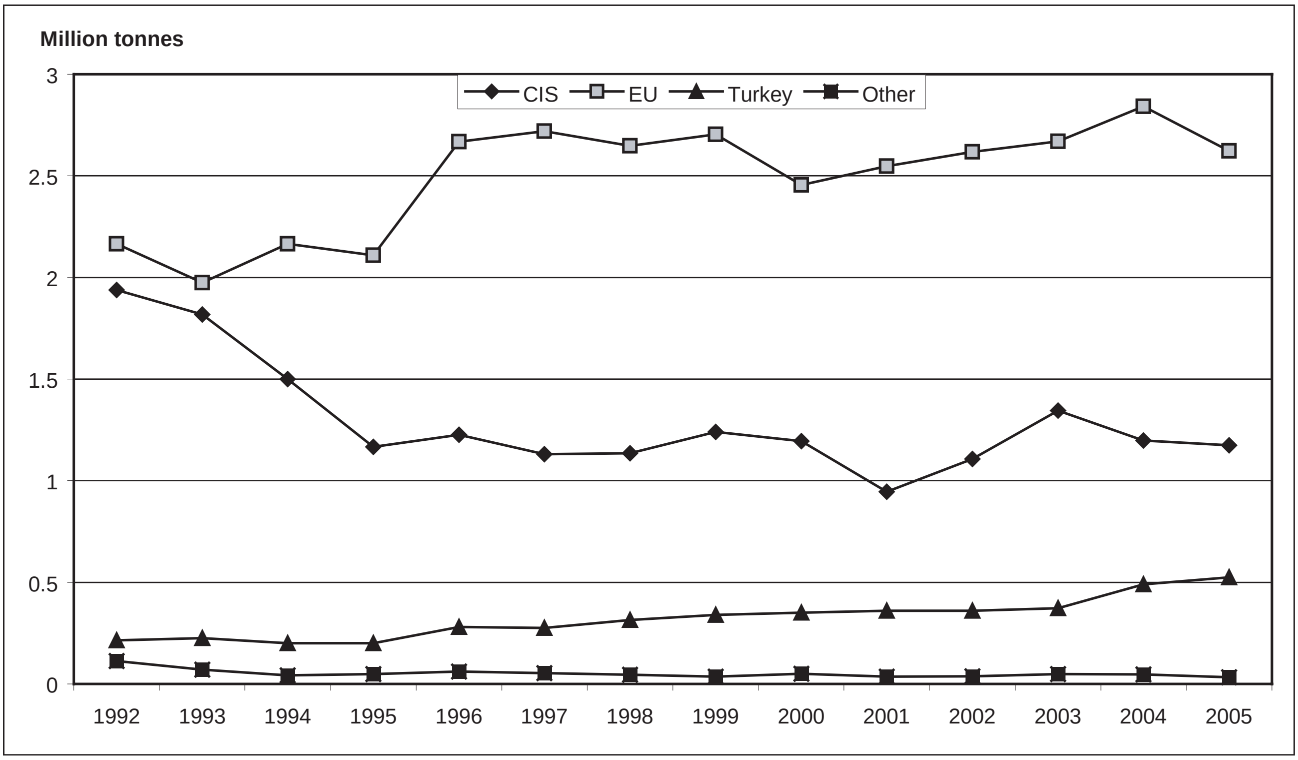
Many water problems are related to non-uniform distribution and to poor levelling of the land. Other related problems include pesticide pollution, soil erosion and

FIGURE 1
Development of rice (paddy) area harvested in the European region



Source: FAOSTAT, 2006.

FIGURE 2
Development of rice (paddy) production in the European region



Source: FAOSTAT, 2006.

deforestation, waterlogging in heavy soils and increasing irrigation costs. Farmers are, therefore, obliged to develop management strategies requiring reduced water consumption and to increase the efficiency of irrigation systems.

In continuously flooded cultivation, the availability of short-cycle and high-yielding rice is one option for reducing the amount of irrigation water used. An even more consistent reduction in water consumption could be obtained, however, by switching to discontinuous irrigation systems and developing profitable varieties suitable for these conditions. This type of water management also contributes to the alleviation of methane emissions from rice. Non-flooded conditions, on the other hand, can lead to increased competition from weeds and there is higher risk of soil salinization. The constraints on rice yield caused by weed growth and soil salinity must also be addressed as new varieties are developed.

Biotic stress

Losses in rice production as a result of diseases, pests and weeds account for about 50 percent of crop potential, in spite of current crop protection. In European rice paddies, failure to control weeds can lead to the complete loss of yield. Diseases, pests and weeds are usually controlled with pesticides and herbicides. Use of these products may, however, result in the appearance of resistant species, cause environmental pollution and disrupt the precarious balance of pests' natural enemies.

Economic factors

Various economic factors influence the sustainability of rice production – at farm level and at the level of the national economy:

- (world) market price for rice versus the cost of production;
- market protection, subsidies and tariff structures;
- economic importance of rice in the producing country;
- role of farmers in the supply chain; and
- concentration in international trade.

In Europe, farmgate prices for rice have declined in recent years, but costs for seed, fertilizer, crop protection, fuel and labour have increased. Farmers must achieve greater efficiency in rice cultivation, and in many West European countries there is a clear trend towards a reduction in the number of rice farms. At the same time, the average farm size is increasing. Operation costs for rice production remain high, making it difficult to compete with imported rice.

The EU and many other countries in the region apply protective measures for domestic production:

- compensatory payments to growers;
- guaranteed floor prices with a system of intervention storage;
- export subsidies promoting competition on third markets;
- import duties;
- administrative procedures (a potential trade barrier); and
- financial guarantees to obtain import licences.

Many countries have subscribed to the objectives of the World Trade Organization (WTO) to reduce tariffs in world trade; the system of import duties is gradually decreasing.

Under the "Everything But Arms" (EBA) programme, in February 2001 the EU made a commitment to give unrestricted, duty-free access to rice imports originating from least-developed countries (LDCs) as of 2009 (Table 2). Until then, duty-free imports will be subject to quantitative ceilings (set at relatively small volumes). Imports from LDCs which exceed the quota will progressively benefit from tariff reductions.

Environmental issues

There is increasing environmental concern about pesticide use, biodiversity, water consumption and methane gas emissions from irrigated rice fields. It is, therefore, important to promote integrated management systems, using adapted varieties and making more efficient use of inputs, including water.

TABLE 2
EC rice concessions under the EBA Preferential Access Scheme

	2003/04	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10
Duty-free quota (*tonnes*)	3 329	3 829	4 403	5 063	5 823	6 696	Free access
Duty reductions	none	none	none	20%	50%	80%	100%

Source: EU, 2001.

CONCLUSIONS

Rice production in Europe has a strong traditional base and is also enterprising, despite the sometimes unfavourable climatic conditions and the difficult economic context.

Strategies for sustainable rice production in Europe promote the development of integrated crop management systems: improved productivity, reduced production costs, and adoption of agricultural practices that safeguard biodiversity and the environment.

Potential for improvement lies in the selection of high-yielding varieties with good tolerance to low temperatures, better water management and improved levelling of the land. In addition, enhanced information exchange and collaboration among rice research institutions at regional and interregional level and related networks (such as MED-Rice[4]) will help to address the future challenges of European rice production.

REFERENCES

EU (European Union). 2001: *Everything But Arms (EBA)*, Council Regulation (EC) No. 416/2001, Brussels (available at ec.europa.eu/trade/issues/global/gsp/eba4_sum.htm).

FAOSTAT. 2006. FAO Statistical Database, accessed April 2006 (available at www.fao.org/faostat/).

La production durable de riz en Europe

La situation actuelle de la production de riz en Europe varie selon les pays. Du fait de la sécheresse qui a frappé le bassin méditerranéen en 2005, la production de riz dans les États membres de l’UE a diminué ainsi que celle des pays de l’Europe du Sud-Est. Par ailleurs, en Fédération de Russie et en Ukraine, la production de riz continue à croître. Une tendance similaire est relevée en Turquie, alors que dans la sous-région de l’Asie centrale la zone cultivée en riz s’est encore rétrécie.

Le riz n’est pas une denrée de base en Europe, mais sa consommation augmente de plus en plus et les importations de riz restent élevées. La consommation de riz *indica* (long grain) a dépassé celle du riz *japonica* (grain court et arrondi) traditionnellement produit et consommé dans la région méditerranéenne. Les habitudes alimentaires évoluent aussi et les variétés particulières de riz, comme le riz parfumé ou aromatique, le riz sauvage et le riz coloré suscitent de plus en plus d’intérêt.

En Europe la production de riz est concentrée essentiellement dans les zones à climat méditerranéen. Les conditions climatiques et agroécologiques de la région représentent néanmoins une série d’obstacles pour une production durable (on peut citer principalement les températures basses, la rareté de l’eau et le stress biotique dû aux maladies, aux ravageurs et aux adventices). Les facteurs économiques tels que les cours du riz sur le marché mondial, le régime tarifaire, la protection des marchés et les subventions ont une incidence sur la durabilité de la production de riz tant au niveau des exploitations qu’au plan national. En Europe, les coûts de fonctionnement relativement élevés de la production de riz ne permettent pas de faire face à la concurrence du riz importé et de nombreux pays prennent des mesures pour protéger leur production nationale. En outre, l’utilisation de pesticides et les émissions de gaz méthane provenant des rizières soulèvent de plus en plus des préoccupations pour l’environnement.

Les stratégies de production durable adoptées en Europe encouragent l’élaboration de systèmes de gestion intégrée des cultures assorties d’une amélioration de la productivité et d’une réduction des coûts de production, ainsi que l’adoption de pratiques agricoles qui protègent la biodiversité et l’environnement.

[4] Inter-regional Co-operative Research Network on Rice in the Mediterranean Climate Areas (www.medrice.unito.it/).

La producción sostenible del arroz en Europa

La situación actual de la producción del arroz en la región de Europa varía en función del país. La sequía registrada en la cuenca mediterránea en 2005 hizo disminuir la producción de arroz en los Estados Miembros de la UE, así como en los países de Europa sudoriental, si bien, por otro lado, la producción de arroz en la Federación de Rusia y Ucrania sigue creciendo. En Turquía continúa aumentando la producción de arroz, en tanto que en la subregión del Asia central la superficie de arroz plantada ha seguido disminuyendo.

Pese a que el arroz no constituye un cultivo alimentario básico en Europa, su consumo va en aumento y sus importaciones se mantienen altas. El consumo de arroz *indica* de grano largo ha superado al consumo de arroz *japonica* de grano redondo a mediano, que se produce y consume tradicionalmente en la región mediterránea. También las pautas de consumo están cambiando y existe un mayor interés por las variedades de arroz especiales, como el arroz fragante o aromático, el arroz silvestre y el arroz colorado.

La mayor parte de la producción de arroz en Europa se concentra en zonas de clima mediterráneo. Las condiciones agroecológicas y climáticas imperantes en esta zona plantean, no obstante, importantes limitaciones para la producción sostenible de arroz, sobre todo las bajas temperaturas, la escasez de agua y el estrés biótico provocado por enfermedades, plagas y malas hierbas. También los factores económicos, como el precio del mercado mundial para el arroz, las estructuras arancelarias, la protección del mercado y las subvenciones, influyen en la sostenibilidad de la producción del arroz tanto a nivel de las explotaciones como de la economía nacional. Los costos relativamente altos de explotación para la producción del arroz en Europa dificultan la competencia con el arroz importado y, por ello, muchos países aplican medidas de protección a favor de su producción nacional. Además, hay un aumento de las preocupaciones ambientales en relación con la utilización de plaguicidas y las emisiones de gas metano procedentes de los campos de arroz de riego.

Las estrategias para la producción sostenible de arroz en Europa fomentan el desarrollo de sistemas integrados de gestión de cultivos con mejora de la productividad y costos de producción reducidos, así como la adopción de prácticas agrícolas que salvaguardan la biodiversidad y el medio ambiente.