# 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 multidisciplinary 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.