

LIFE SUPPORT

2004 IS THE INTERNATIONAL YEAR OF RICE, AN EVENT DRAWING ATTENTION TO THE CONTINUING NEED FOR RESEARCH TO SUSTAINABLY LIFT RICE PRODUCTION.

JANET LAWRENCE REPORTS ON HOW ACIAR-FUNDED RESEARCH CONTRIBUTES TO THIS QUEST.

A CIAR has long supported rice research in developing countries through its close relationship with the Philippines-based International Rice Research Institute (IRRI). This support continues through financial contributions to IRRI's core programs (currently \$A850,000 a year) and through funding projects in which IRRI is a research partner.

IRRI played a key role in the Green Revolution, with the development and release of new short-season, high-yielding rice varieties, and continues to provide improved lines to meet specific growing conditions around the world.

Much of the gains from the Green Revolution were made on the more prospective well-watered parts of Asia. In deciding where to put its own research funds, ACIAR places emphasis on peripheral regions where many marginalised people are farming poor soils and contend with uncertain rainfall and pests and disease.

Current and past ACIAR-funded research includes:

- breeding and selecting better rice varieties for particular cropping conditions;
- improving soil fertility and nutrition for farming systems that include rice – either alone, or in rotation with legumes, wheat or other cereals;
- improving water use in rice-based cropping;
- better weed management; and
- better pest and disease management during growth.

Other rice-related topics that have received ACIAR sponsorship are:

- nutrient enrichment of rice;
- improving storage systems to reduce postharvest grain losses;
- monitoring postharvest grain quality and food safety; and
- grain marketing policy and trade.

Key research issues for improving the global rice harvest are:

1. Increasing rice yields. These can fluctuate dramatically when plants are affected by disease, weeds, pests or climatic variations. The main research strategy is



Green Revolutionary: former principal plant breeder at IRRI Dr Gurdev Khush

There are four main types of rice-growing environments/conditions.

UPLAND RICE is grown on level to steeply sloping fields, with rarely flooded, aerobic soil. Rice is direct-seeded on dry, ploughed soil or dibbled in wet, non-puddled soil.

RAINFED LOWLAND RICE grows on level to slightly sloping, banded fields (where a low ridge of soil separates fields, usually along the lowest contour), with noncontinuous flooding of variable depth and duration. Rice varieties adapted to the anaerobic environment are transplanted in puddled soil or direct seeded on puddled or ploughed dry soil. In the growing season soil can alternate between aerobic and anaerobic states.

IRRIGATED RICE is grown on levelled, banded fields with water control, and the rice is transplanted or direct-seeded in puddled soil. Fields are shallow flooded and soil is anaerobic soil during crop growth.

FLOOD-PRONE RICE is grown on level to slightly sloping or depressed fields, and plants are subjected to more than 10 consecutive days of medium to very deep flooding (50cm to more than 300cm) during crop growth. Rice is transplanted in puddled soil or direct-seeded on ploughed dry soil, aerobic to anaerobic soil, and may suffer from soil salinity in tidal areas.

► to better match rice varieties with growing conditions. Modern varieties suited to their particular growing conditions produce higher yields, but many small farmers still use poorly suited varieties.

Researchers have adopted two main approaches – to use hybrids (combining the desired features from two varieties), or to test biotechnology applications for improved breeds (such as the use of molecular markers to identify desirable traits).

A sustained research effort is under way to develop apomictic hybrid rice, allowing new high-yielding hybrids to be reproduced without the need for male and female crossing. This overcomes the high cost and inflexibility of hybrid seed production. Apomixis is the naturally occurring ability of some plant species to reproduce asexually through seeds that lead to inheritance of genes exclusively from the mother – meaning plants growing from these seeds are identical to the mother plant.

2. Water use and the potential impacts of water shortages. Researchers are seeking varieties that use less water to achieve the same or greater yields. This is an urgent priority because Asia has a looming water crisis. Other projects are studying rainfed rice (around 18 percent of global production), which is susceptible to drought. The need is for drought-tolerant varieties that also have higher yields.

Related to these initiatives is a move to develop agro-ecological maps, combining information on rainfall, soil types and water balance (groundwater etc.) to determine the most suitable rice growing locations.

3. Increased nitrogen efficiency. Nitrogen (N) is essential for plant growth. N fertilisers have been used in Asia since the mid-1960s where they have accounted for about 24 percent of production increases. More than 20 percent of all N fertilisers produced worldwide are applied to rice fields in Asia. Nitrogen absorption depends on the rice variety and the environment, and ACIAR has funded research to lift nitrogen-use efficiency through the timing, rate and methods of fertiliser application.

ACIAR has also devoted considerable funding towards the introduction of nitrogen-fixing legumes into the cropping system as an affordable way to lift N levels.

4. Pests, diseases and weeds. Many avenues of research have sought to control rodents. Farmers have traditionally used poisons and traps, with limited success. Researchers have identified the need to break rodent population cycles, and have had success with the trap barrier system for rats in the ricefield (*see page 10*).

Scientists aim to control some diseases through developing biotechnology applications that introduce disease-resistant genes.

One project has gathered a body of information on rice disorders of all sorts (growth stresses, nutrient disorders, pests, diseases,) and incorporated it into computer-based diagnostic tools called *Rice Doctor*, which gives anyone needing to solve these problems a comprehensive source of information and problem diagnosis.

Weeds also constrain production by out-competing rice plants, especially in the establishment phase. One approach is to attack weeds with bioherbicides (natural enemies such as fungus diseases), which are safer than traditional herbicides that can leave behind dangerous residues. Also, weeds can become herbicide-resistant.

A holistic approach

ACIAR takes a holistic approach to rice research, with projects spanning everything from soil preparation to seed selection, through the whole cropping sequence to after-harvest quality and marketing. One project has sought to increase the micronutrient levels of rice to provide extra vitamins and minerals to people who depend on rice for most of their nourishment.

ACIAR research is bringing particular benefit to the cropping systems of Laos and Cambodia. Scientists are introducing plant breeding strategies for lowland rice, intensifying rice-based cropping systems in rainfed lowlands, developing direct seeding technology, increasing productivity of dry-season irrigated rice, and developing agro-ecological maps for Laos. The research should also benefit Australian ricegrowers.

Identification of suitable rice varieties for drought-prone environments in Cambodia and Laos was possible with methods developed in previous ACIAR projects. Drought-resistant lines identified are being used in field trials to develop new cultivars with good adaptation to rainfed lowland environments and high potential yields under irrigated conditions.

Similar work on rice and other crops has taken place in East Timor. In the Seeds of Life project, ACIAR has combined with five CGIAR centres, government and relief agencies to establish a project to assess a host of varieties for local growing conditions. Scientists and local farmers are now working together to run on-farm trials of selected varieties of rice and five other crops.

Saving water

Demonstration of the water-saving potential of alternative irrigation technologies and conditions for their ► **PAGE 14**

THE MOST IMPORTANT FOOD IN THE WORLD – AND WE NEED MORE

BY **ADAM BARCLAY**, AUSTRALIAN YOUTH AMBASSADOR FOR DEVELOPMENT ASSIGNED TO THE INTERNATIONAL RICE RESEARCH INSTITUTE (IRRI).

It would be fair to say that many – probably a large majority – of Australians do not really appreciate the global importance of rice.

Many of us tend to think of rice as the stuff we eat a couple of times a week with a curry or stir-fry. We are lucky, living in a country where most can afford a diverse range of nutritious food.

But for billions of people – almost half the world's population – rice is much, much more. It is the staple they eat with every meal. There are 250 million rice farms across Asia; most of these are subsistence farms of less than one hectare. Rice is central to cultures, to traditions, and it provides more 'employment' than any other industry. Rice farming has been called "the single most important economic activity on earth."

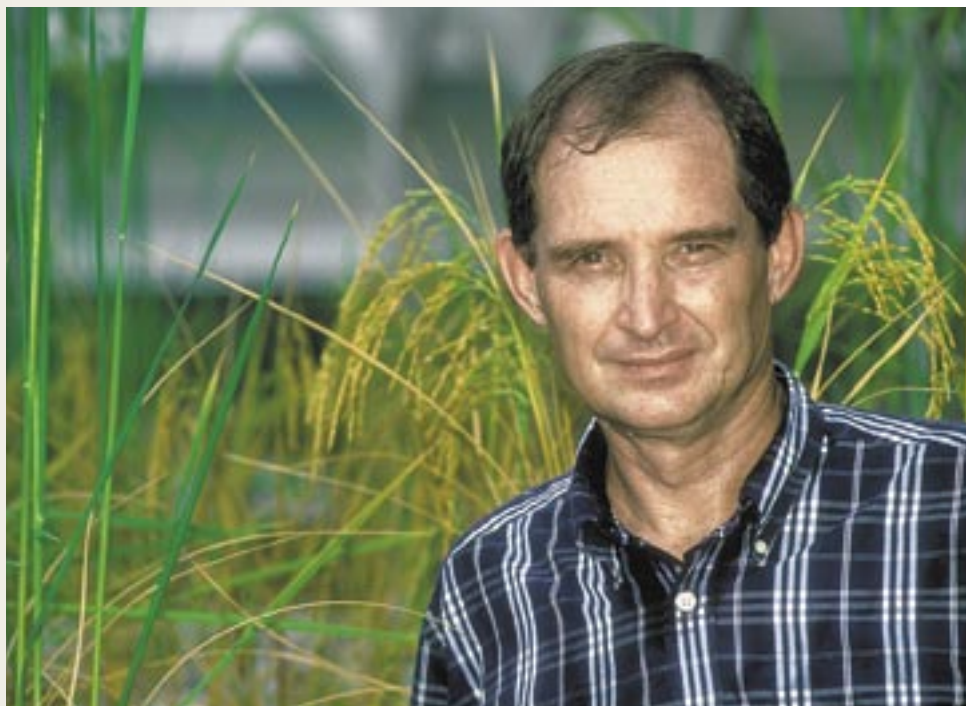
For the poor – 600 million in rice-producing Asia who live on less than \$US1 per day and many more surviving too close to this line – rice is the source of most of their energy and their biggest single expense. The average Bangladeshi, for example, receives from rice almost 80 percent of the calories and two-thirds of the protein that he or she consumes.

In this light, the need for rice research becomes clear. Since it was founded in 1960, the International Rice Research Institute (IRRI) has performed research into rice production and management issues that have arguably saved millions from starvation. And while there is currently enough rice worldwide (although it still does not find its way to everyone who needs it), the rice-consuming population is growing faster than production.

At the same time, urbanisation and environmental destruction are reducing the amount of land available for rice, and there is increased competition for the water needed to grow it. A recent IRRI-led study has shown that global warming may significantly stunt rice production. Also, hundreds of millions of rice-dependent people suffer debilitating malnutrition, and efforts to boost the amount of essential vitamins and minerals in rice are under way.

How, then, does Australia fit into the picture? For a start, Australia exports most of the rice it grows, so any advances in production, such as improved varieties or better management practices, are good for the country.

And Australians around the world are helping to improve the lives and livelihoods of the rice-producing and rice-consuming poor. Noel Magor managed the recently concluded Poverty Elimination Through Rice



Research Assistance program that administered 45 individual projects in Bangladesh.

Harry Nesbitt was last year honoured as a member of the Order of Australia for his work in re-establishing Cambodia's war-ravaged rice industry as leader of the Cambodia-IRRI-Australia Project. When the project began: "... there was just no information anywhere on the constraints to rice production in Cambodia – soils, environmental and social factors such as gender issues," recalls Dr Nesbitt. "We had to start from scratch and expand the program to include soil specialists, agricultural engineers and sociologists."

More Australians are playing an integral role in reviving agriculture in another war-ravaged country – East Timor. IRRI is a partner in the Seeds of Life project, responsible for introducing improved staple food varieties, including re-establishing the country's rice farms.

Melissa Fitzgerald has just joined IRRI to set up and lead the institute's new Grain Quality and Nutrition Research Center, which will help ensure that rice breeders and farmers alike will have access to grain with the best characteristics for local production and consumption. "You can have the highest yielding, or most disease resistant rice in the world, but research institutes ignore grain quality at their peril – if it isn't palatable, consumers won't eat it and farmers won't grow it," says Dr Fitzgerald.

The CSIRO's Grant Singleton has worked with Filipino scientists to "build a better rat trap" and help stem destructive rodent damage in the 2000-year-old World Heritage-listed rice terraces in the northern Philippines.

The Australian Government, through ACIAR, has been a key supporter of rice research in general and IRRI in particular. Australia is building partnerships, including with IRRI, to achieve the goal of all in Asia having access to affordable, nutritious rice, and sustainable production with minimal environmental impact.

As Australia is inextricably linked with Asia, a food secure region is in everybody's interests.

Integral role:

Dr Harry Nesbitt received an Order of Australia for his role in rebuilding Cambodia's rice industry.



'RESEARCH IS ONE OF THE FEW PROVEN AVENUES FOR IMPROVING THE LIVES OF RICE FARMERS AND CONSUMERS ALIKE'

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adoption has helped to determine how, when and to what extent farm practices affect water savings elsewhere. Models being developed will help evaluate the impact of on-farm and regional water management options.

Trials to grow rice in rotation with other crops using a system of permanent raised beds have recently shown promising results in South Asia and Australia. Crops are grown on raised mounds or beds of earth, where irrigation water is only supplied to inter-bed furrows. Rice plants on the beds have a portion of their root systems in unsaturated soil. This allows the beds to be permanent, minimising changes in fields between crop rotations.

Zero-till seeding of rice into wheat residue and of wheat into rice residue on raised beds does not disturb the soil in the same way as ploughing. The use of a drill that penetrates the soil and plants the seeds in the previous crop's residue has proven effective. Funding from a small ACIAR project has helped Indian manufacturers to develop prototype drills that can sow into residue.

Scientists have applied simulation modelling to show that a mungbean crop can be added into a rice-wheat rotation. The findings have led to recommendations of earlier sowing for rice and wheat, which would enable earlier sowing of mungbean and lead to larger, more reliable, mungbean yields as well as more reliable rice and wheat yields.

In the Mekong Delta in southern Vietnam, brackish water floods the rice fields near the lower reaches of the river during the dry season, hampering efforts to grow a second rice crop. Farmers have adapted by growing shrimp in the rice paddies during this time. ACIAR studies have found answers to many of the problems associated with these dual enterprises, greatly assisting the expansion of rice/shrimp farming.

After the harvest

Mycotoxin or pesticide contamination of food and feedstuffs (including rice under certain conditions) is a hazard to the health of people and livestock in Vietnam and Australia. Scientists sampled a range of commodities from both countries to establish the incidence and severity of contamination. They then developed sampling protocols and field-laboratory immunoassays to detect the levels of a range of mycotoxins and commonly encountered pesticides.

Phosphine is the major fumigant for stored grains in China, Vietnam and Australia, due to its low cost, ease of use and acceptance as a residue-free treatment. However,

growing resistance to phosphine by grain pests threatens its continued use. Scientists have identified technical innovations to enhance the efficacy of phosphine and have also characterised phosphine resistance in new strains of major pests.

In West Bengal, drying of rice (and maize) relied on systems that were inefficient in terms of energy use and grain quality and did not provide the service needed to modernise the region's grain industries. Attention to moisture removal during storage was inadequate, and quality deteriorated during storage and transport. A research team is working to scope, develop, test and disseminate improved two-stage systems for drying grain, while enhancing local capacity to design, manufacture and manage grain-drying systems that will benefit smallholders in West Bengal.

In Thailand, the development of a fluidised bed dryer for grains, including rice, has significantly reduced post-harvest losses. Rice and other grains are traditionally dried using a variety of methods, including spreading the grain out on roads to dry in the sun. The resulting losses from disease, contamination and other factors is high.

ACIAR-supported research over more than a decade has resulted in the development of a fluidised bed dryer. Further developments included an aeration system. The dryer is economical to run and can handle large quantities of grain.

Thailand adopted fluidised bed dryers in 1995. Thai rice millers have bought more than 50 dryers from the Rice Engineering Supply Company in Bangkok, and about one million tonnes of the 23-million-tonne Thai rice crop are now dried using fluidised beds. Up to 30 of the mills with fluidised bed driers have also adopted the aeration technology emerging from the project. An annual rate of return of 27 percent has been calculated for the project with forecast benefits to 2020 estimated to total \$A9.4 million.

Freeing up the markets

Because China's rice production is concentrated in certain parts of the country, studies of the internal marketing of rice in China are helping to open up trade between different regions. Economic liberalisation in recent years has given producers new opportunities to choose what to grow and how to sell it. ACIAR has funded studies that have contributed to the development of new grain market policy.

The goal was to help China achieve the benefits of free markets while continuing to meet national grain supply goals. Researchers contributed advice to initiate the transformation of unwieldy state-based grain bureaus into efficient commercial organisations.

Australia through ACIAR continues to foster rice research at a time when support from other avenues is in decline. According to Dr Keijiro Otsuka, chairman of IRRI's Board of Trustees, lack of development of the rice sector is a threat to regional security: "Research is one of the few proven avenues for improving the lives of rice farmers and consumers alike," he said on a recent visit to Australia.

This is reason enough for ACIAR to continue to show leadership in an issue that is vital to the future of the Asian region.