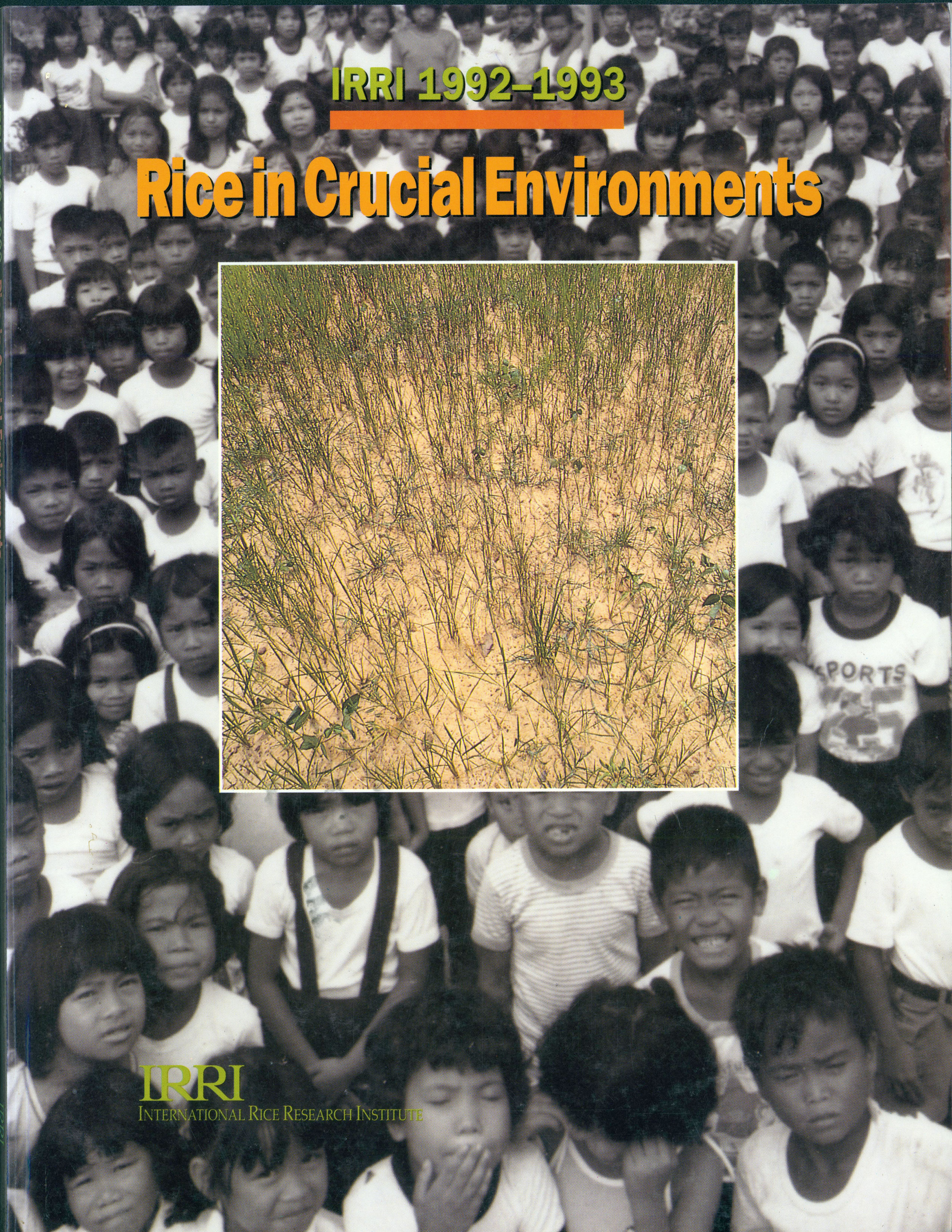


IRRI 1992–1993

Rice in Crucial Environments

IRRI
INTERNATIONAL RICE RESEARCH INSTITUTE

IRRI toward 2000 and beyond

The goal

To improve the well-being of present and future generations of rice farmers and consumers, particularly those with low incomes.

The objectives

To generate and disseminate rice-related knowledge and technology of short- and long-term environmental, social, and economic benefit and to help enhance national rice research systems.

The strategy

To increase rice production efficiency and sustainability in all rice-growing environments through interdisciplinary research and to ensure the relevance of IRRI research and the complementarity of international and national research efforts through close collaboration with national programs.

Contents

Rice Research in Crucial Environments

Each year, global population swells by more than 80 million people. Each year, millions of hectares of prime cropland are shifted. out of agricultural production. Each year, more and more peopie must be fed by the food produced on less and less land, and with what is often forgotten, less water and less labor.

The inherent challenge to agricultural research is to help farmers—in particular farmers in crucial environments of the economically less-developed countries of the world—continue to increase and sustain their productivity. But lands that are intensively cropped—pushed to produce two, three, or even more crops a year—are showing signs of stress. Marginal lands, being forced into production. as people struggle to feed themselves, are deteriorating rapidly. The high-productivity agriculture made possible by today's knowledge depends on a wide range of inputs derived from non-renewable natural resources.

- In South Asia, some 10 million hectares of highly productive irrigated ricelands—l0 percent of the total irrigated area planted to rice in the world—are showing signs of fatigue. Up to 40 percent more nitrogen fertilizer is needed to produce the same amount of rice as 10 years ago. Research into the causes and into opportunities for alleviating the problem is underway.
- For the vast majority of the rice economies of the world, particularly in South. and Southeast Asia where population growth is high, breaking the yield barrier is critical. But the modern high-yielding rice plant designed 30 years ago is resisting current efforts to raise its yield ceiling. Attention is on developing a new plant type designed to produce much higher yields.
- Risk of flood and drought, poor soils, diseases and insect pests, weed infestations are discouraging farmers in the less favorable rainfed lowlands from investing in the modern, high-yielding rice technology and inputs that would increase their production. improved. germplasrn and integrated pest and nutrient management technology are being developed to reduce both the investment costs and. the risks.
- The lowlands in general and irrigation systems in particular depend on well-preserved water catchments in the uplands. Upland rice farming families are among the world's poorest people. Their influence on the extremely fragile upland environments has been Underestimated, and long neglected. IRRI is committed to contributing to new solutions to improved living conditions in these rural environments which are often centers of important rural cultures as well.
- Farmers who crop the fragile and vulnerable delta regions of the great rivers cope daily with the constraints of uncontrolled floods, problem soils, and pests. Identifying alternatives and reducing risk in the flood.-prone areas are critical to improving their well-being and productivity

The inherent challenge to agricultural research is to help farmers—in particular farmers in crucial environ- economically less-developed countries of the world—continue to increase and sustain their productivity.

Bangladesh, R. Cabrera

This annual report for IRRI 1992-1993 highlights some of our current accomplishments in research and international services. The achievements reported here are but a few examples of the Institute's progress toward achieving its goal:

To *improve the welt-being of present and future generations of rice farmers and consumers, particularly those with low incomes.*

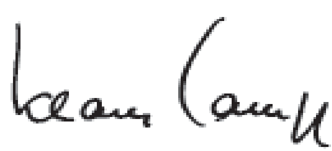
This goal, although stated in somewhat different words, has remained essentially the same since

IRRI's founding in 1960. Given the continuing economic, social, and. environmental changes confronting the world, meeting the goal is only possible through close partnership with all concerned: public and private sectors; governments and nongovernmental organizations; national and international research efforts. IRRI's role is in improving the genetic resource base and the management of natural resources related to the cultivation of rice.

These concerns were at the center of intense discussion among all IRRI staff during the last half of 1992 and into 1993, as we developed the Institute's medium-term plan for 1994-1998. The research agenda we hammered out identifies current crucial issues and anticipates the research needed to alleviate rice production concerns of the decades ahead. It takes into account the continuing constraints of reduced funding and the second staff reduction in three years, and sets priorities for IRRI's role in conducting rice research in crucial environments.

We are confident that IRRI is capable of assuming its share of responsibility for the development of more sustainable and, at the same time, more highly productive rice-based agricultural production systems. The External Review Panel that examined our programs and management in 1992 affirmed that capability.

With a forward-looking program fundamentally changed structures and facilities, and. strengthened scientific leadership, the entire staff of IRRI feels prepared for its continuing adventure in research to improve the world's most important food crop, rice. ■



Klaus Lampe
Director General

Population Growth and Rice Production

The race to avoid a population growth/rice production collision has yet to be won. So far, the race has been an even heat. Although populations of countries where rice is a staple food of countries where rice an average 70 percent over the last 25 years, the higher yields made possible by diffusion of new rice technology kept up. Global rice production doubled, the price of rice on the world market fell by more than 40 percent, and per capita rice consumption increased by an average 25 percent.

But populations in the major rice-consuming countries continue to swell, while growth in production has slowed, dramatically in the 10 countries that account for 85 percent of global production. If these two trends continue, demand in many parts of Asia will outstrip production within just a few years. Changes in the diets of people in some newly-industrialized and. fast-developing countries will not change the general trend..

Poverty alleviation is an additional force behind increasing demand for rice, Millions of Asians and Africans still lack their second, or even their first, daily rice meal. Recent projections show that need for rice will be some 70 percent higher in 2025 than it is today. Yields must more than double just to maintain current

India, R. Cabrera

India, R. Cabrera

Millions of Asians and Africans still lack their second, or even their first, daily rice meal.

Populations in the major rice-consuming countries continue to swell, while growth in production has slowed dramatically in the 10 countries that account for 85 percent of global production.

per capita consumption, and must increase even more to make progress toward overcoming malnutrition and poverty in Africa and South Asia.

Achieving food security

Complacency about the world's ability to handle the population/food equation seems to be growing. In a number of circles, attention is shifting from increasing productivity to conserving natural resources. Donor agencies are allocating more of their limited research funds to projects that aim at conserving the natural resource base and less to those aimed at increasing food production.

What is needed is both, in a mutually-supporting framework.

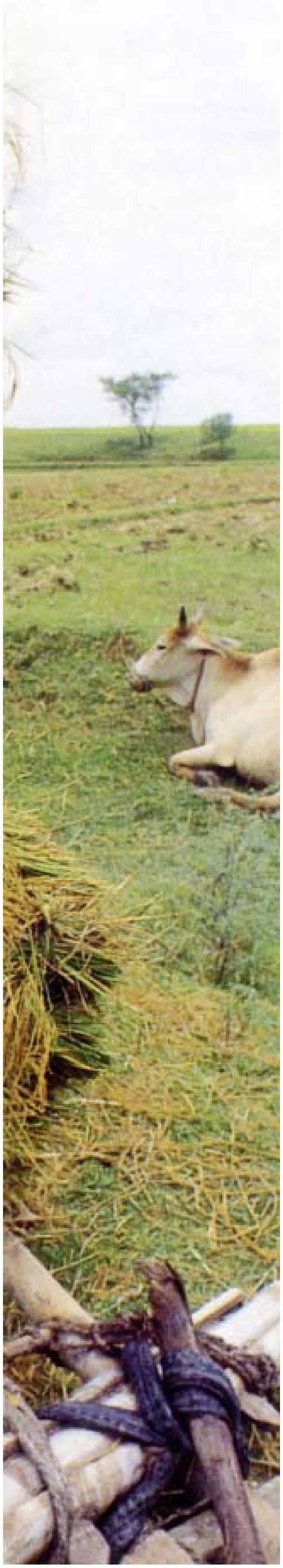
Policymakers in the economically less-developed countries also are shifting emphasis. Many countries are withdrawing subsidies from agricultural inputs, and reducing investments in water resource development and in agricultural research and extension. Instead they are adopting policies that promote cropping diversification at the expense of food production.

Financing for the development and maintenance of the irrigation systems and drainage facilities that fueled the diffusion of modern rices in the 1960s and 1970s has lessened dramatically.

An important factor behind this complacency toward rice production is declining real prices on the international market. But world trade involves an insignificant 4 percent of world production, and international price trends do not reflect the shaky balance of global supply-and-demand.

For example, China and India consume 55 percent of global rice supplies. If a series of natural disasters forced either of them to import just a small fraction of national demand, world rice prices would increase substantially. If Japan and. South Korea open their domestic markets in re-

Bangladesh, R. Cabrera



Many countries are withdrawing subsidies from agricultural inputs, reducing investments in water resource development and in agricultural research and extension, and adopting policies that promote cropping diversification at the expense of food grain production.

sponse to international pressure for liberalization of trade in agricultural commodities, world rice prices can be expected to rise.

On the other hand, if Myanmar and Cambodia decided to exploit their excess production capacity and push for exports, world rice prices would fall below today's level, regardless of supply-and-demand. in other major rice-growing countries.

The continuing decline in international rice prices is primarily the result of increasing competition for a stagnant import market. Only four exporting countries—Thailand, the USA, Vietnam, and Pakistan—compete for two-third.s of the thin world market. The major rice importers are Sub-Saharan Africa, thee EEC countries, Iran, Iraq, and Saudi Arabia. In Asia, only Malaysia and Sri Lanka are major importers.

In general, an important political objective in the major rice.-consuming countries is to achieve self-sufficiency in production and. maintain domestic price stability through procuremen.t and adjustment of stocks. In the poorer rice-dependent countries, achieving self-sufficiency is dictated by the limited availability of foreign exchange to finance major international purchases and by the experience of unfavorable" international deals when price are high in years of supply deficits and low in years of surpluses

Even countries with high income and the capacity to import relatively low-cost rice from abroad have tried to maintain self-sufficiency by encouraging high cost domestic production through support to rice farmers. Policymakers in the major exporting countries face political pressures to

Bangladesh, R. Cabrera

support domestic prices. Adjusting supplies in response to changing demand is seen as an issue that needs to be resolved mostly by production within national boundaries. Very few countries want to depend on exchange across borders.

Signs of declining productivity

Growth in rice production over the last 30 years has been primarily achieved through growth in yield. But recent developments suggest that yield gains are flattening. Reversing that trend will not be easy.

The equation is complicated by a reduction in rice area. As the economies of rice-producing countries expand, prime riceland. is being lost to industrialization and urbanization. During the 1980s, the harvested area of rice declined in China, Japan, Myanmar, and the Philippines.

If environmental concerns induce policies to remove marginal lands from rice production and to move from intensive rice-rice cropping systems to rice-nonrice systems, rice area will decline even faster. This will intensify the pressure to increase yields to meet the anticipated increase in demand.

Irrigated rice accounts for almost 75 percent of total supplies. Most farmers already plant high-yielding modern varieties and. their best yields are approaching the yield potential scientists are able to obtain with today's knowledge. Yields in Japan and South Korea have fluctuated. around 6 to 6.5 tons per hectare and in Egypt, around V tons, for the last three decades. Yields in China; Java, Indonesia, and the Punjab and Tamil. Naclu, India, will soon reach that level. Even those yields are at risk as salinization and degradation of irrigation systems reduce both the area under irrigation and the quality of irrigated land.

In the humid. and subhumid tropics, the gap between farmers yields and experimental yield potential is still large because of such natural forces as floods, droughts, temporary submergence from heavy rainfall, and salinity. Scientists have lad. limited success so far in dev eloping varieties tolerant of such abiotic stresses.

Most of the increase in rice yields in the favorable environments of the last 25 years was achieved through planting genetically improved varieties designed to be responsive t9 inputs and supplying those inputs with intensive application of agrochemicals.

Variation in average yields among countries is highly correlated. with differences in use of chemical fertilizers. In countries where fertilizer use is still low, yields, and production, could be increased by applying more fertilizer, if the risks of such an investment could be reduced. Concerns for environmental, protection, however, may discourage increased use of agrochemicals in general.

What is needed is a next-generation plant type and next-generation cropping technology that relies less on inputs from off-the-farm and more on knowledge-based management to maintain the natural resource base while raising yields. New technology is needed across rice ecosystems, in the risky environments as well as in the favorable environments.

Another factor which could slow growth in productivity is the increasing demand for rice with better eating quality. In China, for example, rising incomes and reduced consumer subsidies for rice are contributing to increasing demand for high quality rice. This rice commands premium prices in urban markets, and farmers are eager to grow varieties with the grain qualities consumers like. Another emerging consumer demand is for environment-friendly food products. In Japan, there is a profitable market for rice produced by organic farming.

These trends are inducing some farmers to grow traditional cultivars that have low yields, but that produce rice appealing to the local market.

Rice scientists have so far had limited success in developing high-yielding cultivars with better grain quality. Quality' factors also depend on consumer preferences in different countries. Research. on quality characteristics and breeding for quality grain must be country-specific, and that research is costly.

The demand for rice

Some argue that the current slowdown of growth in rice production is a response to sluggish demand, particularly where income and food consumption have reached high levels due to rapid economic development. Studies of consumption do show that per capita rice intake largely depends on level of income.

For people at the lowest income levels, rice is a luxury. The poor rely on low-cost sources of food energy—coarse grains and sweet potato. When their incomes increase, their i-ice consumption goes up. Rice becomes less important only at the high incomes where people can afford more expensive foods—vegetables, bread, fish, meat.

In Asia, per capita rice consumption has declined only in Japan, South Korea, Malaysia, and. Thailand—the high and middle income countries. The income threshold. at which higher quality, more varied foods are substituted for rice has not yet been reached for China, India, Indonesia, and Bangladesh—the countries that account for 70 percent of world rice consumption and dominate growth in demand for rice. ■

Bangladesh, R. Cabrera

Crucial Rice Environments

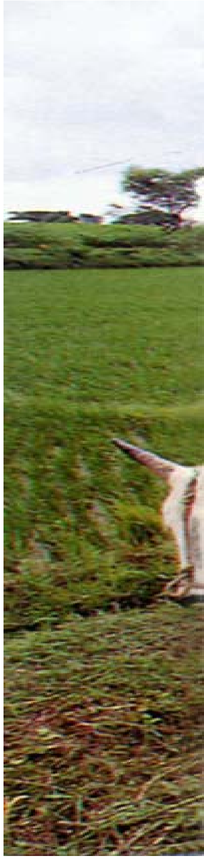
The ecosystems within which rice is grown are characterized by elevation, rainfall pattern, depth of flooding and drainage, and by the adaptation of rice to these agroecological factors.

Philippines, R.Cabrera

Rainfed lowland

Rice is transplanted or direct seeded in puddled soil on level to slightly sloping, bunded or diked fields with variable depth and duration of flooding, depending on rainfall. Soils alternate from flooded to nonflooded. Yields vary depending on rainfall, cultivation practices, and use of fertilizer. Rainfed lowland rice makes up 25 percent of the world's harvested rice area and 17 percent of world production.

Crucial issues. Areas where rainfed lowland rice is the predominant ecosystem are among the world's most densely populated rural regions and home to some of the world's poorest rural and urban populations. The rainfed lowlands must contribute to the production needed to feed expanding urban areas while preserving natural resources and improving the well being of farm families. ■



Crucial Issues in Rice Research

The ability- of farmers to produce enough food bases the ability of the world to conserve natural resources, protect the environment and provide for the development of countries and people. By 2025, more than 5 billion of the world's anticipated 10 billion people will depend on rice as their staple food.

Enabling farmers to grow the rice needed to feed those people requires considerable research effort, arid soon. The challenge is to generate a continuing series of scientific advances in agricultural technology. Protecting the yield and production gains already made also calls for considerable research effort. A strong foundation of strategic research conducted by international centers is fundamental, with important links to national agricultural research systems

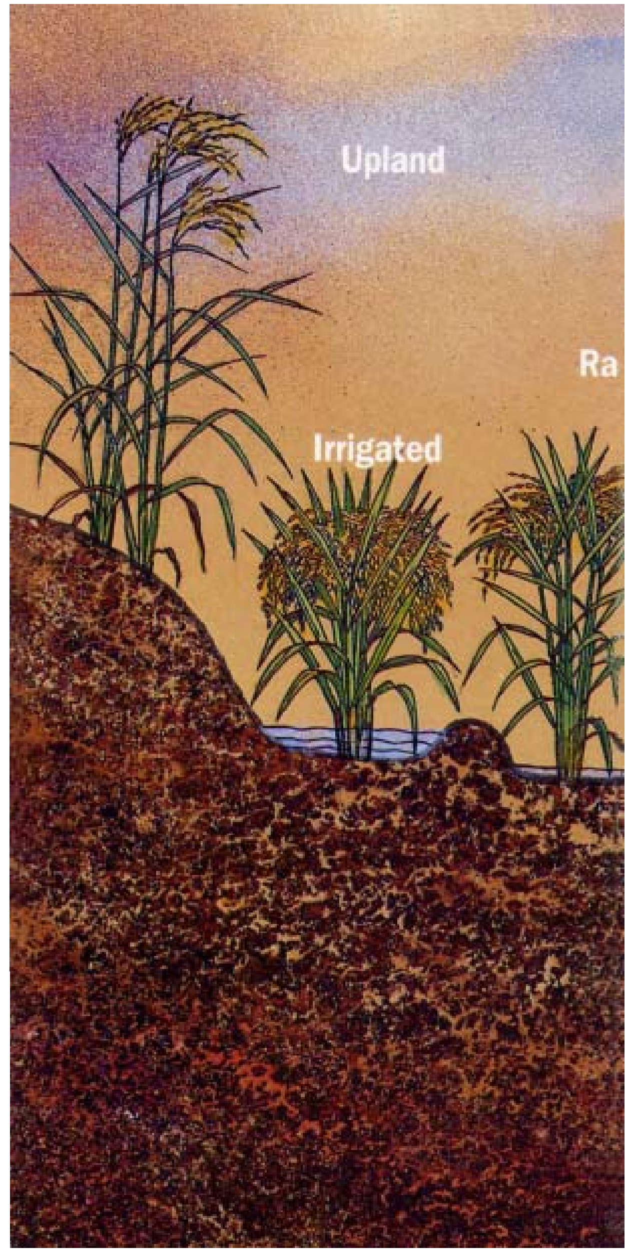
IRRI is working to resolve crucial issues in rice-growing environments, aggressively seeking ways to increase rice production and productivity while conserving the agricultural resource base for the future. Population growth and high population densities in rice-dependent countries translate into crucial research issues.

The challenge is to generate a continuing series of scientific advances In agricultural technology. One example is using the tools of biotechnology in breeding rices resistant to important insects or diseases. This apparatus enables blolistic transformation - inserting foreign genes into rice cells, where they may integrate into the rice genome.

Upland

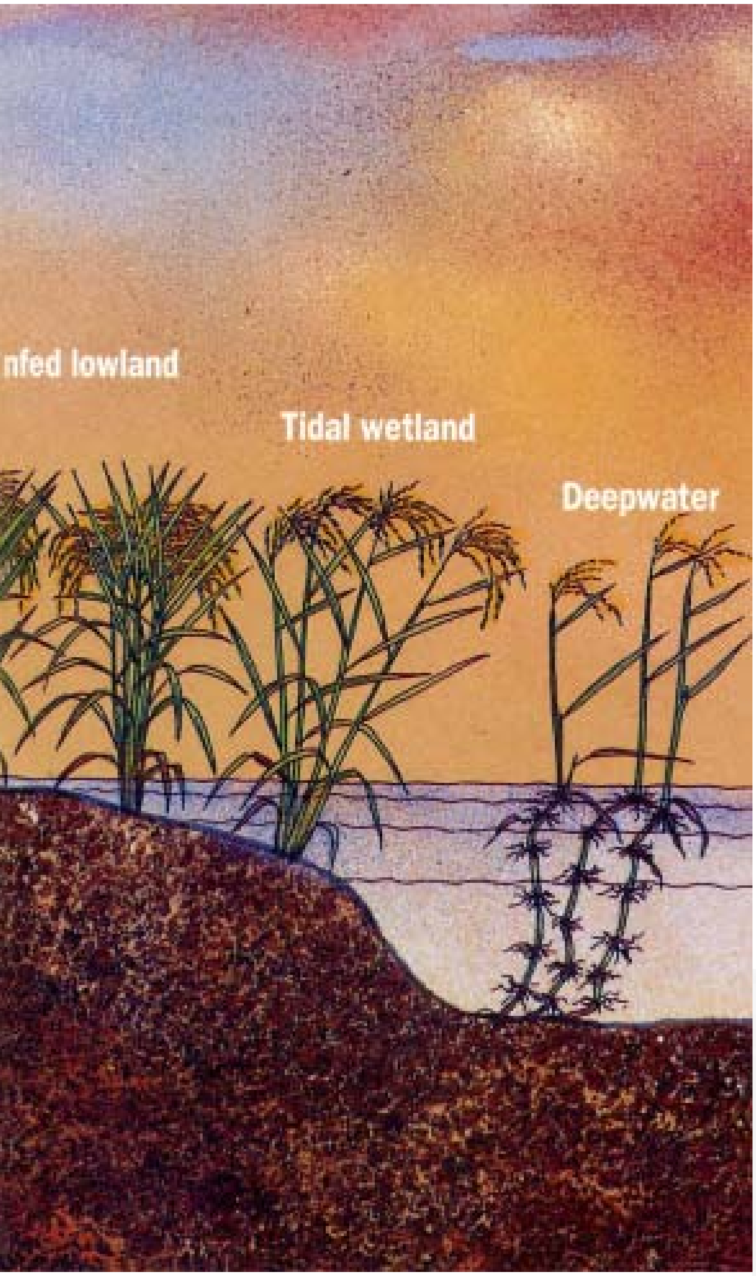
Rice is direct seeded in non-flooded, well-drained soil on level to steeply sloping fields. Crops suffer from lack of'moisture and inadequate nutrition, and current yields are very low. Upland rice makes up 13 percent of the world's harvested rice area and 4 percent of rice production.

Crucial issues. The uplands support millions of people, most of them at the subsistence level. The slash-and-burn agriculture that often follows logging in upland areas opens the way for serious soil erosion and degradation that impacts the lowland watershed. Improved technology is needed that will help rehabilitate degraded uplands and transform them into sustainable agroecosystems. ■



J. Figarola


Bangladesh, R.Cabrera



Deepwater and tidal wetlands (flood-prone)

Rice is direct seeded or transplanted in the rainy season on fields characterized by medium to very deep flooding (50 to more than 300 cm) from rivers and from tides in river mouth deltas. Soils cycle from flooded to non-flooded and may have severe problems of salinity and toxicity. The rice crop grows as floodwater rises, with harvest after the water recedes. More than 15 million hectares in South and Southeast Asia are subject to various types of uncontrolled flooding. West Africa and Latin America also have some flood-prone riceland.

Crucial issues. Rice is often the only crop that can be grown in the flood-prone areas. Yields are low because of problem soils and unpredictable combinations of drought and flood, and crop failures are common. Yet these low-lying areas support more than 100 million people, most of them in poor farm families. They need sustainable production systems. ■

India. S.Fujisaka

Cross-ecosystems

Some issues are common to all rice-growing areas: concepts that link rice science and technology developed at different levels (gene, cell, tissue, plant, ecosystem, global community) and integrate ecosystem components into agroecologies. The research makes use of new techniques and newly-developed methodologies and has a longer time frame and larger spatial domain than ecosystem-specific work. ■

People

Helping improve living and working conditions.

Farmers need input-efficient technologies that allow the rice they grow to be sold at prices profitable to them and affordable by consumers. At the same time, those who work in the ricefield.s must be helped to improve their working conditions, their economic status, their health, their well-being.

Permanency

Sustaining the natural resource base.

The permanency of the food production base on which we all rely, today and for the generations to come, depends on care anti use of the genetic diversity of rice and on husbandry of the natural resource base of soil-water-biological activity.

Productivity

Increasing resource use efficiency.

Increasing the input/output efficiency of nutrients, water, and labor make possible sustainable crop intensification and continuing reduction in the cost of rice production on agricultural, land.

Protection

Caring for the environment.

The world's rising concerns about land degradation, soil erosion, water shortages, and environmental pollution translate, for rice research, into the challenge of developing production systems that minimize pollution, that protect the environent and human health.

Partnership

Supporting and working with partners.

Working with relevant partners has many synergistic benefits: shortening the time needed to solve problems, enabling scientific collaboration across political borders and economic barriers, stretching scarce research resources, speeding the exchange of information and advanced research methodologies.

Vietnam, N.Weir

Irrigated

Rice is transplanted or direct seeded in puddled soil on leveled, bunded fields with water control, in both dry and-wet sea-Sons in the lowlands, in the summer at higher elevations, and during the dry season in flood-prone areas. The crop is heavily fertilized. Using modern technology, yields can reach 5 tons per hectare in the wet Season, more than 10 tons in the dry season. Irrigated rice makes up 55 percent of world's harvested rice area and 75 percent of world rice production. It provides the major supply for urban consumers. Growth in irrigated rice production has been largely responsible for the recent stability of urban rice supplies and prices.

Crucial issues. The irrigated area devoted to rice is declining and yields are stagnating. Evidence is mounting that flooded rice soils are not resilient to intensification pressures, and that the productivity made possible by current technology may not be sustainable. Yet the irrigated system must produce even larger yields, economically and sustainably, if future populations are to be fed. ■

Highlights 1992

PEOPLE:
Helping improve living and working conditions

Better understanding of the way households communities, and nationsmanage their resources, and of the factors that determine the trade-offs people make between maximizing their income in the short-term and sustaining their resource base in the long-term,can help in setting research priorities and in formulating public policy. Evaluating the impacts of policy and of technological change also provides information to guide modification and to set new directions for public policy and research.

Urbanization, income growth and demand for rice

In Asia, two-thirds of the calories in an average person's diet come from grain. Rice is the most important. In some countries, rice contributes more than 75 percent of the total calories consumed.

Even though per capita consumption of rice has been declining in countries with rapid economic growth and high income, consumption continues to increase in the lower income countries. Understanding the factors that contribute to changes in demand can help in formulating national policies toward self-sufficiency in food grains.

As part of an extensive collaborative project involving IFPRI, IRRI, and national programs we studied changes in demand for rice. Variables were the share of rice in total consumption expenditures, the price index of rice and the total price index of all commodities, and the rate of urbanization. The hypothesis: that urbanization affects consumption patterns by shifting the budget share allocated to rice as real income changes.

Cross-section data for the countries that consume 85 percent of world rice production—china, India, Indonesia, Japan, Republic of Korea Pakistan, Philippines, Thailand and Taiwan. China—were used. For Asia as a whole, the demand. for food grains brought about by growth in income is still positive: a 10 percent rise in per capita income will lead to a 3.4 percent increase in rice consumption, a 3.2 percent increase in wheat consumption, and a 1.8 percent increase in coarse grain consumption.

Tanzania, G. Denning

As incomes increase, the demand for food grains also increases. Overall demand for vice in Asia is expected to grow faster than population.

Price elasticities are high for wheat and coarse grains, but relatively low for rice. That is, a 10 percent increase in price would reduce demand for wheat by 6 percent, for coarse grains by 5 percent. But for rice, a 10 percent increase in price would reduce demand. by only 2 percent.

As the rate of urbanization increases, the demand. &.w cereal grams induced by growth in income declines. But the effect is not symmetrical. A 10 percent increase in the rate of urbanization will reduce consumption of coarse grains by 5 percent and of rice by 1 percent, but will increase consumption of wheat by 5 percent. It appears that urbanization induces changes in food habits separately from the changes induced, by growth in income.

The threshold at which per capita consumption of cereals starts to decline with, further increases in income (in economic terms, when the commodity becomes an inferior good) depends on both the propordon of income spent on cereals (the budget share) and the rate of organization.

Overall demand for cereal grains in Asia is expected to grow faster than population (indicated by positive income elasticities of demand). China, India, Pakistan, and. Indonesia—the countries that account for more than 75 percent of total food grain consumption in Asia. and dominate growth in demand. for rice—have yet to reach the income threshold at which per capita consumption of cereals starts to decline.

Demand for rice and wheat is expected to grow at nearly the same rate as increases in income. Wheat will probably have astronger market, because urbanization itself increases demand for wheat (a large part of it in the form of processed anti fast foods) anti lessens demand. for rice.

The lower income countries of Asia continue to be vulnerable to seasonal shortfalls in rice supplies. At a given shortfall, the price of rice must increase much faster than the prices of wheat and coarse grain to reduce demand enough to clear the market. The important point is that any increase in basic food prices puts pressure on the ability of poor people to buy enough food.

Impact of public policy and technology

A *case study of Myanmar.* Rice production in Myanmar during the late 1960s and early 1970s stagnated. at around 8.5 million tons a year. Then the government introduced a policy package designed to encourage farmers to adopt modern, rice technology. Production grew a spectacular 5 percent a year well into the middle of the l980s.

Almost half the increase in production can be traced to greater use of chemical fertilizers, more than a third. to adoption of modern high-yielding cultivars, and more than a tenth to an increase in the area under irrigation.

In 1987 policy shifted. Subsidies on agricultural inputs were withdrawn and. the private sector was allowed to participate in rice marketing. The fertilizer-to-rice price ratio increased rapidly, use of fertilizer dropped precipitously, and rice yields fell

A *case study of Indonesia*. Productivity of rice farming in Indonesia grew by nearly 3 percent a year 1969-89. Technological change was the driving force.

Farmers' adoption of modern high-yielding varieties contributed 28 percent of the increase. The next most important factors involved the availability of information: the government's agricultural intensification program contributed 27 percent and improvement in literacy contributed 20 percent. Breeding of second and third generation improved high-yielding varieties also made asignificant contribution. ■

IRRI, R. Cabrera

Information in the rice genetic resources data base includes descriptors on morphological characters of all accessions.

IRRI, R. Cabrera

IRGC contains about 74,500 accessions of *O. sativa,* 1,200 of *O. glaberrima*, and 2,100 of wild species. The base collection contains seed samples of 54,682 accessions, packed In partially evacuated aluminum cans and maintained in long-term storage. The total active collection includes seed samples of about 20,000 accessions of *O. sativa*, 550 of *O. glaberrima,* and 1,400 of wild species prepackaged in 10-gram aluminum foil packets, ready to send requesting rice breeders.

PERMANENCY:
Sustaining the natural resource base

The permanency of the food. production base on which the world relies, now and for the years to come, depends on the care and use of the genetic diversity of rice and on husbandry of the natural resource base of agriculture-soil, water, biological activity. Preserving genetic resources in perpetuity, evaluating the long-term effects of intensive cropping of ricefields, mitigating farmers' risks through characterizing resource use, arresting degradation are necessary activities.

Preserving and using genetic resources

The International Rice Germplasm Center (IRGC) acquired 2,318 samples from 19 countries in 1992—2,111 of cultivated rices and. 207 of wild rices The new samples came mainly from. China, Cambodia, Laos, Philippines, Banglades h, and Vietnam. More than 470 were collected, during missions in which. IRRI scientists worked with scientists of the host country.

IRGC and, national program staff members collected wild rices in India, Indonesia, Myanmar, and the Philippines In the first exploration through West Kalimantan, Indonesia. the ream found. three wild *Oryza* species: *O.officinalis* from the coastal areas, *O. ridley*i from low-lying forests, and *O. rufipogon* from the middle reaches of the Kapyuas River. Tidal swamp rices were collected, from Sintang

O. nivara was collected from saline tracts in Uttar Pradesh, India. Collections also were made from the only known Philippine population of *O. rufipogon*. This species has perennial features and will be a genetic source for development of the perennial rice plant projected for the upland rice ecosystem.

Both. upland and rainfed traditional cultivated, rices adapted to high altitudes were collected from. fields between 1,300 and. 1,600 meters above sea level in Chin state, Myanmar.

Rice genetic resources data bases

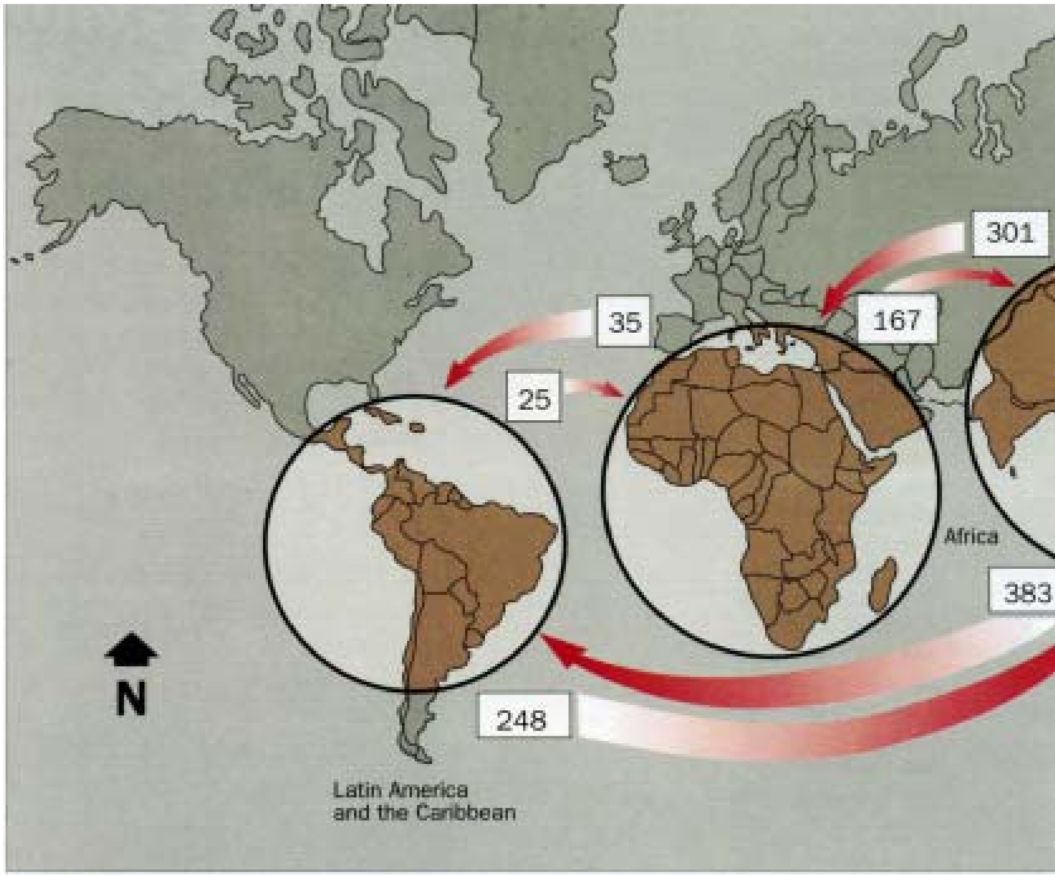
We have integrated genetic resources data base tables for more efficient information searches and added new variables for some descriptors, including a uniform set of color descriptors applicable to all *Oryza* species.

Other information in the data base includes seed viability data on. about 45,000 accessions and isozyme profiles for 2,811. accessions. The isozyme profiles, developed, in an ORSTOM-IRRI collaboration. are part of the the increasing use of new biotechnology tools for more precise characterization. We updated the cultural type file, passport table, and characterization data base. All germplasm data bases at IRRI now use the IRGC accession number as the principal descriptor

We also updated the International Rice Genealogy Data Base—records of the genetic ancestry of rice varieties and hybridizations made by national programs. Rice breeders in national rice improvement programs were asked to provide the pedigrees of new varieties released by their programs.

The data set now contains more than 100,000 crossing records; the genealogies of more than 2,500 post-IRS varieties released in 68 countries, mostly in Asia, Africa, and Latin America; 1,600 pre-IR8 varieties that farmers continue to grow or that rice breeders still use in their hybridization programs; and about 1,500 varieties used. in developing post-IRS varieties.

By tracing the ancestry of rice cultivars to their original land race progenitors, we can measure the degree of genetic diversity in rice, determine the cytoplasmic sources of different cultivars, and identify the genetic sources of shared traits.



Germplasm dispersal

External consultants examined the diffusion of rice germplasm by analyzing data. on new rice varieties released in 18 countries from 1965 to 1990. Of 1,709 modern varieties released, 390 were borrowed. (that is, they were developed, in one country and released in another). Most of the borrowed varieties were made available through the International Network for Genetic Evaluation of Rice (INGER); IRRI provided three-fourths of them.

About 75 percent of all the new varieties have at least one borrowed parent, more than 45 percent have at least one parent from IRRI, and more than 35 percent have at least one parent from another country. About 80 percent of these parental borrowings appear to have been chosen from INGER nurseries.

The varietal pedigrees indicate that genetic diversity is increasing. Only three varieties released before 1965 had more than four ancestors. The 222 varieties released after 1986 can he traced to five or more ancestors and 72 have more than 15 ancestors.

The share of ancestors delivered through IRRI-developed breeding lines continues to grow. IRRI provided more than one-half the ancestors for varieties released 1965-74 and nearly three-fourths the ancestors for varieties released 1981-90.

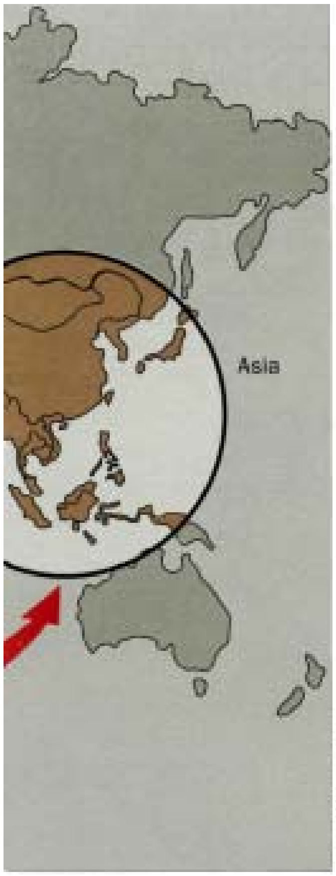
INGER is a primary conduit of new varieties: since 1988, 58 entries in INGER nurseries have been released as varieties in 18 countries in Asia, Africa, and Latin America. Those entries were developed by plant breeders in 13 different countries and at IRRI, IITA, and CIAT

Analysis of the economic implications estimates the average value of a released variety at $2.5 million dollars per year, in perpetuity. The annual value of an INGER nursery is conservatively estimated at $105 million. Adding 1,000 accessions to IRGC generates more than 14 new varieties, with a value of $325 million. An additional land. race introcluced by IRRI is worth $50 million. (R. Evanson and D. Gollin. Genetic Resources in Agricultural Productivity Change. Yale University, unpublished.)

Genetic diversity at the DNA level

Characterization of conserved germplasm at the gene level enables scientists to better use this precious resource andimproves management of materials in. the IRGC. This year we used biotechnology—isozyme and molecular markers at the DNA level—to identify diversity within the genus *Oryza*.

We chose a sample of 500 accessions of cultivated rice, half representative of the IRGC collection and half a selection of successful varieties and elite lines, their ultimate parents, and the donors of their resistance to abiotic and biotic stresses.



The interconti-nental flow of rice breeding lines through INGER.

Most had already been analyzed for 15 isozyme loci, in an earlier ORSTOM-IRRI project. This further exploration involved analysis for 30 restriction fragment length polymorphism (HELP) loci distributed over the genome. on mitochondrial DNA RFLP probes, and one chiropodist DNA marker assessed through polymerase chain reaction (PCR). A 68-accession subset was analyzed. with 17 primers for randomly amplified, polymorphic DNA (RAPD)

The indicas and japonicas, and their reciprocal recombinations, appear to represent the main structure of diversity in cultivated rice on all chromosomes. Although isozymes, RFLP or RAPD markers can be used to classify rice germplasm according to these naturally cohesive gene pools, their use is not strictly necessary. The results of a combination of morphological, physiological and simple biochemical tests will lead to the same classifications.

Gene mapping and manipulation

Molecular-aided selection can increase the efficiency of rice breeding. The most common technique used to identify marker genes is RFLP analysis. IRRI is a focal point of efforts to integrate existing genetic maps of rice, to provide researchers everywhere with a single, more complete map of the rice genome.

This involves orienting the RFLP map developed at Cornell University, USA; locating isozyme and morphological or physiological genes on that map via linkage to existing DNA markers; adding RAPD markers to underpopulated. regions of the genome; and developing flew markers aimed at increasing the ease of use and degree of genetic variation detectable by the ma.rkers The IRRI-Cornell Shuttle Project plays a central role in integration of rice genome data.

A detailed survey of the molecular diversity in rice undertaken this year had two major purposes:

- To detect genetic trends arising from domestication and modern breeding that could be important in designing breeding programs -
- To establish a data base on the diversity of the large IRGC collection that will aid future gene tagging activities and improve strategies for gene and quantitative trait loci (QTL) tagging.

We selected 147 traditional and modern cultivars to represent the breadth of available molecular and agroecological diversity and used 197 single restriction enzyme probes mapped by Cornell University scientists to examine their RFLP. The number of RFLP alleles distinguished per locus was relatively low, and 22 percent of the probes did not reveal any broad. variation, or polymorphism The distribution of loci with no polymorphism was not random; some clusters delimited. about 10 percent of the mapped genome, corresponding to gaps on chromosomes 2 and. 4 and to a chromosome fragment missing in the intraspecific genetic map on chromosome 7.

Now we can generalize to the entire mapped genome. The genetic diversity of indica and japonica rices has arisen primarily from separate domestication of different wild ancestors. Recombination of indicas and japonicas appears to be the orb gin, of most detectable DNA differences .A trend toward additional introgression detected, in modern varieties results from the use of japonica or intermediate indica / japonica parents in crosses.

The results allow a detailed description of the genetic differentiation of cultivated rice at the DNA level and have important implications for gene or QTL tagging strategies. The results also point to a paradox:the molecular markers identify a genetic trend of introgression between indicas and japonicas. Yet rice breeders repeatedly note that indica and japonica cultivars have poor combining ability. This focuses on the need to improve the compatibility between these groups of rices and for a long-term breeding program to introgress discrete traits.

Sustaining intensively cropped rice

In intensive rice production systems, irrigation is used to produce two or more crops a year on.. the same piece of land. More fertilizer and pesticides are applied to each crop. With the increase in number of rice crops, other crops are displaced, thus lessening diversity in the system. The intensively cropped. irrigateci farms of tropical Asia produce more than 70 percent of the world's rice.

The increased productivity of intensified. systems is largely responsible for the recent stability of rice supplies and. the decline in rice prices that is benefiting poor consumers. But growth in production is leveling off, and some farmers' fields are showing signs of decreasing total factor productivity. Evidence is mounting that continuously flooded ricefields may not be resilient to the pressures of the intensive cropping that is currently meeting rice production needs

Intensification of irrigated, rice production began with the introduction of modern high-yielding varieties in the 1960s-only yesterday, in terms of the history of agriculture. Such rapid change in the way land is used raises broad. questions:

- Flow is intensification influencing the productive capacity of the soil?
- How is intensification impacting the quality of the environment and the well-being of farm families?

We are focusing first on identifying the key processes and. properties that govern soil quality, changes in the pest environment, and input requirements. Data from long-term experiments on continuously cropped irrigated rice in the tropics indicate declining yield trends even with improved cultivars and where nutrients—including micro nutrients—added. There is evidence that, contrary to what occurs in oti er systems, soil organic matter and total nitrogen. content increases.

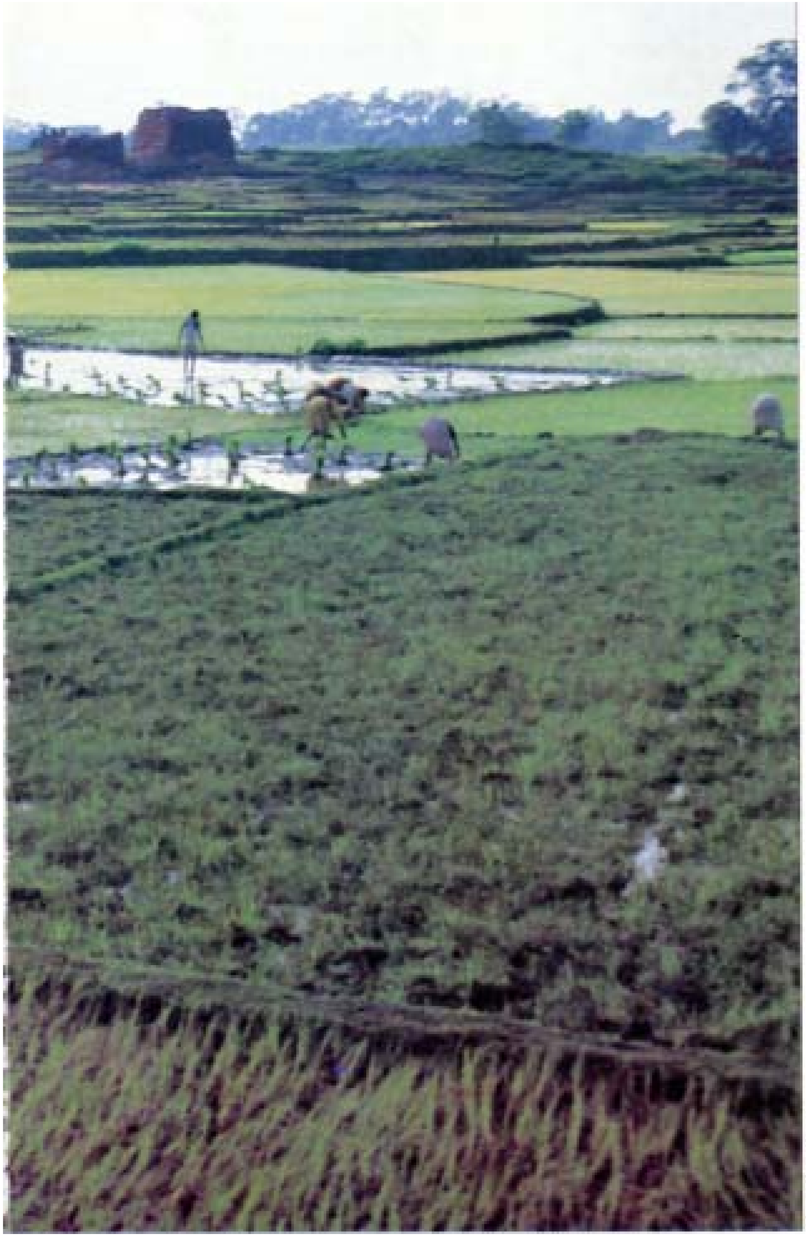
We measured the relationships among soil properties, soil nitrogen-supplying capacity, plant health and nitrogen use efficiency on both irrigated and rainfed. farmers' fields during the rainy season in. central Luzon, Philippines. Yields on control plots without added. nitrogen

varied widely, from 2.9 to 6.4 tons per hectare, meaning that effective sod nitrogen-supplying capacity (estimated. by the crop's nitrogen uptake) ranged from. 44 to 134 kilograms of nitrogen per hectare.

The farmers did not appear to recognize the relationship between yield and the soil's capacity to supply nitrogen, and did. not adjust the amount of fertilizer they applied to match their soil conditiom Yet it is hypothesized that the soil nitrogen-supplying capacity is partly responsible for the decline in factor productivity in such intensive systems.

Greater ability to predict the nitrogen-supplying capacity of flooded rice soils would enable farmers to better match their nitrogen Fertilizer inputs to the indig~enous soil supply. That would be a major step toward developing sustainable, more profitable flooded rice systems.

The change in the basic capacity of the soil to supply nitrogen also affects the optimal time and amount



India, R. Cabrera

Intensive systems are producing the rice that keeps urban supplies and prices stable. But growth in production is leveling off, while populations continue to increase.

of nitrogen to apply to a rice crop for its most efficient use, the synchronization of availability and. crop need. As nitrogen-supplying capacity decreases, the match of supply with crop demand deteriorates. The timing of nitrogen fertilizer app1ications must be carefully adjusted.

The best time is a function of the plant's nitrogen status and growth stage. Total nitrogen need can be predicted by a simulation model. A chlorophyll meter can,, give a quick estimate of leaf nitrogen status.

We put all of this together in an experiment on the IRRI Research Farm across the 1992 wet season and 1993 dry season. Two wet seeded and two transplanted crops each season received the amount of nitrogen predicted by seasonal demand..

For two crops, the nitrogen was applied at the standard recommended times (for transplanted rice, 2/3 at transplanting, 1/3 at panicle initiation; for wet-seeded rice, equal splits at seeding, midtillering and panicle initiation). For the other two crops, nitrogen was applied on the basis of knowledge, when leaf nitrogen status indicated it was needed.

Knowledge-based timing produced. 5 kilograms more grain for each kilogram of nitrogen applied than did routine application-a 20 percent increase in fertilizer input efficiency.

Sustaining rice - wheat yields

A relatively new intensified cereal cropping system is rice in the rainy season, wheat in the dry season. Rice - wheat systems are found on more than 15 million hectares of the Ganjetic Plain in Asia.

An international collaboration of Bangladesh, India, Nepal, Pakistan, IRRI, and CIMMYT is identifying constraints to the productivity of this intensive system. Soil nutrient depletion and. groundwater depletion appear to be affecting its long-term sustainability.

Less crop diversity may exhaust soil, nutrients. Also, as farmyard mamire is increasingly 'used. for household fuel rather than being applied to the fields, micronutrients are not replaced.

Loss of groundwater results from increased pumping to irrigate both crops. Other factors include using floodwater to control weeds in rice, pumping to charge canals, and overuse of water in general (given subsidized. electrical rates).

Sustaining rainfed rice environments

Farmers in rainfed areas confront variable, diverse environments, and their crops are vulnerable to both drought and flooding. Traditional rice-based cropping has been low intensity. Now, population growth is pressuring intensification of rainfed. cropping in Asia, in both the lowlands and the uplands. Farmers are shortening fallows to plant more rice and other crops, but are not increasing inputs to sustain the demand on the system.

Research indicates significant potential for increasing the efficiency with which resources are used in different rainfed. rice environments, and for large increases in system productivity. More thorough analysis of the environments will enable developing strategic management, matched with adapted cultivars

Characterizing agro-ecoregions

Geographic information systems and crop process models are helping us characterize the biophysical and socioeconomic resources of the principal rainfed. rice environments. This knowledge will help researchers assess the probabilities of the occurrence of a stress 'and its severfly, understand and manipulate nutrient dynamics, and design systems that use natural resources in a sustainable manner

The relative favorability of a rainfed. rice-growing area is a function of slope, hydrology, soil, and length of growing season. Upland and fiood-prone or deepwater areas are characterized primarily by spatial factors. The heterogeneous rainfed lowland, areas are more complex, and a. temporal dimension is needed for useful characterization. Given different combinations of hydrology and soil, an area that is favorable one year may be drought-prone or flood-prone the next.

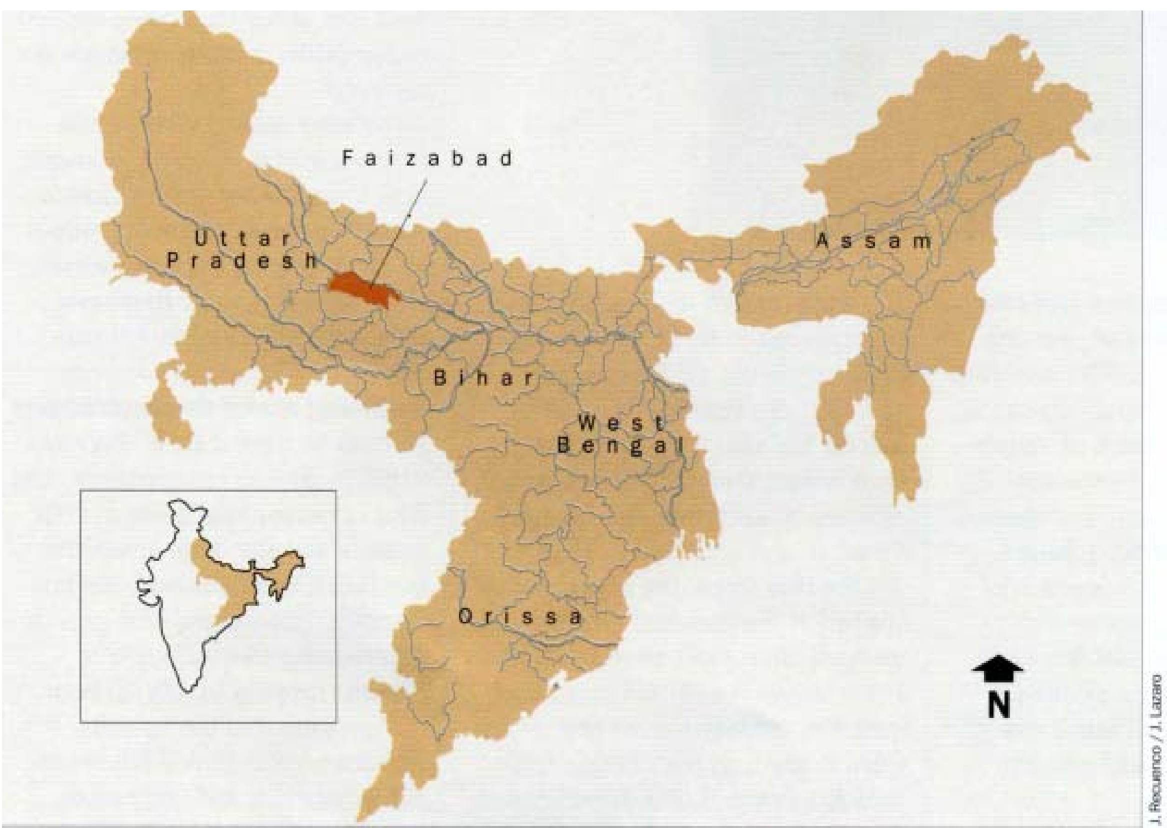
Analyzing an agricultural area. involves evaluating the relative importance of critical parameters on different spatial scales. The aim is to improve our understanding of the biophysical and socioeconomic constraints that farmers face. The variables considered. includ.e

- extent of land area,
- population dependent on the land for livelihood,
- existing production systems,
- use of natural and human resources,
- available infrastructure
- government policies and investment, and
- potential for improvement.

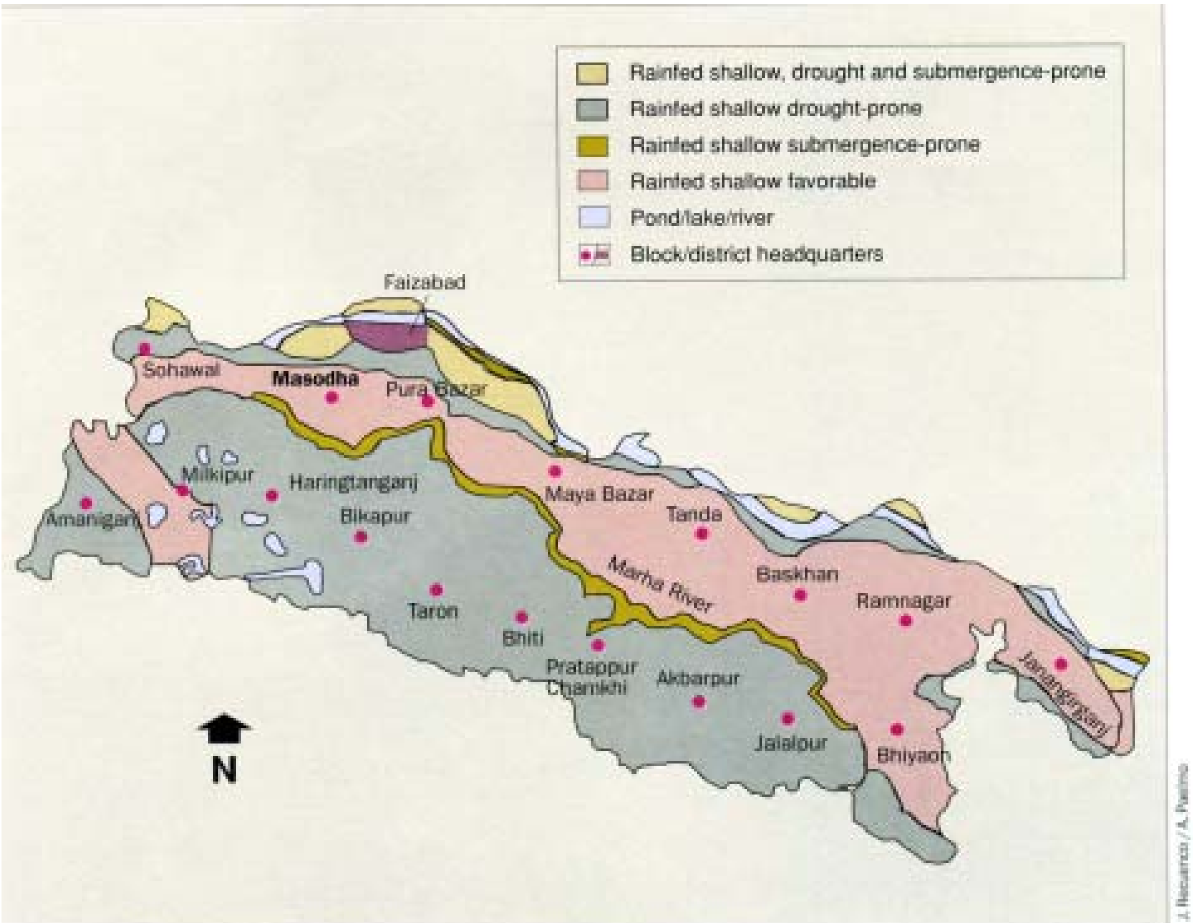
This year, we analyzed. eastern India in a pilot study in cooperation with the Indian Council of Agricultural Research and with state agricultural universities and departments of agriculture.

At the mega level, eastern India is obviously a priority region for research on rice: it contains two-thirds of the total national rice area and is home to half the country's population Most depend on rice farming, but yields average only 1.8 tons per hectare.

At the macro level, only slightly more than 20 percent of the rice area is irrigated. Nearly half is rainfed. lowland; the remainder is divided about equally between upland and deep to very deep water



Analysis of Eastern India went from the general region through state and district. steps to focus on one block, Masodha in Faizabad area, Uttar Pradesh state.



About 40 percent of the Faizabad area is favorable rainfed lowlands, 51 percent drought-prone, 2 percent submergence-prone, and 4 percent both drought- and submergence-prone.

Depth and extent of flooding on the rainfed lowland farms vary widely from year to year, depending on when the monsoon begins and ends anti on the rainfall pattern and amount.

Analysis of Faizabad district in Uttar Pradesh state used information from remote sensing satellites, selective field checks, and auxiliary data. Maps at the 1:250,000 scale delineated physiographic units, land use patterns, soils, anti areas of flooding and drought in rice We integrated, information on climate, groundwater, irrigation sources, landholding, and input use.

About 40 percent of the area is favorable rainfed lowlands, 51 percent drought-prone, 2 percent submergence-prone, and 4 percent both. drought- and submergence-prone

The next focus was on Masodha block in Faizabad district. The majar part—21,000 hectares with 8,000 hectares of riceland—was classified as shallow favorable rainfed. About 14 percent is affected by flooding, 10 percent by sodicity, and 2 percent by waterlogging. Only 32 percent of the groundwater potential for irrigation has been developed.

At the micro level, rapid rural appraisal of 90 sites in. the Masodha block involved agroecosystem mappingand diagnostic surveys. The analysis focused on spatial, temporal, resource flow, and decision patterns. Static factors included land types and uses, sources of water, and soil properties. Dynamic factors were field water depth and rainfall; cropping pattern and crop calendar; crop yields, varieties and management practices; insects, diseases and weeds; production costs and returns; labor supply pattern; assets, income distribution and landholding, and demography by social class and gender

The area was zoned into agroecosystems to identify problems and opportunies, and. to set research priorities on the basis of coverage, number of households affected, complexity, severity, frequency of occurrence, importance in the farming system, and farmers perceptions.

This empirical picture of the entire region is providing a basis for formulating the research agenda and allocating research resources at the national, regional, and zonal levels. It also is a case study of how to use this methodology.

IRRI, R. Cabrera

Tall leaves capture more solar radiation and help support large panicles with bigger grains.

IRRI, R. Cabrera

Current generations of a new rice plant being developed at IRRI have sturdy stems, large panicles, law tillering, and dark green leaves.

PRODUCTIVITY:
Increasing resource use efficiency

The greater rice production needed to meet growth in demand must come from new breakthroughs at the yield frontier and in factor productivity. We cannot target a 50 percent increase in rice production without much higher input/output efficiency of nitrogen, water, and labor Basically, this means matching improved cultivars with improved resource management Higher factor productivity has an additional benefit: the increased, production resulting from changes in plant and cropping efficiency adds very little to farmer costs. Gains can he shared by producers and consumers.

Developing a new rice plant

Work continues to develop prototypes for a rice plant that will have much higher yield potential than today's best varieties. This year, we selected additional donors (mostly tall tropical japonicas) for such traits as sturdy sterns, large panicles, low tillering, and dark green leaves, and made 296 crosses aimed at increasing the harvest index (the ratio of grain to straw an important key to higher yields)

The main avenue for improving the harvest index is to increase the size of rice panicles (more and bigger grains) and reduce the number of unproductive tillers. Large panicles can be induced by controlling excessive tillering through water and fertilizer management and by selecting varieties with large panicles and low tillering capacity, such as the new plant type.

Meanwhile, our more conventional breeding program continues to make incremental improvements in yield. Breeding line IR60819-34-2-1, which has more spikelets per panicle, outyielcled IR72 in the wet season (6.5 t/ha to 5.9 t/ha with 90 kg N/ha). We also developed short-statured lines with the *sd-1* dwarfing gene from Shen Nung 89-366, a japonica from China.

Predicting yield potential for rice

Maximum rice yields achieved in tropical environments so far are about 10 tons per hectare; in temperate environments, 15 tons per hectare. Attaining that yield potential depends on the variety grown and on temperature and solar radiation.

We have developed, a computer model. that estimates the yields attainable in different environments, interprets differences in yield in terms of physiological variables, and predicts the yield potential of a particular variety in a given environment.

ORYZAl simulates rice yield in different seasons in relation to the crop s nitrogen status Extensions can he added to take into account soil components and nitrogen and water uptake. The model calculates daily dry matter production (panicles, leaves, stems. and, roots), summed across the growing season, to explain differences in biomass production and yield at different nitrogen levels, with different varieties, during different seasons, in different environments.

Its advantage over other models is that it assesses the impact on yield of planting (late, weather, and latitude at a given leaf nitrogen content.

We used ORYZA l to simulate the impact of global climate change on rice production. Global circulation models are predicting an average temperature increase of 1 0C and a 50 ppm increase in carbon dioxide. With the increase in temperature, ORYZA1 predicted an 8-9 percent yield reduction for IR72 and IR581O9-113-3 grown with high nitrogen inputs at IRRI in both city and wet seasons. Increased carbon dioxicie partly reversed this effect to a predicted yield reduction of 3 percent. But a 5 percent reduction in radiation also resulted in 3 percent yield, reduction.

Model, analyses suggest that varieties with longer grain-filling duration will be needed to reverse the negative effects of a temperature increase

National agricultural research systems are involved in development of ORYZA1 and related models through the Systems Analysis and Simulation of Rice Production (SARP) research network supported by IRRI and the Centre for Agrobiological Research. and Wageningen Agricultural University, the Netherlands.

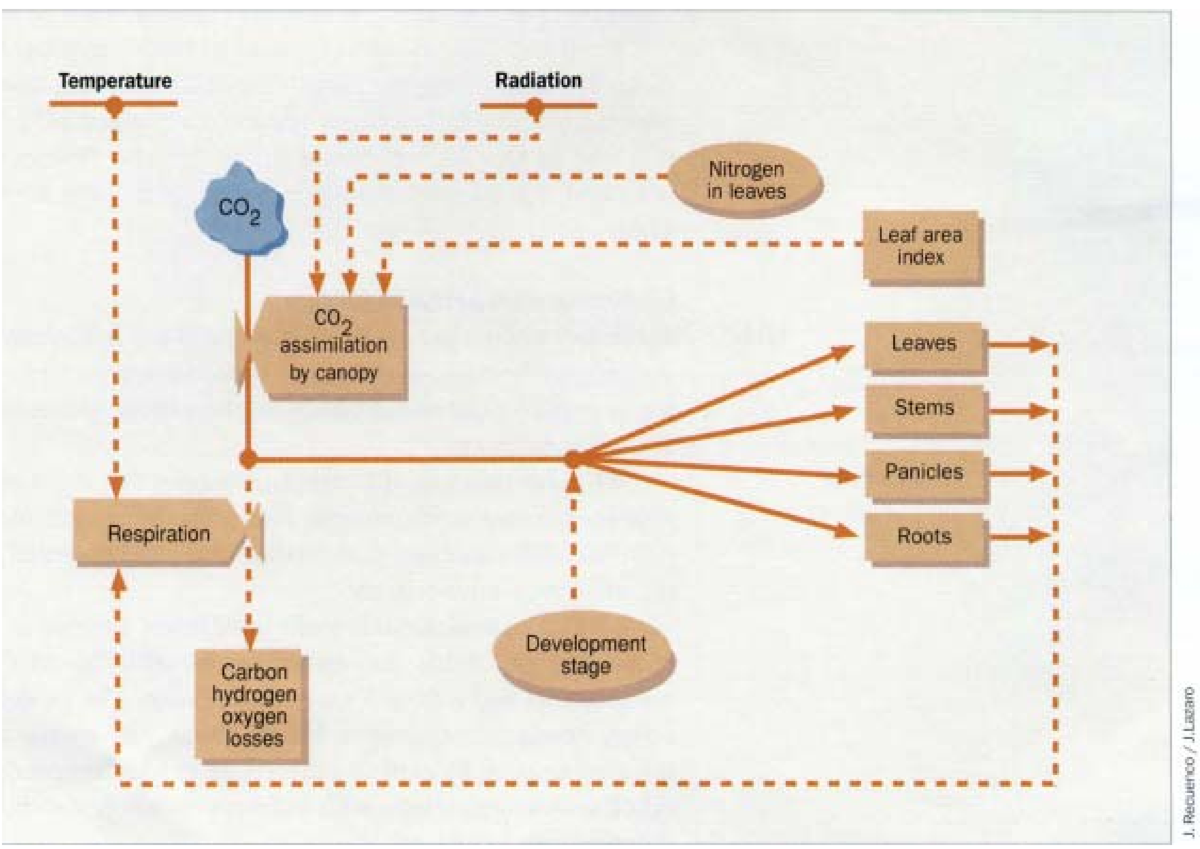
Wet seeding to save labor and water

With the shrinking availability and increasing cost of labor and water. combined with new short-duration cultivars anti herbicides for weed. control, farmers are switching from transplanting to direct seeding their rice crops. Wet seeding-broadcasting pregerminated. seed. onto puddled. soil-is a popular practice in irrigated, and favorable rainfed lowland areas of Malaysia, Philippines, Thailand., and. Vietnam.

We monitored 60 farms in the Upper Pampanga River Integrated Irrigation System of the Philippines Two wet seeded. rice crops gave a higher profit than two transplanted crops, the result of higher yields and lower labor costs. Yields from wet seeded rice were S percent higher in the dry season. 11 percent higher in the wet season

We also compared water use efficiency in two blocks of the systern, one planted largely to wet seeded rice, one largely transplanted. A lighter soil texture in the wet seeded rice area allowed greater water loss to percolation., resulting in higher water demand. Even so, transplanted rice used 25 percent more water than wet seeded rice.

Farmers who wet seeded finished their land soaking and puddling three times faster than farmers who transplanted. The ratio of water demand to water supplied was much more efficient in the wet seeded. fields, primarily because farmers used herbicides rather than water depth to control weeds.



Schematic representation of ORYZA1. Solid lines represent flows of material; dotted lines, flows of information. Input requirements are latitude, daily weather (solar radiation, minimum and maximum temperature), plant density, date of emergence or transplanting, and morphological characteristics of the variety. Time of integration is one day.

But increased use of herbicides may predispose a direct-seeded system to chancres in weed composition and to herbicide-resistant weed. races.

Intensifying rainfed lowland rice

One way to improve the well-being of rice farming families in the rainfed. lowlands is to intensify the system by adding another crop, such as a legume before or after the rice crop. But cropping intensification demands that more nutrients be supplied and can increase disease and insect pest pressure. Direct seeding of rice leads to a greater weed management problem. especially with dry seeding.

Minimizing the risk of drought

We compared transplanted and city seeded. rainy season rice crops in moderately drought-prone Urbiztondo, Pangasinan, Philippines, for their relative vulnerability to drought. Dry seeded rice was at significantly lower risk than transplanted rice.

Farmers were able to complete dry seeding operations after only 150 mm of rainfall had accumulated; transplanting operations had. to wait For 600 mm accumulation. The dry seeded crop, established 47 clays ahead. of transplanted rice in 1991 and 38 clays ahead in 1.992, captured. 400 mm of early season rainfall Its reproductive and maturity periods coincided with the more assured rainy period of the area's unimodal rainfall pattern.

We used these values and long-term weather data to estimate the probability of drought risk to the rainfed. crops. The concept is called relative water supply—the ratio of available water to rue water- demand of the crop.

Transplanted rice is expected to suffer severe drought stress about once in 4 years; dry seeded rice would not. The dry seeded crop's advantage is earlier establishment and. earlier harvest.

The farmers who dry seeded their rice saved $48 per hectare labor costs. Even with lower yields in the 1992 wet season, due td) severe weed infestation, dry seeded rice was slightly more profitable than transplanted rice There was no difference between row seeding or broadcast sowing in crop estahlishment of dry seeded rice, but row seeding simplified weed control.

Farmers are intensifying their systems with a mungbean crop after rice. The mungbean crop following dry seeded rice averaged $115 per hectare higher return than mungbean following transplanted rice. The return-to-cost ratio for labor and fixed capital, plus current inputs, was highest with a fallow - dry seeded rice - mungbean cycle.

Drought/flooding tolerance

Rices tolerant of the major constraints in the rainfed 1owlands—drought and flooding—would be a boon to farmers who are struggling to increase their productivity and profits. Varieties that can produce an adequate yield after the stress of too much or too little water, and that are responsive to favorable conditions, allow farmer-s to increase their inputs with much less risk

Identifying sources of tolerance for water stress is one focus of our work to improve germplasm.

Submergence: We dry seeded 1,312 breeding lines in a tank, then submerged the one-month-old seedlings for 10 days. Only 22 percent were tolerant of submergence.

Drought: We dry seeded 1,182 breeding lines in moist puddled soil kept saturated for 45 days, then drained and dried the plot to -10 bar soil moisture content. Only 18 percent were tolerant of drought.

Mechanisms of anoxia tolerance

Direct seeded rice often germinates or emerges in flooded soil, without oxygen. The seeds of some varieties survive this seeds of some varieties survive this seeds situation better than others. In a direct seeded crop, high survival rates translate into more uniform crop establishment, and that boosts productivity.

The enzymes that limit the ability of rice to survive under anoxia are not known, but we do know that the alcohol fermentation pathway in plant tissues allows the production fo energy from glycolysis to continue without oxygen. We studied the two enzymes in that pathway, alcohol dehydrogenase (ADH) and pyruvate decarboxylase (PDC). We also studied the two phosphorfructokinases enzymes that control glycolysis, ATP- and PPI-dependent PFK.

Rice varieties Calrose and FRI3A had the highest in vitro activities for ATP-dependent PFK and for PDC. This could allow higher rates of alcohol fermentation, and may be one reason for their anoxia tolerance. Anoxia-tolerance IR42 had the lowest activity for these key enzymes of anaerobic metabolism. In all varieties, PPI-dependent PFK and PDC were 50 to 500 times lower than ADH. activity.

Enzyme activity can be used to indicate metabolic limitations of intolerance varieties and to identify mechanisms of tolerance. Next, we will develop probes for tolerance for flooding and utilize molecular engineering to increase expressions of these enzymes in rice.

development of constructs for transforming rice with genes for ADH and PDC is underways in a special project in collaboration with laboratories in Australia and the United States.

Drought resistance in dry seeded rice

Dry seeded rice is more tolerant of drought than transplanted rice because it has a deeper and stronger root system. Even so varieties differ in their response to water deficiency; other plant characteristics also contribute to drought tolerance.

We subjected BR2O, BR21, IR64, and IR72 to water deficit at the vegetative stage and. at the reproductive stage. IR72 coped best with (drought at the vegetative stage; its plants were larger, nitrogen uptake at panicle initiation and flowering was greater, and total non-structural carbohydrate content was higher.

IR72, however, performed poor est with drought at the reproductive stage; its larger plants transpired more water than other cultivars and it suffered more damage. BR2O, with smaller plants, had the highest yield..

All cultivars had the same relationship between leaf water potential and CO_2 assimilation Leaf area and whole plant transpiration are the primary factors that affect leaf water potential: the larger the leaf area., the greater the transpiration and. the faster and more severe the water deficit stress.

In the field., however weed. transpiration and soil evaporation may overshadow any potential benefit to the rice crop of a small, water-conserving canopy

Upland rice varieties

Upland farmers in northern Mindanao, Philippines, primarily grow traditional low-yielding rice varieties. We asked about their selection criteria. Important characteristics are yield, early maturity, eating quality, lodging resistance, disease resistance, drought tolerance, and adaptation to different soil types.

These upland farmers regularly make reasoned choices of traditional rice varieties and practice sound management. They are successful to the extent allowed by the risks inherent in the system, but could. benefit from new varieties targeted to different agroecological niches.

IRRI's role is to make available to upland rice breeders improved germplasm that combines traits for tolerance for constraints with traits for higher yields. For example, the ability of a crop to compete with weeds would improve the productivity of labor. We found that tiller number, dry weight, and. leaf area index contribute to the competitiveness of rice against weeds.

There appears to be considerable scope for breeding upland cultivars that are more phosphorus-efficient. Factors identified so far indude internal plant mechanisms that regulate the amount of phosphorus in aboveground dry matter and external mechanisms—such as root diameter,length, and density—that affect the plant's ability to extract phosphorus from the soil. Other external mechanisms are root hair length and, density, release of agents that can mobilize organically-bound phosphorus ,solubilization effects due to root-induced changes in soil chemical conditions, and mycorrhizal effects.

Rice-based deepwater systems

Low-lying areas subject to uncontrollable flooding are home to more than 100 million poor farmers and. their dependents in South and. Southeast Asia. Rice is often their only crop. They need ways to increase their rice harvests and to expand. their cropping options.

One example is Bangladesh. More than half of that country's 10.2 million hectares of riceland is flooded to depths of 30 to 180 centimeters during the rainy season. Projections indicate that double-cropped rice—an early winter rice crop using boro varieties followed

by a transplanted deepwater rice crop in the rainy season—could be successful on 2.64 million hectares where only one winter rice ct-op is now grown. The next step is to breed high-yielding varieties adapted to winter temperatures and

to design cultural practices suitable for rainy season water depths.

Improved deepwater rice germplasm

Thai and IRRI breeders have defined the characteristics needed in a more productive plant type for areas with maximum flooding depths of about 100 cm. Ability to elongate as floodwaters rise is an important trait.

Lowlying areas subject to uncontrollable flooding are home to more than ioo million poor farmers and their dependents In South and Southeast Asia. Rice is often their only crop.

Transferring the high tillering and fast elongating ability of an accession of *0. rufipogon* to deepwater rice breeding lines shows promise for developing the new plant type within the next five years.

Salt tolerance for tidal wetlands

Rate of leaf elongation is a simple, reliable index of salt tolerance in rice. It is nondestructive and more convenient than. measuring dry weight or the relative rate of growth in following up on the effects of salt on plants.

An immediate decrease in the leaf elongation rate as salinity increased indicates that tolerant Nona Bokra rice plants respond to the osmotic stress imposed by salinity, not to the ionic stress. After the initial stress, growth rates recovered and remained constant, suggesting that Nona Bokra plants adapted

On the other hand, the leaf area index of nontolerant IR28 giants decreased. steadily with high salinity, indicating slowly increasing ionic stress with the influx of sodium into the leaves.

Now we can use RFLP mapping to identify the genes for differential response, and develop faster, more rebable screening for donors of tolerance for salinity. ■

Philippine L. Rose

Integrated Pest Management (IPM) is based on the premise that no single pest control method will be successful and long-lasting by itself Biological, physical, and chemical methods are integrated into cohesive strategies designed to provide sustainable crop protection. The empha sis is on maximize-ing natural control mechanisms. An IPM strategy uses a combination of resistant varieties, agronomic practices known to reduce yield losses due to pests, and conservation practices that preserve and increase the natural enemies of pests. Pesticides are applied only to avoid economic yield loss, and then only pesticides that cause minimal harm to humans and the environment are used.

PROTECTION:
Caring for the environment

Growing enough rice to feed burgeoning populations is pressuring fragile environments. The issues include land degradation, soil erosion water shortages, and pollution. For IRRI, this translates into research on ways to protect the environment and human health, while helping poor farmers improve the profitability of their rice-based, systems.

Developing IPM technology

Environmental and. health problems resulting from unsafe use of pesticides, and. the need. to find, less expensive methods of pest control are impelling national and international organizations and. groups to reevaluate pesticide use and to turn to integrated pest management.

Development of an IPM strategy requires knowledge based on a combination of strategic and applied research, to investigate the ecological factors that affect pests and. to design and evaluate new control methods. It also depends on farmer participation and on changes in public policy.

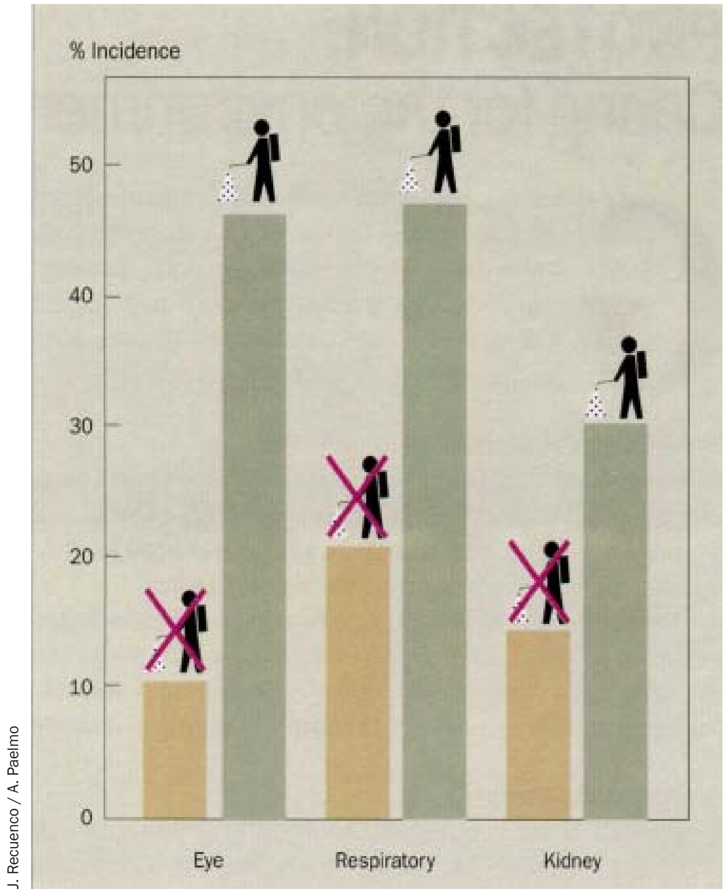
Host plant resistance

A rice plant that is genetically resistant to yield-threatening pests—what is called host plant resistance—is a key element in reducing the use of pesticides in. rice production. For three decades, IRRI plant breeders have ensured that each new elite cultivar and breeding line possesses a wide range of genes for resistance to pests and diseases. This means a continuous effort in breeding activities to keep ahead of evolving anti changing pests.

Land races, cultivated rice and. closely related wild rices have been the sources of genetic resistance. Pest and pathogen populations change over time, however, and genetic resistance breaks down, while some pest and disease problems remain intractable. Increased generic diversity against pests and cultivars with more durable resistance are needed. Biotechnology acids a new dimension to the search for improved host plant resistance:

- Wide hybridization makes it possible for breeders to use genes drawn from the wider pool of the entire *Oryza* genus. Tissue culture enables the rescue of embryo seeds from hybrids between *O.sativa* and distantly related species of the genus, such as *O. ausiraliensis* After several cycles of backcrossing to the cultivated, rice, chromosomal stability is restored, with pieces of the wild. genome integrated into the chromosomes of the elite parent. Several useful genes have been transferred from different wild species into cultivated rice.
- Genetic engineering makes it possible to transfer into rice specific genes originating from any living organism or virus, or even from chemical synthesis. The first group of useful foreign genes to be put into rice are intended to improve pest and disease resistance:

Farmers who routinely use pesticides are twice as likely to have health problems as those who rarely use them



— CryIIA a ncl CryIA(b) endotoxin genes of Bacillus thuringiensis (B.t.) for insect resistance.

— soybean trypsin inhibitor for insect resistance

— two barley genes, chitinase and. ribosome inactivating protein (RIP), for resistance to the fungal diseases sheath blight and blast

• Molecular marker technology increases the efficiency with which specific desirable genes can be combined in improved breeding lines. Useful genes are tagged with flanking DNA markers, accelerating the ability of plant breeders to screen for their presence. Such markers will be especially useful in breeding for resistance to pests and. diseases that are not endemic at IRRI headquarters or for genes with overlapping effects that can contribute to complex and more durable resistance.

Reducing disease epidemics

Epidemiology is one area of strategic IPM research. An example is rice tungro disease. Information about its epidemiology is limited In collaboration with NRL we measured the incidence and spread of tungro in different rice varieties and. the effect that introduced sources of infection had on its spread. These studies were made on the IRRI research farm in both the wet and dry seasons.

Tungro appeared earlier and spread faster, with higher final incidence, in the wet season than in the dry season.. The strong effect of introduced inoculum suggests that the availability of primary inoculum has a significant influence on disease dynamics. Roguing—removing infected plants and. replacing them with healthy plants—did not reduce incidence of the disease. Establishing an isolation distance between a virus source and the susceptible rice varieties may be a practical way of reducing disease incidence.

We continued to search for genetic resistance to the two viruses that cause rice tungro disease. Results this year suggest that resistance to the bacilliform virus in seven accessions of *O. rufipogon, O. officinalis*, and *O.ridleyi* does not depend on vector resistance. These wild, rices could be useful in transferring tungro resistance into improved cultivars.

Farmers' pest management decisions

A multidisciplinary integrated pest survey in central Luzon, Philippines, monitored the ricefields of 89 farmers across four seasons. We related data on diseases, insect pests, weed infestation., cropping practices, and yield to the Burners' perceptions of Pest problems and to their socioeconomic and technical backgrounds.

We found a close relationship between the backgrounds of the farmers, their perceptions of pests, and their use of pesticides. While all farmers used insecticides, only the more experienced. older farmers did so in response to a perceived rest threat. Younger farmers were less concerned about insect pests and said they noticed fewer pests. Ten~ ants were more concerned about pests than leasers and owners.

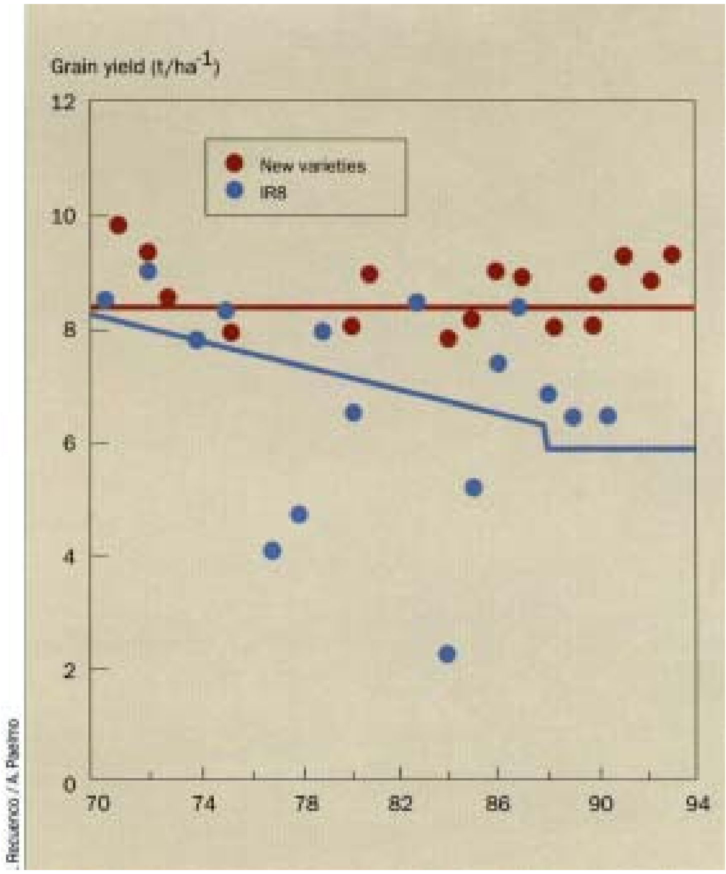
These differences in farmers backgrounds and. their pesticide decisions suggest that the introduction of IPM practices into a cropping system must be tailored to the farmers' perceptions

Pesticide-related health damage

We estimated the effects of impaired health on farm productivity in Laguna, Nueva Ecija, and Quezon Provinces, The Philippines. These areas are characterized by intensive irrigated rice systems—2-3 crops a year. Damage to farmers' health caused by improper and excessive pesticide applications reduces pro-cluctivity enough to wipe out profits from the rice crop.

The stud.y tracked 152 rice farmers for two years. Two groups usedi pesticides regularly, one rarely used pesticides. Those who routinely used pesticides were twice as likely to have health problems as those who rarely Lised them. The costs of treating th.e pesticide-related illnesses increased, in direct relation to the frequency of pesticide use. The value oF crops lost to pests was lower than the expense of treating the pesticide-related illnesses.

Inadequate storage, unsafe handling practices, short intervals between spraying, and inefficient sprayer maintenance were found to result in enormous exposure to chemicals of both the farmer and. his household.



Plant breeding to incorporate new genetic diversity for pest resistance into improved lines has maintained a quiet revolution, ensuring approximately one third of current yields without the need for extra chemical pest control. Yields of the original high-yielding varieties, exemplified here by IR8, would have declined an average 1.3 percent a year, a total of about two tons per hectare. New varieties with host plant resistance have maintained their yield potential.

Capturing genes for resistance

It takes substantial effort to transfer a resistant gene into a desired genetic background, in particular when stable resistance is the objective. Cultivars face a variety of pathogen populations in the field, and the genes conveying resistance need to be characterized against a spectrum of pathogen populations.

An improved set of near-isogenic lines allows the genes carried in those lines to be studied in detail and provides a specific set of differential’s For classifying pathotypes. We collaborated with. Hokkai do University to eliminate lines with identical resistant genes from. our set for classifying the rice blast fungus, and reduced the set from 22 to 5 lines. This makes using the lines to type virulence more efficient.

Rice yellow mottle virus resistance

Rice yellow mottle virus is a. threat to intensified, rice cultivation in sub-Saharan Africa. Traditional varieties in Madagascar are susceptible to the insect-transmitted. vinis, which thrives on ratoons and. in stubble.

We looked for resistance among more than 200 entries evaluated at Tsararano station in Marovoay The cultivars included traditional farmers varieties, entries from the INGER in Africa screening set, and improved breeding lines and varieties. Upland varieties FARO 11 and FARO 43, and lowland selections T0X3219-14-2-4, T0X3219-51-1-3-2-2B, and T0X3233-3 I -&2-3-2A were confirmed resistant. Wild rice species *O.longisiaminata*, which is widely distributed in sub-Saharan Africa and Madagascar, could be another source of resistance.

The rice yellow mottle virus research in Madagascar is a collaboration of FOFIFA, IRRI, and.GTZ Plant Protection Service.

Groundwater quality

Many rural areas depend on. shallow groundwater for their domestic water supply. Many groundwater aquifers, especially in irrigated areas, are connected hydraulically with the ricefields. Water containing nitrate residues from applied nitrogen fertilizer may reach these aquifers through deep percolation. Unsafe concentrations of pesticide residues also may accumulate.

We studied household. water supplies in two intensive rice cultivation areas of the Philippines, the Upper Pangasinan River Irrigation System in Nueva Ecija Province and the Santa Cruz River Irrigation System in Laguna Province. Water samples were collected once a month from manually-operated shallow tubewells.

Screening for resistance to rice yellow mottle virus in Madagascar is a collaboration of FOFIFA, IRRI, and GTZ Plant Protection Service.

Nitrate residues were found. at all sites, but concentrations were considerably below the maximum 10 ppm permissible. Nearly all the water samples 113 Laguna had detectable levels of the pesticides carbofuran and. endosulfan. Levels were lower in Nueva Ecija where farmers use less pesticide.

This is importan.t baseline data against which to measure groundwater quality in relation to changing crop management over the long term.

Protecting the upland

The uplands of the humid tropics are being impacted by special problems related to population pressures and agricultural intensification. In general, the basic problem is the soil degradation associated with deforestation by commercial logging, followed by the movement of excess population onto the cleared land

The intensive cultivation and overgrazing that follow lead to rapid leaching soil acidification, and crosion. The result is loss of soil fertility, declining yields, and land degradation This affects not only the riplands, but also the sustainability of lower parts of the watershed.

As population densities increase, what are the economically and environmentally viable protecHon options? In the long run, a system of farming that closely mimics the dense natural vegetation of the humid. forests would work best. In the short run, people must be helped to feed themselves while rehabilitating and sustaining their environment.

Appropriate land use and public investment can help to prevent the problem. In Southeast Asia, public policy—unchecked logging and poor conservation efforts—contributes more to soil degradation than does population-induced agricultural intensification.

Upland cultivation. by itself does not necessarily lead to land degradation. Soil erosion develops and accelerates when the farming system does not include conservation measures. If farmers are to. .invest in conservation, they need to see the profitability of the practices. This implies that they have secure access to land, with the ability to make long-term decisions that will enhance current and. long-term payoffs.

Indigenous control of soil erosion

Hedgerows are among the options proposed for controlling soil erosion and sustaining soil fertility-. Researchers from the Visayas State College of Agriculture (VISCA) and IRRI found that some farmers a.t the Matalom, Philippines, Upland Rice Research Consortium site already were using a contour hedgerow system to control erosion. In fact, several claimed they invented the approach as long ago as 1944.

The general practice was to leave narrow bands unplowed. along visually estimated contour lines. Volunteer weeds and grasses grew to form a hedgerow that helped stop soil movement. But six farmers had stopped cultivating their hedgerowed Odds because the hedgerows attracted grazing cattle and because soil nutrients had been depleted.

Of the 20 farmers who yesponded to technical advice and adopted contour hedgerow technol ogy within the last 10 years, nearly all had abandoned or fallowed their fields. They said grazing animals had damaged. the hedgerows and adjacent rice plantings, and soil nutrients had been depleted The *Leucaena leucocephala* trees planted in the hedgerows were being harvested, for firewood.

It appears that upland farmers recognize and actively seek solutions to their soil erosion problems. It is important that the technology fit the social environment and be integrated, into other cropping technologies.

Methane from flooded ricefields

Although we know flooded ricefields are a major source of tie greenhouse gas methane, there is considerable uncertainty as to how much the production of rice con tributes to atmospheric methane levels. More precise measurement of methane production and emission is needed. if we are to devise ways to reduce emissions without sacrificing rice yield.

We used a continuous measuring system to assess methane emissions from flooded rice soils and to dentify controlling factors. Methane fluxes were higher in the dry season than in the wet season. Within a season, a rice crop had three emission peaks: soon after transplanting, during the early reproductive stage, and a: ripening. Daily emissions seemed. to be controlled by ternperature, with the highest emissions in. the early afternoon and the lowest late at night.

The mode of applying fertilizer did. not affect emission patterns, hut adding organic matter such as straw and green. manure greatly increased methane emission from. transplanting through the reproduction phase. Cultural practices, such as soil disturbances or soil drying during rice growth., released large amounts of trapped methane.

Measurements in the laboratory showed that the pattern of entrapped methane and release of methane by bubblin.g (called ebullition) closely followed the total flux pattern. Soils can be categorized into four groups according to the pattern and amount of methane they produ cc during anaerobic incuba.-tion.

Methane production and emission in relation to rice growth is clearly complex. More accurate estimates of methane emission from wetland rice will take into account soil properties, water regime, organic amendments, and. cultural practices.

We also measured nitrous oxide emissions under similar at conditions. Nitrous oxide fluxes were inversely related, to methane emissions. Nitrous oxide emissions during fallow and during a flooded, rice crop were high immediately after rainfall an and low during growth. duration, except after nitrogen application. Mid-season drying of the field. suppressed methane fluxes without increasing nitrous oxide emissions. ■

Bangladesh, R. Cabrera

Bangladesh, R. Cabrera

Collaboration has many synergistic benefits: shortening the time needed to solve problems, speeding the transfer of information and advanced research methodologies, enabling scientific collaboration across political borders and economic barriers, stretching scarce research resources.

PARTNERSHIPS: Supporting and working with others

Virtually all IRRI's work involves some form of collaboration, of partnership This has many synergistic benefits: shortening the time needed. to solve problems, speeding the transfer of information and advanced research methodologies enabling scientific collaboration across political borders and. economic barriers, stretching scarce research resources. Important partnerships include bilateral agreements, shuttle research, and joint ventures Consortia and networks streamline collaboration and cooperation.

The International Network for Genetic Evaluation of Rice (INGER)

INGER promotes genetic diversity in different ecosystems through global exchange evaluation and use of improved breeding materials,including varieties and elite lines originating from sources worldwide. Some entries in the yield and stress nurseries for different rice ecosystems demonstrate high levels of yield stability and stress tolerance over a wide range of specific biotic and abiotic stress hot spots.

In 1992, 638 sets of 19 nurseries—10 for different ecosystems and 9 for stress tolerance, a total of 1,300 entries-were distributed to 35 countries: 13 in Asia, 3 in West Asia and North Africa, 9 in sub-Saharan Africa anti 4 in Latin America, plus Australia.

In addition, INGER-Latin America composed and distributed nursery sets of germplasm suitable for moisture-favorable conditions and tar acid soils and INGER-Africa prepared and sent 9 nursery sets to 1 3 countries in West Africa and 17 countries in east, central, and southern Africa.

In follow-tip activities, 775 entries were evaluated in additional yield trials in 20 countries, and 602 entries were used in the crossing programs of 19 countries. Three entries were released, as varieties: 0R142-99 from India was released as Santepheap 3 in Cambodia, Barkat (.1(73-13) from India was released, with the same name in Bhutan, and 1119763-111-2-2-3 from IRRI was released as Pant Dhan 10 in India.

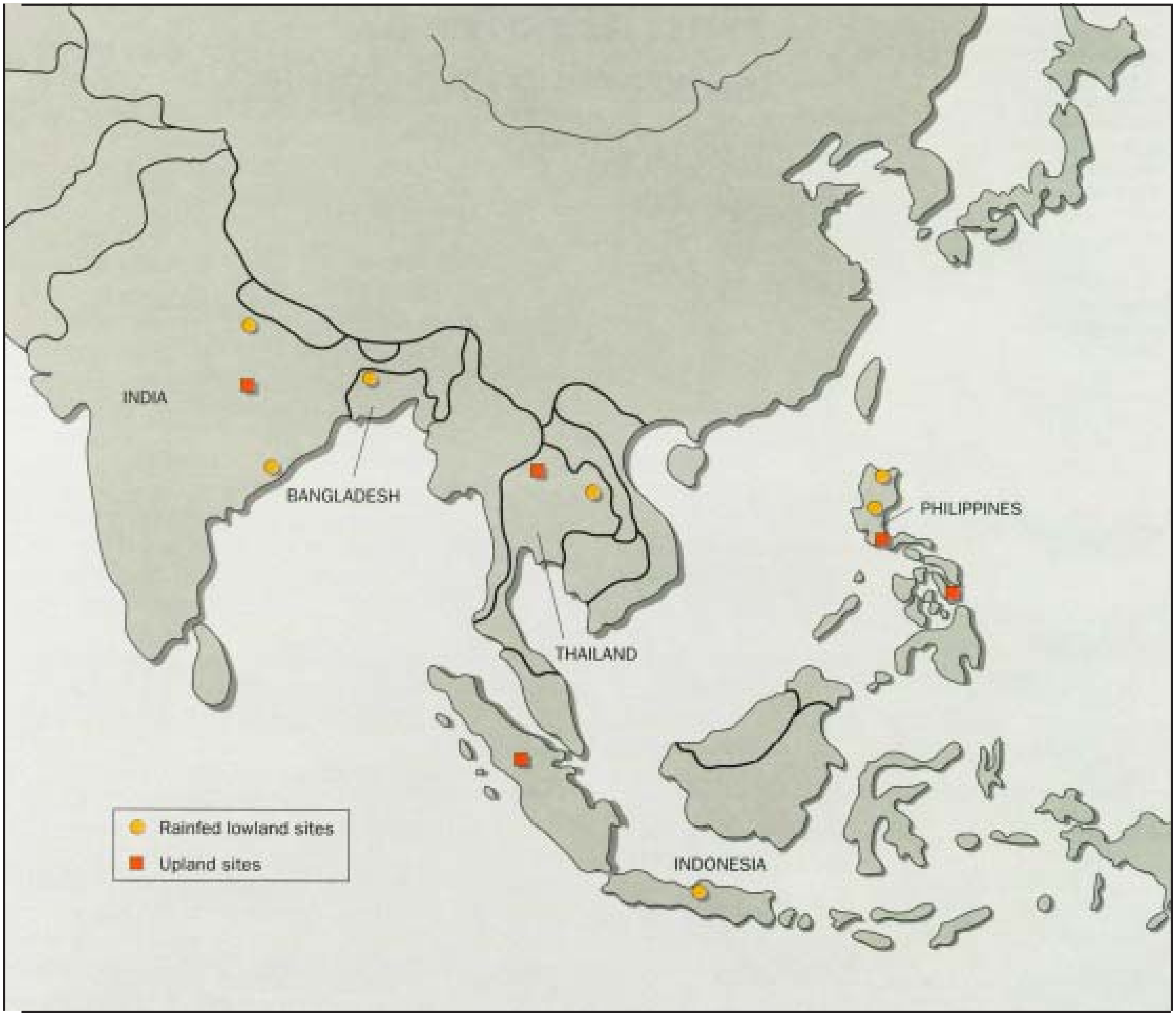
The Rainfed Lowland Rice Research Consortium

The heterogeneous, variable. and widely dispersed environments of rainfed lowland rice and the related major abiotic and biotic constraints are challenging consortium members to link with other research initiatives.

Major breeding activities for the rainfed lowlands have been transferred from IRRI headquarters in the Philippines to consortium sites: Central Rice Research Institute (CRRI). Cuttack, India, for medium-deep water (50 X 7(0 cm); Ubon, Thailand, for shallow water with low fertility soils.

The Upland Rice Research Consortium

Improving the productivity of upland rice and. improving the well-being of farming families in the uplands of tropical Southeast Asia involve working with both the biophysical environment and the socioeconomic environment. The issues are the same across the region: impoverished rural com-



Rainfed Lowland Rice Research Consortium

Bangladesh	Bangladesh Rice Research Institute, regional station at Rajshahi.
India	Central Rice Research Institute, Cuttack, Orissa, and Narendra Dev Agricultural University Experiment Station, Faizabad, Masodha.
Indonesia	Central Research institute for Food Crops, Sukamandi Research Institute Jakenan Experiment Station, Central Java.
Philippines	Philippine Rice Research Institute, Batac, Ilocos Norte.
Thailand	Rice Research Center, Libon.
IRRI	tarlac, Pangasinan, Philippines.

Upland Rice Research Consortium

India	Central Rice Research Institute, Hazaribagh Rice Research Centre.
Indonesia	Agency for Agricultural Research and Development and Central Research Institute for Food Crops, Sitiung Research Station, Sumatra.
Philippines	Philippine Rice Research Institute, Matalom, Leyte.
Thailand	Ministry of Agriculture, Samoeng Research Station, Northern Thailand.
IRRI	Cavinti, Laguna, Philippines.

munities, poor soils, the need for food security.

Rice is only one component of the complex cropping systems of the uplands. Farmers need flexible systems that closely associate food production with cash crops and livestock. The technology must protect natural resources; in particular, the cycle must arrest soil erosion arid water runoff.

Consortium members are carrying out research on drought, weeds, blast, poor soils, and land management.

The Asian Rice Farming Systems Network (ARFSN)

ARFSN participants evaluated technology at 39 key sites in 16 countries of Asia and in Madagascar. They tested cropping, crop-animal, and crop-fish systems, examined the roles of women in rice farming, evaluated equipment for timely operations in intensive cropping, evaluated varietal selections of forage crops, and used geographic information systems (G IS) to extrapolate recommended domains for promising agricultural technologies.

The International Network on Soil Fertility and Sustainable Rice Farming (INSURF)

INSURF continued to focus on sub network activities in the irrigated, rainfed lowland, and upland rice ecosystems. Participants tested improved soil fertility management practices and evaluated their contribution to sustaining rice-based cropping systems. Cooperators in Bangladesh, India, Indonesia, Malaysia, the Philippines and Thailand used Soil Taxonomic and Fertility Capability Classification to characterize a large number of testing sites. This information will help in developing extrapolation domains.

The Integrated Pest Management Network (IPMN)

IPMN focuses on interdisciplinary research that involves both national scientists and. extension specialists. Diagnostic workshops enable national system teams to derive research, extension, and. policy priorities. Country teams also evaluate farmer participatory research as a means of communicating IPM concepts, such as plant compensation for damage due to pests and. natural control of rice pests.

Country and regional projects

Some economically less-developed countries still need assistance in improving their research capacity. The special Country and regional projects coordinated, by IRRI are designed to help national programs make the transition, from institution, development to research col1aboration. Each project's research plans are coordinated with IRRI is work, to capture the synergistic benefits for both.

During 1992, external funding supported special project work with the national rice research systems of Bangladesh, Bhutan, Cambodia, Egypt, Lao PDR, Madagascar, Myanmar, and Vietnam ■

Training

A crucial need in rice research is continuing enhancement of the ability of national agricultural research systems to carry out their research agenda. A number of national programs still lack a critical mass of adequately trained, personnel.

During 1992, 239 scholars and research fellows from 34 countries participated. in degree and postdegree training at IRRI. Some research fellows are assigned to work at consortia key sites.

The Institute actively encourages and. assists national systems to share in regional training responsibilities, thus making better use of resources and stimulating more i-c-search collaboration. This year, IRRI began. to decentralize its training prograrri by transferring its Rice Production Training Course to Thailand. Thai and IRRI trainers led 27 participants from 7 countries through the course.

Some 650 national program researchers were trained in short-term courses at IRRI and in-country during 1992.

Courses at IRRI headquarters

Training and. technology transfer
Engineering for rice agriculture
Integrated. Pest Management
International Network on Sustainable Rice Faming Systems
Farming systems research
Geographic Information Systems training on extrapolation of agri.-cultural technologies
Rice seed health testing
Irrigation water, management
Rice biotechnology
Gender analysis and its application to rice-based farming systems research
Research management (IRRI-ISNAR-UPLB)

Collaborative courses in country

BHUTAN: Research data analysis and management;
Practical on-farm trial
CAMBODIA: Research report writing and making effective oral presentation;
Rice production aim training and. technology transfer;
Special rice production
MYANMAR: Weed control in telecaster rice
PHILIPPINES: Geographic information system and data collection;
Integrated Pest Management (PhilRice-FAO-IRRI);
Data management for on-farm trials (Bureau of Agricultural Research-IRRI)
INDIA: Farming systems research workshop;
Experiential and knowledge-sharing in environmental characterization workshop;
Experimental design and data analysis
Lao PDR: Integrated pest management workshop;
Pest monitoring
THAILAND: Project management system workshop;
Rice production research
VIETNAM: Logical framework approach to agricultural research planning. ■

Information and knowledge exchange

International conferences and workshops bring together scientists from all over the world., to discuss current problems, review the latest research results, and develop research strategies. IRRII sponsored 32 conferences workshops and collaborative research planning meetings during 1992, with 1,073 participants From some 40 countries.

The 21st International Rice Research Conference at IRRI headquarters 21-25 April 1992 drew 245 participants from 30 countries. Technical papers were presented within key research themes: hybrid rice, nutrient processes and. managemerit, and. pest science and management.

The second group of Outstanding Young Women in Rice Science was recognized: Mrs. A..i-Na Hsu of Taiwan, Dr. Watanalai Panbangred of Thailand, Dr. N. Shobba Kini of India, and Mrs. Young Rice Son of Korea. Their outstanding scientific contributions exemplify the important role women play in rice research and development.

International conferences/ workshops 1992

Application of soil water engineering for paddy field management. Bangkok, Thailand

Potential for nodulation and nitrogen fixation in rice at IRRI

international Rice Research Conference at IRRI

Satellite remote sensing for agricultural projects, IRRI-Scot Conseil workshop/seminar, at IRRI

Botanical pest control, IRRI-ADB project workshop, at IRRI

Interpretation of data from experiments on upland soils, IBSRAM-IRRI training workshop, at IRRI

Women in rice farming systems, Chiang Mai, Thailand

Lou g-term nutrient management strategies for sustainable productivity of rice-based cropping systems, ICAR-IRRI collaboration, New Delhi, India

Research and collaborative work plan meetings 1992

PhilRice-IRRI, at IRRI

Deepwater rice research planning meeting, at IRRI

Rainfed lowland rice research consortium meeting, at IRRI

IPM network workshop on rice leaffolder management, Beijing, China

France-IRRI, at IRRI

Thailand-IRRI, Bangkok, Thailand

SARP planning workshop, at IRRI

Korca- IRRI, at IRRI

Rice supply and. demand project planning workshop. at IRRI

IRRI-ICAR, Cuttack, India

SARP3 planning workshop, at IRRI

IPM network review and planning workshop, at IRRI

Upland rice-based Firming systems research planning meeting, Chiang Mai Thailand

Upland Rice Research Consortium Steering Committee meeting, at IRRI

China-IRRI, at IRRI

Viernam-IRRI, Hanoi, Vietnam

BRIRI-IRRI, Joydebpur. Bangladesh

ICRISAT-IRRI collaborative meeting on agroecological zones, at IRRI

ARFSN-INSURE-IPMN joint meeting, in Vietnam

International Rice-Wheat Collaboration advanced workshops, Faizabad, India

CIAT-IRRI collaborative research meeting, at IRRI

Sri Lanka-IRRI, at IRRI

IRRI publications released in 1992

International rice research newsletter, vol. 17, nos. 1, 2, 3, 4, 5.6 (1992:)

Rice literature ii pd.ate, February, April, June, August, October, December (1992)

IRRI 1991-1992: sharing responsibilities. 1992. 80 pages.

Program report for 1991. 1992. 322 pages.

Biofertilizer germplasm. collections at IRRI. E. R Watanabe, P. K Roger, J. K. Ladha, and C. Van Hove. 1992. 66 pages.

Biological nitrogen fixation for sustamable agriculture. J. K. La d.ha, T. George, and 13. B. Bohol. 1992. 209 pages. (with Kluwer Academic Publishers)

Consumer demand. for rice grain quality. Edited by L. J. Unnevehr B. DulL and B. 0. Juliano. 1992. 245 pages. (with International Development Research Centre, Canada)

A farmer's primer: on growing rice. Revised edition. B. S. Vergara. 1992. 219 pages.

Frontiers of nutrition and food security in Asia, Africa, and Latin America. 1992. 171 pages. (with the Smithsonian Institution)

Nodulation. and nitrogen fixation in rice: potential and prospects. Edited by G. S. Khush and J. Bennett. 1992. 136 pages.

Rice in deep water. David Catling. 1992. (with The Macmillan Press Lid)

Rice in Latin America: improvement, management, and marketing. Ecutot: Pederico Cuevas-Perez. 1992. 288 pages. (with CIAT)

Rice production in Uttar Pradesh: progress and. suggestions for improvement. M. D. Pathak. 1992. 253 pages. (with Wiley Eastern Limited)

IRRI, R. Cabrera

IRRI Today

Looking Ahead:
Rice research in a time of change

Developing IRRI's Medium-Term Plan for 1994-1998 dominated Institute activities during the latter part of 1992 and. well into 1993. This second plan within IRRI's strategic framework, Toward 2000 and beyond, was developed with. .full participation of th.e IRRI staff, both internationally and nationally recruited, and of its partners worldwide. The process started with the appointment of a Task Force. Its members carried out careful. logical framework planning and identified the hard choices to be made if criti cal objectives were to be met within the limited funding projected.

All IRRI staff reviewed the resulting program and the first draft of a plan for 1994-1998 was written. Colleagues from Africa, North and South America, Europe, and. Asia; nongovernmental, organizations and. national at ricultural research systems; and basic, strategic, applied and adaptive research. interests reviewed it at IRRI during November 1992. Their insights sharpened the focus for further revision... The final plan was submitted to TAG in February 1993.

Imbedded in the plan are new approaches to research on crucial issues in rice environments. The first identifies challenges of enormous breadth and critical impact. The achievements expected. from these.> Mega Projects is high; the speed. and extent of their success depends on the resources that can be applied. Mega Projects include:

- Raising the irrigated rice yield plateau.
- Reversing trends of declining productivity in intensively-cropped irrigated systems.
- Improving rice - wheat cropping systems.
- Enhancing the conservation of rice genetic resources.
- Exploiting biodiversity for sustainable pest management.

The second new approach is the challenge of stretching research horizons. Exploring New Frontiers requires applying imaginative insight using sophisticated methodologies. New Frontier projects include:

- Developing a hybrid rice that captures apomixis, to harness hybrid vigor for resource-poor farmers who cannot afford to purchase seed for each crop.

• Assessing opportunities for nitrogen fixation in rice, to reduce production costs and lessen dc-pendence on non-organic fertilizer Sources, thus conserving natural re-sources.

• Exploring the role of alleloparhy and biologtcai control of weeds, to reduce the need to apply herbicides.

• Developing a perennial rice plant, to help control erosion on upland. slopes win I e providing poor farm families with part of their 1asic food supply.

IRRI's Medium-Term Plan for 19944998 affirms the Institute's commitment to preparing for agri-cultures future, a future that con-serves soil, water, natural resources and biodiversity while increasing rice production, generating rural in~come and improving the well-being of rice-dependent people, in par-ticular women and children.

External Reviews

Two CGIAR/TAC external review panels examined IRRI and its pro-grams during 1992: the Fourth Ex-ternal Program and Management Re-view and the Intercenter Review for Rice. Both panels visited. IRRI in April 1992: members of the External Review Panel returned 4-25 Septem-ber for the main information collect-ing phase and to prepare their re-port. We quote a few excerpts from the summary of that report:

". . . We have found IRRI well along in a radical transformation of its programme objectives, staffing organization, and management.

". . . We have been deeply im-pressed by the dedication and en-ergy with which the management and still of IRRI have been pursuit-ing the transformation of its life and work.

". . . This External Review finds an IRRI that is visibly different in both scientific and management terms in many ways a rejuve-nated IRRI-an IRRI that has higher promise to lead the world of rice research into the next century.

Peer reviews of projects

A 5-member international expert panel reviewed crop and. resource management networks 4-S May 1992. Key recommendations were to integrate research undertaken within the networks into appropriate re-search projects, develop guidelines for establishing and. discontinuing trials, establish information ex-change and link network activities to research projects.

Four international experts re-viewed IRRIs research on environ~mental characterization 16-20 No-vember 1992. Key recommendations are to

• Increase the systems focus of research by integrating diagnostic studies, model anti data develop-ment, and experimentation.

• Give priority to establishing primary environmental data files.

• Develop a relational geo-graphic information system (GIS) data base.

• Continue collaboration with national and international agencies to stimulate more agroecological analysis.

Renovation of the Physical Plant

In 1990, we began rehabilitating IRRIs aging physical plant with spe-cial funding from Germany and Ja-pan. Reniocleling of the Laboratory, Training, and Conference Center (LTCC building) has provided new facilities for the Agronomy, Plant Physiology and Agroecology Divi-sion. Remodeling of N. C. Brady Laboratory Annex has upgraded mo-lecular- biology laboratories Major renovation of the Service Building has made more efficient work space in the Agricultural Engineering Divi-sion.

We also rehabilitated the Ge netic Resources Center. Phytotron, information Center (including major renovation of the Library) and aging electrical power facilities, and Ito-proved fire safety and security, F. F. Hill Hall has been converted into new offices for administration

IRRI's infrastructure mci re-search facilities are ready to carry out the work of IRRIs medium-term plan for 1994-1998 and beyond.

Remodeling of the Laboratory, Training, and Conference Center (LTCC building) has provided new facilities for the Agronomy, Plant Physiology and Agroecology Division.

Kenzo Hemmi Laboratory

The new laboratory building was dedicated 9 April 1992 as *Kenro Hemmi Laboratory*. Hemmi Lab houses the offices and laboratories of the Soil and Water Sciences Division and the Analytical Services Laboratories. IRRI's collection, of biofertilizer germplasm is maintamed within the Soil and Water Sciences Division.

Increasing efficiency, reducing costs

IRRI now has 50 percent fewer intionally recruited staff positions than it had in 1989. We began with a special staff separation program in 1989. Vacant positions 1990-1992 were frozen,then cancelled. A second special separation program in eady 1993 completed the reduction.

An internal task force identified areas where costs could be reduced, efficiency improved, and operaflons streamlined. The recommendations included improving inventory control and. rationalizing equipment purchases. ■

1992 Financial Statements

The International Rice Research Institute
(A NONSTOCK, NONPROFIT ORGANIZATION)

FINANCIAL STATEMENTS
DECEMBER 31, 1992 AND 1991

Report of Independent Accountants

To the Board of Trustees of
The International Rice Research Institute
(A nonstock, nonprofit organization)

We have examined the statement of assets, liabilities and fund' balances of The International Rice Research Institute (a nonstock, nonprofit organization) as at December 31, 1992 and 1991, and the related statements of sources and applications of funds and of changes in financial position for the years then ended. Our examinations were made in accordance with generally accepted auditing standards and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

As explained more fully in Note 2, the Institute's financial statements are prepared on the basis of accounting practices prescribed for international agricultural research centers seeking assistance from the Consultative Group on International Agricultural Research. Such practices conform with generally accepted accounting principles, except in the manner of accounting for commitments as actual liabilities.

In our opinion, except for the effects on the financial statements of recognizing commitments as actual liabilities, as described in the second paragraph, the financial statements referred to above present fairly the assets, liabilities and fund balances of The International Rice Research Institute as at December 31, 1992 and 1991 and its sources and applications of funds and the changes in its financial position for the years then ended, in conformity with generally accepted accounting principles consistently applied.

Joaquin Cunanan & Co.
Makati, Metro Manila, Philippines
February 21, 1993

Statement of assets, liabilities and fund balances
December 31, 1992 and 1991

	1992	1991
ASSETS		
Current Assets		
Cash and short-term placements (Note 3)*	$36,362,464	$33,586,509
Accounts receivable - donors (Note 4)	5,976,747	7,244,122
Receivables from officers and employees	237,024	296,850
Advances to projects and other receivables	1,295,478	1,230,336
Inventory of materials and supplies	1,555,852	1,789,387
Prepaid expenses	180,677	214,419
Total current assets	45,608,242	44,361 ,623
Property and Equipment (Note 5)	50,297,877	43,285,178
Less: Accumulated depreciation	24,516,429	22,418,932
	25,781,448	20,866,246
	$71,389,690	$65,227,869
LIABILITIES AND FUND BALANCES		
Current Liabilities		
Accounts payable and accrued expenses (Note 6)	$13,911,387	$16,352,355
Grants applicable to succeeding periods (Note 7)	12,262,402	13,863,696
Other liabilities (Note 8)	1,150,470	683,534
Total cuarrent liabilities	27,324,259	30,899,585
Accounts Payable and Accrued Expenses (Note 6)	8,608,083	7,764,981
Other Liabilities (Note 8)	1,374,418	1,279,342
Capital Replacement Fund (Notes 2 and 3)	4,992,576	1,833,892
Fund Balances		
Invested in property and equipment (Notes 2 and 5)	25,781,448	20,866,246
Core operations (Notc 2)	19,906	(1,381,614)
Workicg capital	2,718,501	2,718,501
Self-sustaining operations	311,676	196,599
Communication and publications	524,698	463,772
	3,574,781	1,997,258
Cumulative translation adjustments	(265,875)	586,565
	29,090,354	23,450,069
	$71 ,389,690	$65,227,869

*(See accompanying notes to financial statements)

Statement of sources and applications of funds
December 31, 1992 and 1991

	1992	1991
Sources of Funds		
Core operations:		
Grants	$28,873,247	$25,984,979
Earned income	1,304,823	1,729,086
Foreign-currency transaction adjustments	12,122	2,281
Balance - previous year	(1,381,614)	-
	28,808,578	27,716,346
Capital - transfer from core operations	819,048	3,963,277
Working capital:		
Balance - previous year	2,718,501	2,718,501
Complementary projects - Grants	12,890,106	8,293,172
Self-sustaining operations:		
Revenue	1,105,674	939,125
Balance - previous year	196,599	428,769
	1,302,273	1,367,894
Communication and publications:		
Revenue	180,983	262,030
Balance - previous year	463,772	416,012
	644,755	678,042
Cumulative translation adjustments	(852,440)	(94,489)
	$46,330,821	$44,642,743
Applications of Funds		
Core operations	$30,414,932	$30,385,921
Overhead recovery	(1,626,260)	(1,287,961)
Capital	819,048	3,963,277
Complementary projects	12,890,106	8,293,172
Self-sustaining operations	990,597	1,171,295
Communication and publications	120,057	214,270
	43,608,480	42,739,974
Fund Balances		
Core operations	19,906	(1,381,614)
Working capital	2,718,501	2,718,501
Self-sustaining operations	311,676	196,599
Communication and publications	524,698	463,772
	3,574,781	1,997,258
Cumulative translation adjustments	(852,440)	(94,489)
	2,722,341	1,902,769
	$46,330,821	$44,642,743

STATEMENT OF CHANCES IN FNANCIAL POSITION DECEMBER 31, 1992 AND 1991

	1992	1991
SOURCES OF FUNDS		
Excess of revenue over expenses (expenses ova revenue)		
Core operations and self-sustaining activities	$725,083	($1,660,513)
Add (deduct) items not affecting cash during the year:		
Depreciation of property and equipment	2,611,935	1,833,892
Translation adjustments	852,440	94,489
Gain on disposal of property and equipment	-	(13,670)
	4,189,458	254,198
Disposals and write-off of property and equipment	3,602,038	4,048,975
Decrease in:		
Accounts receivable-donors	1,267,375	-
Receivables from officers and employees	59,826	-
Advances to projects and other receivables	-	29,918
Inventory of materials and supplies	233,535	-
Prepaid expenses	33,742	95,703
Increase in:		
Short-term accounts payable and accrued expenses	-	4,493,806
Current portion of other liabilities	466,936	273,683
Long-term portion of other liabilities	95,076	-
Grants applicable to succeeding periods	-	6,957,778
Long-term accounts payable and accrued expenses	843,102	549,147
Capital replacement fund	3,158,684	1,833,892
Funds invested in property and equipment	4,915,202	-
TOTAL SOURCES OF FUNDS	18,864,974	18,537,100
APPLICATION OF FUNDS		
Acquisitions/adjustments of property and equipment	11,129,175	4,895,642
Increase in:		
Accounts receivable-donors	-	3,446,229'
Receivables from officers and employees	-	151,241
Advances to projects and other receivables	65,142	-
Inventory of materials and supplies	-	244,752
Decrease in:		
Short-term accounts payable and accrued expenses	2,440,908	-
Grants applicable to succeeding periods	1,601,294	-
Long-term portion of other liabilities	-	48,098
Cumulative translation adjustments	852,440	94,489
Funds invested in property and equipment	-	973,555
Payment of loan payable	-	2,200,000
TOTAL APPLICATJON OF FUNDS	16,089,019	12,054,0%
INCREASE IN FUNDS	2,775,955	6,483,094
CASH AND SHORT-TERM PLACEMENTS		
January 21	33,586,509	27,103,415
December 31	$36,362,464	$33,586,509

Notes To Financial Statements December 31,1992 and 1991

1. General

The International Rice Research Institute (Institute) was established in 1960 to undertake basic research on the rice plant and applied research on all phases of rice production management, distribution and utilization with the objective of attaining nutritive and economic advantage or benefit for the people of Asia and other major rice-growing areas.

As a nonstock, nonprofit organization under Republic Act No. 2707 and an International organization under Presidential Decree No. 1620, the Institute was conferred the status of an international organization in the Philippines snd was granted among other privileges and prerogatives, the following tax exemptions:

a) exemption from the payment of gift, franchise specific, percentage, real property, exchange, import, export, documentary stamp, value-added and all other taxes provided under existing laws or ordinances. This exemption extends to goods imported and owned by the Institute to be leased or used by its staff;

b) exemption from payment of gift tax; all gifts, contributions and donations to the Institute are considered allowable deductions for purposes of determining the income tax of the donor; and

c) exemption from payment of income tax of non-Filipino citizens serving on the Institute's technical and scientific staff on salaries and stipends in United States dollars (US$) received solely from, and by reason at, service rendered to the Institute.

The Institute receives support from various donor agencies and entities primarily through the Consultative Group on International Agricultural Research (CGIAR. CGIAR is a group of donors composed of governments of various nations and international organizations and foundations.

2. Basis of financial statements presentation and significant accounting policies

The accompanying financial statements, expressed in US$, are prepared on the basis of accounting practices prescribed for international agricultural research centers seeking assistance from the CGIAR. The CGIAR - prescribed accounting practices conform with generally accepted accounting principles, except in the manner of accounting for commitments.

A summary of the Institute's significant accounting practices is set forth to facilitate the understanding of data presented in the financial statements.

Foreign currency transactions - The financial statements of the Institute are stated in US$. Philippine peso and other foreign currency-denominated transactions are translated to US$ for reporting purposes at standard bookkeeping rates which approximate the exchange rates prevailing at the dates of the transaction. Exchange differences resulting from the settlement of foreign currency-denominated obligations at rates which are different from which they were originally booked are credited/charged to operations. Exchange differences resulting from the translation of balances of foreign currency-denominated accounts are carried in the "Cumulative Translation Adjustments" account.

Revenue - Revenue from unrestricted core grants are pledged on an annual basis and are recognized in the accounts when there is probability of collection in the year the grant is pledged. These are utilized to fund core programs and the regular operating requirements of the Institute.

Restricted core grants and grants for complementary projects are recognized as income when funds are committed or received from the donors to the extent of expenses actually incurred. Disbursements from these sources are limited by conditions embodied in agreements with donor organizations.

Grants are identified with specific periods and are taken up in the financial statements without regard to the date on which these are actually received. Excess of grants received over expenses is shown as “Grants Applicable to Succeeding Periods, a liability account in the Statement of Assets, Liabilities and Fund Balances.

Expenditures and commitments - Liabilities for purchases of goods and services are taken up in the accounts as incurred and/or as obligated without regard to the actual timing of payment. Obligated expenditures1 also calied con’iniitments, are those which are contracted and/or committed for goods or services to be received or performed at a future date.

As of December 31, 1992 and 1991, goods and services not yet received but treated as expenses and accounts payable amounted to $10,939,644 and $11,669,660, respectively.

Inventory of materials and supplies - Inventory of materials and supplies is stated at cost using the moving average method. Materials in transit are stated at invoice cost.

Property and equipment - Property and equipment acquired prior to 1991 are carried at cost or estimated value. Acquisitions starting 1991 are stated at cost and are acquired through a capital grant or grant designated by the Institute or donor for the purpose. Depreciation is computed on the straight-line method over the estimated useful lives of the related assets. Replacement and renovation of assets and property are financed through funded reserves equivalent to the accumulated depreciation charged annually to operating expenses.

3. Cash and short-term placements

Cash and short-term placements at December 31 consist of

	1992	1991
Unrestricted	$5,748,723	$ 3,726,376
Restricted	30,613,741	29,860,133
	$36,362,464	$33,586,509

The restricted cash balance includes $4,992,576 and $452,278 as of December 31, 1992 and 1991, respectively, which represents fund set aside for replacements of or improvements on property and equipment.

4. Accounts receivable - donors

Accounts receivable from donors consist of unreleased balances of approved grants at December 31 and are classified as follows:

	1992	1991
Core grants		
Unrestricted	$3,095,390	$3,272,162
Restricted	200,000	1,276,704
Complementary project grants	2,681,357	2,695,256
	$5,976,747	$7,244,122

The Secretariat of CGIAR assists the Institute in following up the release of core grants by donors. Substantially all of the receivables from core grant donors at balance sheet date have been obligated for expenditures.

5. Property and equipment; leases

Property and eqpipment at December 31 are classified under the folAowing accounts:

	1992	1991
Cost		
Research center:		
Buildings and improvements	$23,957,605	$20,274,416
Site development	324,665	266,581
Research, machinery and equipment	15,415,790	12,631,451
TransportMica equipment	5,129,425	4,919,074
Furnijzare and fixtures	1,022,533	903,104
Library items	437,369	437,369
Assets-hi-transit	775,035	-
Construction in progress and other projects	3,235,455	3,853,183
	50,297,877	$43,285,178
Less: Accumulated Depreciation		
Research center:		
Buildings aad improvements	9,929,774	9,346,003
Site development	96,850	43,534
Research, machinery and equipment	9,898,943	8,896,708
Tranqiertation equipment	3,984,606	3,623,369
Furniture and fixtures	606,256	509,318
	24,516,429	22,418,932
	$25,781,448	$20,866,246

The land used as sitg for research activities is leased for a period of 25 years up to year 2000 from the University of the Philippines for a nominal rent and is renewable upon mutual agreement of the parties. Pursuant to the tvtexnorandurn of Understanding between the Government of the Rdpublic of the Philippines and the Institute, all the physical plant, equipment and other assets bekmging to the Institute shall become the property of the University when the Institutes operations are terminated.

In support of any expansion of the agricultural research program “of the Institute and .the University, the Philippine Government authorized the University to acquire by negotiated sale or by expropriation certain private agricultural property under Presidential Decree No. 457.

The Institute also leases land and other property from third parties for project experimestal sites for periods ranging from one to five years.

6. Accounts payable and accrued expenses

The short-term and long-term accounts payable and accrued expenses consist &outstanding commitments and accrued liabilities at December 31 as follows:

	1992	1991
Outstanding jomznitxnents for core and cApital operations	$14,835,090	$18,463,165
Outstanding commitments for complementary projects	2,975,350	1,061,768
Accrued expenses	4,709,030	4,592,403
	22,519,470	24,117,336
Less: Short-term liabilities	13,911,387	16,352,355
Long-term liabilities	$8,608,083	$7,764,981

Accruals of unused sick and vacation leaves represent about 81% and 73% of the accrued expenses in 1992 and 1991, respectively.

7. Grants applicable to succeeding periods

Grants applicable to succeeding periods at December 31 consist of grants received iii advance for the following:

	1992	1991
Unrestricted core	$ 2,000,000	$ -
Restricted projects	3,016,569	3,037,475
Complementary projects	7,245,833	10,826,221
	$12,262,402	$13,863,696

8. Other liabilities

The current and long-term other liabilities substantially represent reserves for estimated expenditures to be incurred for trainees participating in various programs. The estimated expenditures cover postdoctoral scholars, research fellows and trainees stipends, board and lodging, other direct expenses and reimbursable overhead costs to be incurred by the Institute. Funding for these reserves is derived from charges against grants for trainees, including special projects.

9. Staff benefit plan

The Institute maintains a noncontributory provident fund for the benefit of its Nationally Recruited Staff. Monthly contribution to the fund is computed at 10.5% of the employees' basic salary. The plan provides for lump-sum payment in Philippine peso to qualified employees/members, upon their separation from the Institute, under certain conditions.

Contributions to the fund amounted to $555,730 in 1992(1991 - $546,437).

10. Reclassification of accounts

Certain accounts in the 1991 financial statements were redassified to conform with the 1992 financial statements presentation.

Schedule of sources and applications of core operations, capital, working capital and complementary proj ects funds

December 31, 1992 and 1991

	1992	1991
Sources of funds		
Core grain and earned income:		
Unrestricted:		
Government of japan	$ 6,727,545	$ 6,357,391
United States Agency for International Development	5,400,000	5,400,000
International Bank for Reconstruction and Development	2,500,000	2,887,000
European Economic Community	2,289,121	2,313,265
Overseas Development Administration - United Kingdom	1,553,760	1,555,016
Canadian International Development Agency	1,383,648	1,576,942
Swedish Agency for Research Cooperation	856,516	805,143
BMZ, Germany	837,037	710,430
Danish International Development Agency	784,025	573,466
Government of Australia	645,915	665,890
Government of Korea	200,000	200,000
Government of Finland	193,367	555,546
Government of Belgium	150,000	150,376
The Ford Foundation	150,000	150,000
Government of the Philippines	123,000	121,960
Government of Norway	121,560	103,339
Government of India	100,000	100,000
Peoplets Republic of China	80,000	50,000
Government of Italy	68,900	80,199
Government of Spain	30,000	30,000
Earned income	1,304,823	1,729,086
Stabilization mechanism fund - inflation! foreign exchange adjustments	-	630,000
Foreign-currency transaction adjustments	12,122	2,281
	25,511,339	26,747,330
Restricted:		
United Nations Development Programme	1,562,750	1,910,634
The Rockefeller Foundation	451,134	280,554
Government of Netherlands	269,476	163,124
Government of France	239,102	255,931
Government of Italy	200,000	200,000
Government of Korea	30,000	30,000
The Ford Foundation	-	62,000
The Swiss Development Cooperation	305,606	22A17
Balance of grants - previous year	1,308,966	2,224,196
	4,367,034	5,148,856
Transfer to complementary projects	-	(400,000)
Grants applicable to succeeding periods	(1,415,776)	(1,308,966)
	2,951,258	3,439,890
Fund balance - previous year	(1,381,614)	-
	27,080,983	30,187,220
Transfer to capital fund	(598,491)	(3,860,969)
Transfer from current operations	1,381,614	-

	1992	1991
Restricted (essential) projects:		
Government of Japan	556,712	924,491
Asian Development Bank	421,744	258,059
Government of Belgium	74,509	166,242
The Ford Foundation	-	200,000
The Rockefeller Foundation	-	59,929
Government of Australia	-	41,861
United States Agency for International Development	-	26,737
	1,052,965	1,677,319
Balance of rants - previous year	1,728,509	556,502
	2,781,474	2,233,821
Grants applicable to succeeding periods	(1,600,793)	(1,728,509)
Transfer from (to) complementary projects	(15,652)	810,440
Transfer to capital fund	(220,557)	(102,308)
	944,472	1,213,444
	28,808,578	27,539,695
Capital fund - transfer from core operations	598,491	3,860,969
- transfer from essential projects	220,557	102,308
	819,048	3.963.277
Working capital fund balance - previous year	2,718,501	2,718,501
Complementary grants:		
United States Agency for International Development	2,230,433	2,615,443
Government of Australia	1,472,052	904,529
United States Environmental Protection Agency	1,052,259	933,642
BMZ/GTZ	947,157	6,793,015
The Rockefeller Foundation	916,581	402,023
The Swiss Development Cooperation	832,232	582,690
International Development Research Centre	557,326	613,422
Government of Netherlands	349,501	369,950
Overseas Development Administration - United Kingdom	295,687	152,723
Government of Sweden	204,446	-
Islamic Republic of Iran	128,000	-
United Nations Development Programme	66,540	-
Government of Korea	55,058	117,839
Asian Development Bank	52,875	1,500,840
Government of Japan	38,200	78,400
Government of Denmark	35,010	58,200
Government of Belgium	34,274	120,315
The Ford Foundation	12,492	163,000
Food and Agriculture Organization	5,286	59,399
Canadian International Development Agency	-	173,882
Government of the Philippines	-	32,356
Others	17,657	32,490
	9,303,066	15,704,158
Balance of grants - previous year	10,826,221	4,125,220
	20,129,287	19,829,378

	1992	1991
Transfer from restricted core operations	-	400,000
Transfer to (from) essential projects	15,652	(810,440)
Grants applicable to succeeding periods	(7,245,833)	(10,826,221)
Funds returned to donor	(9,000)	(122,894)
	12,890,106	8,469,823
	$45,236,233	$2,691,296
APPLICATIONS OV RJNDS		
Core operations		
Programs	$18,871,585	$20,802,369
General administration and operation	8,940,762	7,749,660
Depreciation expense	2,602,585	1,833,892
Overhead recovery	(1,626,260)	(1,287,961)
	28,788,672	29,097,960
Capital	819,048	3,963,277
Complementary projects	12,890,106	8,293,172
	42,497,826	41,354409
EXCESS OP SOURCES OVER APPLICATIONS (APRUCATLONS OVER SOURCE) OP FUNDS		
Core operations	19,906	(1,381,614)
Working capital	2,718,501	2,718,501
	$2,738,407	$1,336,887

IRRI trustees 1992

IRRI international staff 1992

KLAUS LAMPE, Ph D, *director general*
FERNANDO A. BERNARDO, Ph D, *deputy director general for international programs*
KENNETH S. FISCHER, Ph D, *deputy director genera/for research*
MICHAEL F. L GOON, MBA, *deputy director generalfor finance and administration*

ADMINISTRATIVE PERSONNEL
ERNEST W. NUNN, Ph D, *director, operations*
EDWARD N. SAYEGH, BBA, *director, finance*
BENITO S. VERGARA, Ph D, *director, administration, and pare-time liaison scientist Jbr China*
KWANCHAI A. GOMEZ, Ph D, *statistician and head, biometrics, and head, liaison, coordination and planning*
PEDRO G. BANZON, LLB, *manager security and safety*[2]
REBECCA C. PASCUAL, MS, *manager, food and housing services*
ORLANDO G. SANTOS, MPS, *senior farm and grounds superintendent*
JAMES J. MULLANEY, MBA, *consultant adviser*
DIOSCORO L. UMALI, Ph D, *consultant*

STAFF POSTED TO NATIONAL AGRICULTURAL RESEARCH SYSTEMS

Bangladesh
JERRY L. MCINTOSH, Ph D, *research systems specialist and IRRI representative*
NOEL P. MAGOR, M Agr, *consultant*[3]

Cambodia
HARRY J. NESBITT, Ph D, *agronomist and team leader*
RAM CHET CHAUNDHARY, Ph D, *plant breeder*
PETER FRANCIS WHITE, Ph D, *soil scientist*

Egypt
RICHARD L. TINSLEY, Ph D, *agronomist and team leader*
DERK HILLERISLAMBERS, Ph D., *plant breeder*
ADUSUMILLI NARAYANA RAG, Ph D, *agronomist (weed scientist)*

India
BRIJNANDAN GHILDYAL, Ph D, *liaison scientist*

Indoncsia/Malaysia/Brunei
CEZAR P. MAMARIL, Ph D, *agronomist and liaison scientist*
GENARO 0. SAN VALENTIN, Ph D, *agronomist*

Japan
TADASHI MORINAKA, Ph D, *liaison scientist*[1]
MASAMI HIMEDA, D Agr, *part-time liaison scientist*[2]

Lao PDR
JOHN M. SCHILLER, Ph D, *agronomist and team leader*
SUVIT PUSHPAVESA, MS, *plant breeder*
WALTER RODER, Ph D, *agronomist*

Madagascar
VETHAIYA BALASUBRAMANIAN, Ph D, *soil scientist and learn leader*
SUSAN W ALMY, Ph D, *agroeconomist*
MARTHA M. GAUDREAU, Ph D, *cropping systems agronomist*
TOMAS MASATO, Ph D, *plant breeder*

Myanmar
ROSENDO K. PALIS, Ph D, *farming systems agronomist and IRRI representative*

Thailand
DONALD W. PUCKRJDGE, Ph D, *agronomist and IRRI rep resentative, and program leader deepwater and tidal wetlands rice ecosystem research,*

Africa
KRISHNA ALLURI Ph D, *liaison scientist and INGER regional coordinator*

Latin America
FEDERICO F. CUEVAS-PEREZ, Ph D, *liaison scientist and INGER regional coordinator*

STAFF AT HEADQUARTERS

Agricultural engineering division
GRAEME R. QUICK, Ph D, *agricultural engineer and head*
TERENCE WOODHEAD, Ph D, *physicist and liaison scientist/rice-wheat coordinator*
JEFFREY J. HASTINGS, BS, *project leader*[2]
WESLEY BUCFIELE, Ph D, *visiting scientist*[2]
MATh BORU DOUTHWAITE, MS, *consultant*[1]
KENNETH R. JAMES, MS, *consultant*[3]
Y. SINGH, Ph D, *consultant*[1]

Agronomy, plant physiology and agroccology division
KENNETH (3. CASSMAN, Ph D, *agronomist and head*
SURAJIT K. DE DATTA, Ph D, *agronomist and program leader; rainfed lowland rice ecosystem research*[2]
DENNIS P. GARRifY, Ph D, *agronomist*[2]
KEITH T. INGRAM, Ph 1), *agronomist*
MARTIN V KROPFF, Ph D, *agronomist/crop modeler*
KEITH MOODY, Ph D, *agronomist*
TIMOTHY U SEYUER, Ph D, *plant physiologist*
MINORU YAMAUCHI, Ph D, *plant physlologist*
VIRENDRA PAL SINGH, Ph D, *associate agronomist*
ROBIN B. MATTHEWS, Ph D, *visiting scientist'*
SI-IAOBfNG PENG, Ph D , *visiting scientist*
UPENDPA SINGH, Ph D, *visiting scientist'*
DANiEL C. OLK, Ph D, *associate visiting Scientist*[1]
CHARLES .ASI-IURST, BS, *consultant*[3]
LISA BEAN, BS, *consultant*[3]
ABDULLAHI O. EGEH, Ph D, *consultant*[3]
RANK GREENWAY, Ph D, *consultant*[3]
JAMES W. JONES, Ph B, *consultant*[3]
PIERCE H.. JONES, Ph D, *consultant*[3]

H. H. VAN LAAR, BS, *consultant*[1]
CURTIS WELDON, BS, *consultant*[3]
MARCO WOPEREIS, MS, *consultant*[1]

Entomology division
DALE G. BOYL'RELL, Ph D, *entomologist and bead*
KONG LUEN HEONG, Ph D, *entomologist*
JAMES A. LITSINGFR, Ph D, *entomologist*[2]
LUIS REY L VELASCO, Ph 1), *visiting scientist*[1]
KENNETH SCJ-IOENLY, Ph D, *associate visiting scientist3*
ROBERT BOS, Ph D, *consultant2*
MICI-IAEL J. WAY, Ph D, *consultant3*

Plant breeding, genetics and biochemistry division
GURDEV S. .KHUSH, Ph D, *principal plant breeder and bead*
JHON BENNET, Ph D, *senior molecular biologist*[1]
NING HUANG, Ph D, *plant molecular geneticist'*
RYGICHI IKEDA, Ph D, *plant breeder*
BIENVENIDO O. JULIANO, Ph D, *chemist*[4]
SURAPONG SARKARUNG, Ph D, *plant breeder*
DHARMAWANSA SENADHIPA, Ph D, *plant breeder*
SANT S. VIffiVIANI, Ph D, *plant breeder*
FRANCISCO JAVIER ZAPATA, Ph D, *tissue culture specialist*
DARSHAN S. BRAR, Ph D, *associate plant breeder*
SUSAN R. MCCOUCH, Ph D, *associate geneticist*
MICHEL A. ARRAUDEAU, MS, *visiting scientist and program leader, upland rice ecosystem research*
MOO SANG LIM, Ph D, *visiting scientist*
GERARD SECOND, Ph .D, *visiting scietntist*
N. PANDA, Ph ID, *consultant*[2]
CHUANYIN WV, Ph D, *consultant*[3]

Plant pathology division
TWNG WAH MEW, Ph D, *plant pathologist and head*
HIROKI KOG.A.NAZAWA, Ph D, *plant pathologist*
PAUL & TENG, Ph D, *plant pathologist and program leader, cross-ecosystems research*
ROBERT S. ZEIGLER, Ph D, *plant pathologist and program leader, rainfed lowland rice ecosystem research*[1]
REBECC.A NELSON, Ph D, *associate plant pathologist*
EVANGELYN C. ALOCILJA, Ph D, *visiting scientist*[2]
CHRISTOPHER C. MUNDT, Ph D, *visiting scientist'*
JEAN-CLAUDE PROT, Ph D, *visiting scientist*
SERGE SAVARY, Ph D, *visiting scientist*
ALAN K. WATSON, Ph D, *visiting scientist*

Social sciences division
MAHABUB HOSSAIN, Ph D, *agricultural economist and head'*
CRISTINA C. DAVID, Ph D, *agricultural economist and acting head*[2]
JAMES SAMUEL FUJISAKA, Ph D, *social scientist*
PRABHU L PINGALI, Ph D, *agricultural economist and program leader irrigated rice ecosystem research*
ELEANOR H. HUKE, BFA, *visiting scientist*[3]
ROBERT K HUKE, Ph D, *visiting scientist*[3]
SARAH J. TISCH, Ph D, visiting scientist[1]
MUBARIK ALl, Ph D, *associate visiting scientist*
ELEAZER 0. HUNT, Ph D, *associate visiting scientist*

Soil and water sciences division
HEINZ-ULRICH NEUE, Ph D, *soil chemist and head*
SADIQUL L BHUIYAN, Ph D, *agricultural engineer*
GUY JOSEPH DUNN KIRK, Ph D, *soil chemist*
JAGDISH K. IADHA, Ph D, *soil microbiologist*
TO PHUC TUONG, Ph D, *water management engineer*
MICHAEL J. HEDLEY, Ph D, *visiting scientist*[3]
KEVIN BRONSON, Ph D, *associate visiting scientist*[1]

Genetic resources center
MICHAEL T. JACKSON, Ph D, *head*
SANG-WON AHN, Ph D, *plant pathologist (INGER)*
V SESHU DURVASULA, Ph D, *plant breeder and global coordinator, International Network for Genetic Evaluation of Rice* (INGER)
DUNCAN A. VAUGHAN, Ph D, *associate geneticist*
ROBERT EVENSON, Ph D, *consultant*[3]
DOUGLAS GOLLIN, Ph D, *consultant*[3]

Information center
THEODORE HUTCHCROFT, Ph D, *visiting scientist and acting head*[1]
CAROLYN DEDOLPH, MS, *science editor and writer*
M. LARUE POLLARD, Ph B, *editor*
MARINUS CORNELIS VAN DEN BERG, BS, *head, computer services*
LINA M. VERGARA, MS, *librarian*[2]
GEORGE T. BRANOSBERO, MS, *visiting scientist3*
LESLIE ROSE, MS, *visiting scientist*
DEEANNA ADKINS, *editorial associate*[2]
CRISPIN C. MASLOG, Ph B, *consultant*[1]
WALTER ROCKWOOD, MS, *consultant*[1]
WILLIAM H. SMITH, BS, *consultant'*

International programs management office
GLENN L. DENNING, Ph D, *scientist-international collaboration and head*
ROMEO C. BRUCE, Ph .D, *consultant*[2]
BIBIANO Ad. RAMOS, MS, *consultant*[2]

Network coordination
ERNESTO L. AVAGON, Ph B, *associate agronomist and coordinator; International Network on Soil Fertility and Sustainable Rice Farming (INSURF)*
VIRCILIO R CARANGAL, Ph D, *agronomist and coordinator, Asian Rice Farming Systems Network (ARFSN)*
HARDJOSUBROTO SUBAGJO, Ph D, *consultant*[3]

Training center
ELLIS L. MATHENY. JR., Ph D, *head*
ROBERT T. RAAB, Ph D. *training and courseware specialist*

---

[1]Joined during the year
[2]Left during the year
[3]Joined and left during the year
[4]On study leave
[5]Diecl during the year
[6]TransfeJTed. from Agronomy, plant physiology and agroecology division
[7]Promoted

Consultative Group on International Agricultural Research (CGIAR)

The CGIAR is a worldwide network of research centers supported by an international donor group. IRRI is part of this global system. Through research and education, the CGIAR helps make farming in developing countries more productive—the first stepping stone out of poverty. For farmers and the rural poor, increased agricultural production leads to better nutrition, higher incomes and improved standards of living. Increased and more stable production of food staples also leads to lower prices, which allow poor people in the cities to satisfy more of their food needs.

Some 2,000 scientists representing 60 different nationalities conduct research at CGIAR centers and in collaboration with national program scientists in some 40 developing countries.

Mission of the CGIAR

Through international research and related activities, and in partnership with mational research syatems, to coetribution to sustainable improvements in the productivity of agriculture, forestry and fisheries in developing countries in ways that enbance nutrition and well-being, especially among low-income people.

CIAT-Centro Internacional de Agricultura Tropical. with headquarters in Colombia. Focus on gerrnplasm development in beans, cassava, tropical forages and rice for Latin America, and On resource management in humid ecosystems in tropical America (hillsides, forest margins and savannas).

CIFOR-Center for International Forestry Research, with headquarters in Indonesia. Focus on conserving and improving the productivity of tropical forest ecosystems.

CIMMYT-Centro Internacional de Majoramiento de Maiz y Trigo, with headquarters in Mexico. Focus on increasing the productivity of resources committed to maize, wheat and triticale in developing countries.

CIP-Centro Internacional de la Papa. with headquarters in Peru. Focus on potato and sweet potato improvement, and on natural resource conservation in the Andean region.

IBPGR-Intemational Board for Plant Genetic Resources, with headquarters in Italy. Focus on conserving gene pools of current and potential crops and forages.

ICARDA-International Center for Agricultural Research in the Dry Areas, with headquarters in Syria. Focus on increasing the productivity of farming systems involving wheat, barley, chickpea, lentils, pasture legumes and small ruminants in North Africa and West Asia.

ICLARM-International Center for Living Aquatic Resources Management, with headquarters in the Philippines. Focus on improving production and management of aquatic resources in developing countries.

ICRAF-International Council for Research in Agroforestry, with headquarters in Kenya. Focus on mitigating tropical deforestation, land depletion and rural poverty through improved agroforestry systems.

ICRISAT—International Crops Research Institute for the Semi-Arid Tropics, with headquarters in India. Focus on contributing to more sustainable agricultural production systems through improved productivity of sorghum, millet, chickpea, pigeonpea and groundnut.

IFPRI—International Food Policy Research Institute, with headquarters in the United States. Focus on identifying and analyzing policies for meeting the food needs of developing countries, in particular the poorer countries.

IIMI—International Irrigation Management Institute, with headquarters in Sri Lanka. Focus on strengthening the development, dissemination and adoption of lasting improvements in the performance of irrigated agriculture in developing countries.

IITA—International Institute of Tropical Agriculture, with headquarters in Nigeria. Focus on

ICRISAT—International Crops Research Institute for the Semi-Arid Tropics, with headquarters in India. Focus on contributing to more sustainable agricultural production systems through improved productivity of sorghum, millet, chickpea, pigeonpea and groundnut.

IFPRI—International Food Policy Research Institute, with headquarters in the United States. Focus on identifying and analyzing policies for meeting the food needs of developing countries, in particular the poorer countries.

IIMI—International Irrigation Management Institute, with headquarters in Sri Lanka. Focus on strengthening the development, dissemination and adoption of lasting improvements in the performance of irrigated agriculture in developing countries.

IITA—International Institute of Tropical Agriculture, with headquarters in Nigeria. Focus on

and stability of banana and plantain grown on small farms in developing countrie&

IRRI—International Rice Research institute, with headquarters in the Philippines. Focus on generating and disseminating rice-related knowledge and technology of long-term environ-mental, social and economic benefit.

ISNAR—International Service for National Agricultural Research, with headquarters in the Netherlands. Focus on institutional development and strengthening of national agricultural research systems.

WARDA—West Africa Rice Development Association, with headquarters in Cote d'Ivoire. Focus on improving rice varieties and production methods among smallholder farm families in the upland/inland-swamp continuum, the Sahel and mangrove swamp environments.

Philippines, M. Cairns

Credits

WRITER/EDITOR
LaRue Pollard
GRAPHIC DESIGNER
Ramiro Cabrera

TYPESETTING
Erlie Putungan

PHOTOS
Cover: IRRI photo file; R. Cabrera
backcover: IRRI photo file; S. Fujisaka
flyleaf: R. Cabrera
p14: @1993 Nevada Wier

The International Rice Research Institue (IRRI) was establish in 1960 by the Ford and Rockefeller Foundations with the help and approval of the Government of the Philippines.Today IRRI is one of 18 nonprofit international research centers supported by the Consultative Group on International Agricultural Research (CGIAR).The CGIAR is sponsored by the Food Agriculture Organization of the United Nations (FAO),the International Bank for Reconstruction and Development (World Bank),and the United Nations Development Programme (UNDP).Its member –ship comprises donor countries ,international nad regional organizations, and private foundations.

IRRI receives support through the CGIAR from a number of donors including FAO,UNDP,World Bank, European Economic Community,Asian Development Bank,Rockefellr Foundation,Ford Foundation, and the international aid agencies of the following governments: Australia, Belgium, Canada, People's Republic ofChina,Finland,France, Germany, India, Islamic Republic of Iran,Italy ,Japan,Republic of Korea ,the Netherlands, Norway Philippines ,Spain Sweden ,United kingdom, and United States

The responsibility for this publication rests with the International Rice Research Institute.

International Rice Research Institute
P.O. Box. 933 1099 Manila Philippines
Fax:(63-2) 818-2087,522-4240
Electronic mail: %IN" Postmaster @ IRRI.CGNET.COM"
Telex: (ITT) 40890 RICE PM
(CWI) 14519 IRILB PS
(RCA) 22456 IRI PH
(CWI) 14861 IRI PS

1993
ISBN 971-22-0044-2
International Rice Research Institute
P. O. Box 933, 1099 Manila, Philippines