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BEYOND IR8 IRRI's second decade

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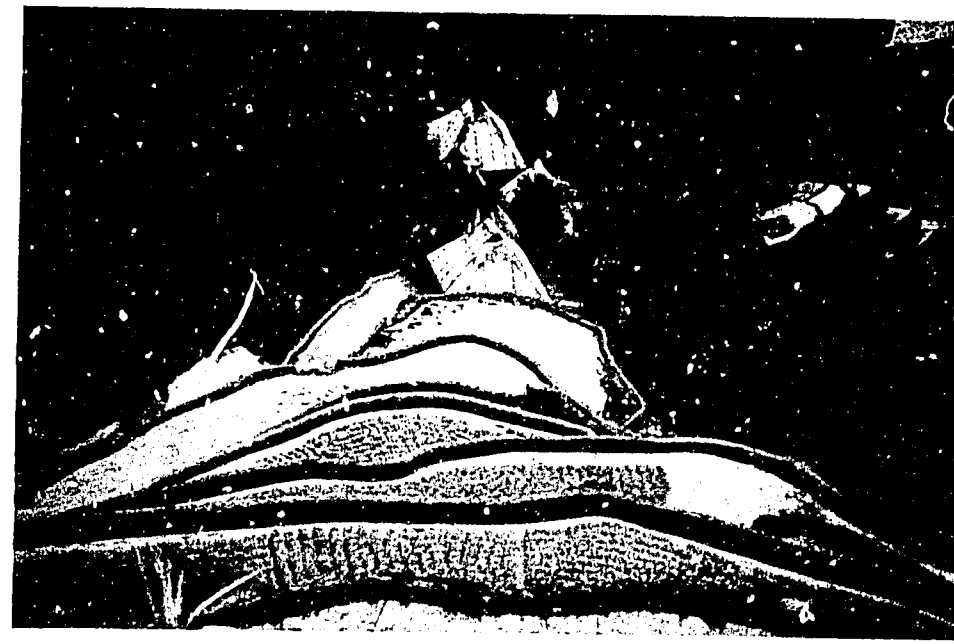
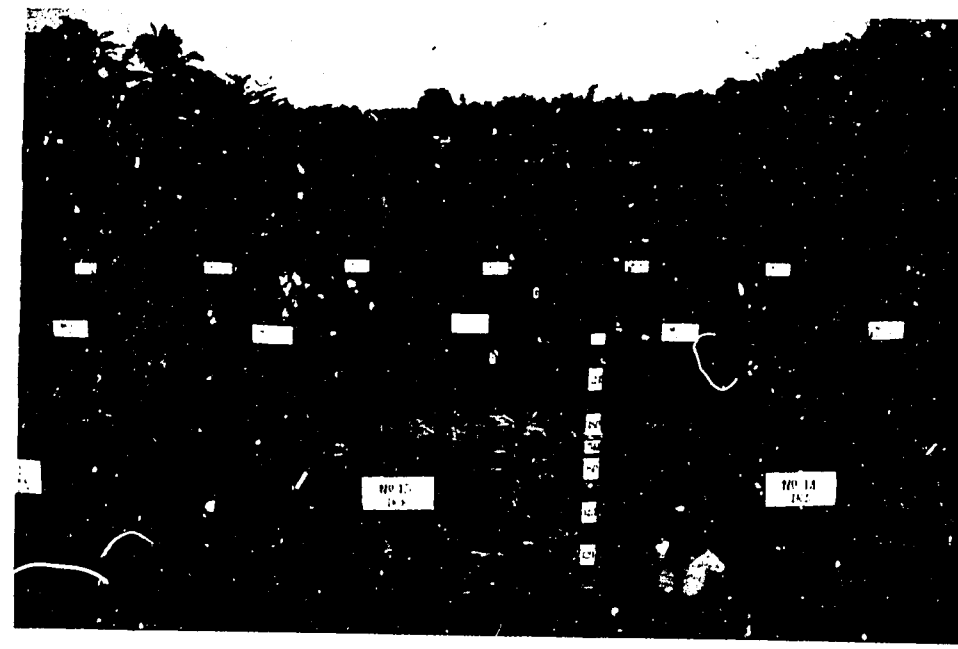
April 1980

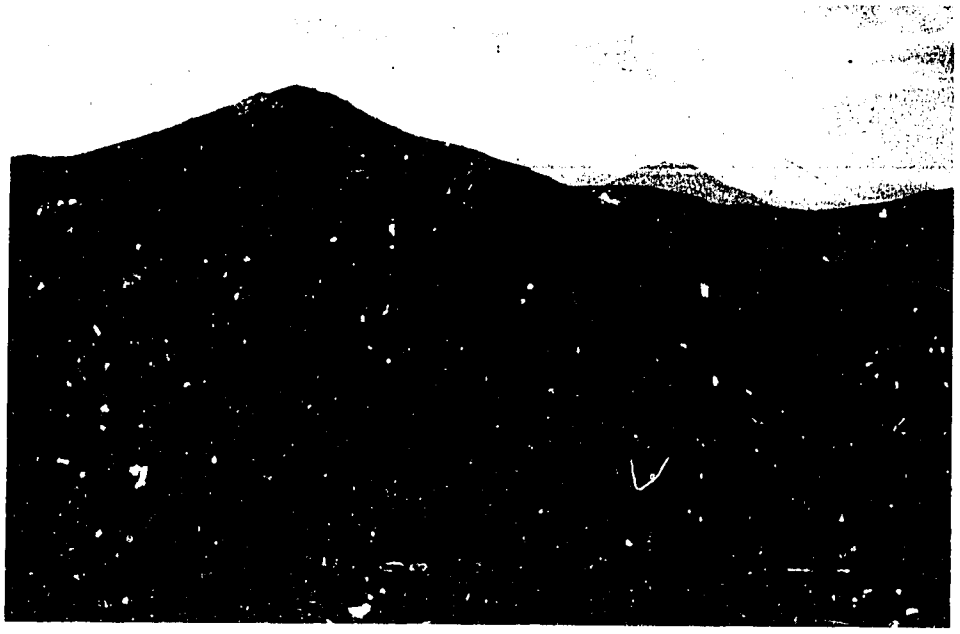
BEYOND IR8

IRRI's second decade

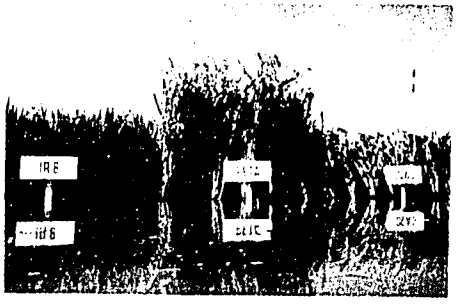




Modern rice performed best for the farmer who had irrigation. IRRI second-decade research broadened its focus to give more attention to farmers who depend on rainfall for their crop.



IRRI breeders made 37 crosses in 1962. The eighth cross used Peta, a tall traditional variety from Indonesia, and Dee-geo-woo-gen, a semidwarf variety from Taiwan. IR8 came from that cross.



Traditional rices like this one were replaced by IR8 in many Asian farmers' fields. These old rices lodged and gave low yields, but some had characteristics that scientists later bred into modern rices.

"IR8 was to tropical rices what the Model T Ford was to automobiles . . . a rugged variety that could go almost anywhere."

The research facilities at Los Baños expanded rapidly during the second decade.

On 28 November 1966 IRRI released IR8, a rice variety that revolutionized food production in the tropics. It was characterized by short stature, stiff straw, high number of tillers, and erect leaves. When properly fertilized it produced yields double — even triple — those of native tropical varieties. IR8's enthusiastic acceptance by farmers all over the world inspired such terms as *miracle rice* and *green revolution*.

IR8 and its companion modern rices that soon moved from national rice research stations to farmers' fields had great potential to increase rice yields. And that potential was realized in areas where rice farmers had good irrigation and used adequate fertilizers, and where pest damage was low. For example, yields increased sharply in the Punjab in India and Pakistan, and in Cuba, Colombia, and the Philippines where the new rices — IR8 and its immediate sister varieties — were widely adopted.

IR8 had great impact on national rice improvement programs. By the early 1970s, farmers in many countries were planting locally developed semidwarfs. IRRI material, mostly progeny of IR8 or other early IRRI rices, provided the genetic building blocks for many of those local semidwarfs.

But the worldwide impact of the new varieties was less than expected. More than three-fourths of the world's rice farmers still have not adopted the new rices. And even where the adoption was high, the increase in farmers' yields and the national production levels generally were only modest, leading some to suggest that the green revolution had never materialized.

Why is it that some farmers did not adopt the new rices? Was it because of backwardness? Lack of cash? Some cultural barrier?

Reasons such as these account for the failure of many farmers to adopt IR8-type rices. But one overriding factor was that the new rices did not fit most rice-growing situations. IR8 and its companion varieties best fitted the needs of farmers who had irrigation. But most of the world's rice farmers depend on rainfall and when the rains start late or are too light — or stop for several days in midseason — yields drop sharply. In addition, the new rices were no more resistant than the traditional rices to the wide array of insects and diseases that attacked the crop. In fact, the new varieties' profuse tillering and dense foliage sometimes made them more attractive to the rice pests.

IRRI reorganization put the rice farmer in sharper focus and complemented the focus on the rice plant during the IR8 decade.

There were other reasons farmers did not adopt the new varieties. Some areas, even with adequate water for a rice crop, were at a high elevation where cold air or cold water, or both, stunted or killed the new rices. For other rices, temperature posed an opposite problem when high air temperature damaged the rice flowers and kept the plants from forming grains.

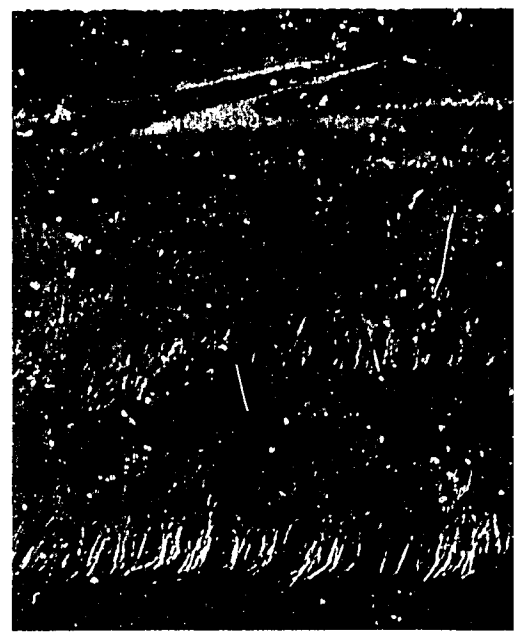
And in vast areas with potential for rice production the soils lacked necessary elements, or contained toxic ones that adversely affected the rice plant — especially the new varieties.

With these conditions — some faced daily by three out of four of the world's rice farmers — many did not choose to shift to the new rice technology. Even if they had the money to buy the fertilizers and pesticides that boosted yields for IR8, they would not risk a crop loss from other causes. They stayed with their low-yielding but low-risk traditional rices.

Thus, IRRI entered the second decade after the release of IR8, with an expansion in core research at Los Baños and cooperative work with national rice research programs to include emphasis on the needs of the farmers who were not able to use the IR8-inspired technology.

The reorganization put the *rice farmers* in sharper focus, and complemented the focus on the *rice plant* during the IR8 decade. At the same time IRRI work was increasingly integrated with that of counterparts in national rice improvement programs. Research networks were created so that IRRI became a catalyst and coordinator for rice research, and less of an independent operator.

To establish research on the diverse problems faced by farmers not able to use the technology of the IR8 era -- rainfed fields in danger of floods or drought, soils that damage and weaken rice plants, high or low temperature — IRRI established a Genetic Evaluation and Utilization (GEU) program to develop rices for a broad variety of growing conditions. The GEU approach allowed scientists from many disciplines to focus on improvement of the rice plant. IRRI GEU scientists worked closely with scientists in national rice programs in Asia, Africa, and Central and South America to jointly develop and evaluate improved rices and technology for all rice-growing areas. Around the world, plant breeders and problem-area scientists — agronomists, pathologists, entomologists, physiologists, and soil and cereal chemists — started to work together in GEU teams.



Even though the crop looks good from a distance, salinity may keep the rice yield in the fields (top) far below what it could be with a salt-tolerant variety. The field in the bottom photo typifies problems still faced by rice farmers – rainfed fields, lodging of the tall traditional varieties that still do best in many areas, possible drought, and even crop damage by low temperatures.

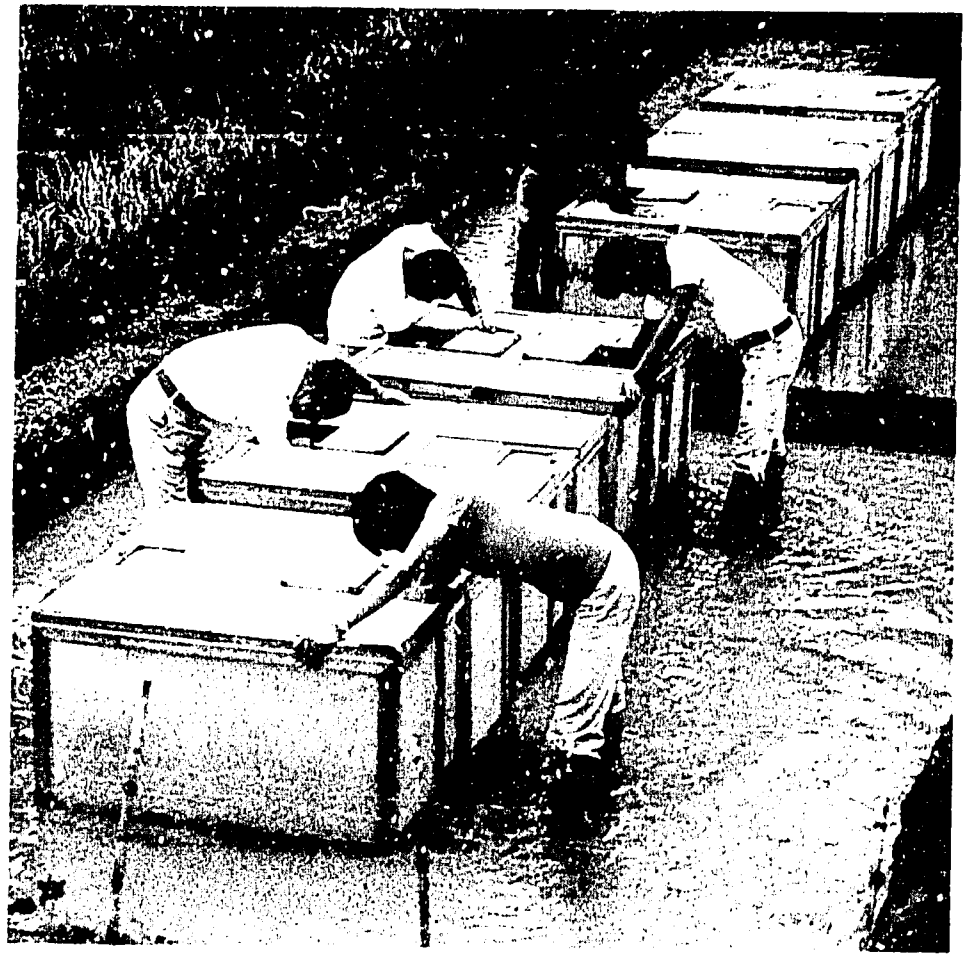
IRRI research in the second decade has focused on farmers who could not take advantage of the IR8-type rices.

During the monsoon season, rice farmers on millions of hectares regularly face floodwaters too deep for the modern rices. IRRI GEU teams work closely with scientists in Bangladesh, India, and Thailand to develop new rices for deepwater farmers.

This rice crop in an upland area in Asia under severe the problems the farmer who grows rice as a dryland crop might face anywhere — low fertility, adverse soil conditions, drought, and weeds. New rices of the modern rices fit such farmland.

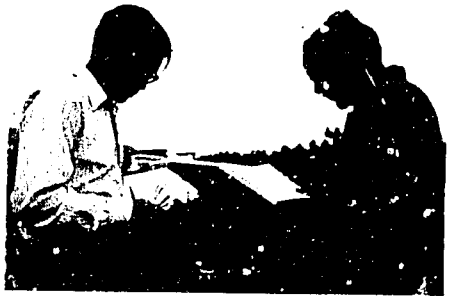
The modern varieties grown in rainfed fields such as these produce well during years of high and normal rainfall. But with average or below average rainfall, rices with drought resistance are required.

The planthoppers remain as destroyers of rice plants and spreaders of rice diseases.



IRRI scientists rear millions of insects, use them to artificially infest hundreds of thousands of seedlings in field cages such as these, and measure the resistance of the rice plant both to the insects and to the diseases they spread

Our GEU effort has produced rices that withstand the combined attacks of the most troublesome diseases and insects.



Computers can print the fieldbook and analyze the data, but there is no substitute for the eyes of the scientist in the field.

Members of the GEU teams stand in IRRI plots that bring together the full range of varietal improvement achieved in 20 years of work – IR8 as IRRI's first variety and IR50, an IRRI line released as a variety by the Philippine Government in 1979.

The key to improved varieties lies within the rices in the IRRI world germplasm bank that can withstand one or more problems — pests, adverse soils, floods or drought, extreme temperatures. To locate those key rices, the GEU team grows and closely observes more than 200,000 germplasm bank entries and breeding lines annually When a rice with the needed resistance or tolerance is found, it is crossed with varieties that have other desirable traits, and the progeny are grown in natural local environments with no pesticides applied. Only the hardiest and most promising lines are saved.

The GEU teams concentrate on these problem areas:

• *Disease and insect resistance.* The early modern rices — IR8 and its early sister lines — all fell short of expected yields when disease and insect attacks were severe. Those early varieties yielded best in fields protected by fungicides, insecticides, and herbicides. Where protection was not provided — often the case in the farmers' paddy — the pests took a high toll.

Two major factors influenced *engineering* of new rice varieties in IRRI's second decade. Foremost was an unanticipated buildup of the diseases and insects attacking the crop and the development of new strains or biotypes of those pests. Secondly, some rice pests developed resistance to the existing pesticides and new pesticides became more expensive, primarily because of rising energy costs.

The changing pests and the rising pesticide costs, as well as the sharpening of the focus on the less privileged farmers — small farm, rainfed crop, limited cash and credit — influenced shifts in rice pest research. To serve those farmers' needs, the GEU teams give priority to developing rices with built-in disease and insect resistance. At the same time other team members — entomologists, pathologists, agronomists — seek better pest management techniques.

The GEU effort produced lines that withstand the combined attacks of half a dozen of the most troublesome insects and diseases even without the protection of commercial insecticides and fungicides. GEU scientists also built genetic protection against a dozen rice pests into thousands of experimental lines, and shared such lines with rice research programs worldwide.

• *Drought resistance.* The rainfed rice farmer in lowland river valleys and estuaries can level and enclose his paddies to catch and hold rainwater. The upland farmer grows his rice on land where such paddies cannot be made. For both farmers, drought — even the short drought periods during critical stages of plant growth — spells disaster. Crosses between drought-resistant rices in the germplasm bank and rices of known high-yield potential promise less risk and better yields for all rice farmers.

In South and Southeast Asia alone, IRRI research seeks rices for 100 million hectares of adverse soils with the potential to grow rice.

• *Grain quality and protein content.* Farmers often grow the traditional low-yielding rice only because people prefer it and therefore buy it. Work by GEU scientists produced many rices that combine high yield with acceptable grain quality. For millions of people, most of them in Asia, rice is the main source of protein. Most rice grains contain 7 to 8% protein, but the GEU protein team developed elite lines that contain 9 to 10%.

• *Adverse-soils tolerance.* Another GEU team works on improved rices that can tolerate soils with such problems as salinity, alkalinity, iron toxicity, and acidity, as well as deficiencies in phosphorus, zinc, and other essential elements. Early in the second decade of IR8, the team tested lines that offer new hope to rice farmers on millions of essentially nonproductive hectares.

A 1975 survey of soils in rice-growing areas pinpointed 100 million hectares of problem-soil land in South and Southeast Asia with the potential to grow rice. Saline soils, for example, cover 62.5 million hectares, most of which now grow a poor crop of rice. In 1976, IRRI started breeding and selecting for salinity-tolerant rices; by 1979 varieties with excellent performance in saline soils were being tested for release to farmers.

• *Deepwater and flood tolerance.* Vast rice-growing areas in Asia are hit by periodic flooding. In some places floodwaters recede within a few days, but in others water 1–6 meters deep may persist for weeks. Traditional varieties grow in both areas but give low yields. A GEU research team has combined the *elongation gene* of the traditional varieties with other desirable characteristics of the modern rices. The resulting varieties are replacing the low-yielding traditional rices in the deepwater areas.

• *Temperature tolerance.* By crossing the farmers' traditional cold-tolerant rices with the modern tropical varieties, a GEU team developed high-yielding rices that thrive in cool climates. Heat-tolerant varieties are also being developed for irrigated areas in arid regions where low humidity and temperatures above 40°C cause sterility in rice flowers.

Those who do the backbreaking transplanting often return to reap a meager crop on Asia's problem soil lands. New and better rices for farmers on millions of hectares of problem soils are in advanced testing.

Ice-cold water flows into paddies at an Office of Rural Development (ORD) substation in Korea that was specially built to screen rices for cold tolerance. IRRI-ORD cooperation in developing cold-tolerant rice started in 1977.

Although the traditional rices have "better taste," the modern ones are accepted by consumers.

Millions of children depend on rice for a major part of their needed protein. For them, any increase in protein content is important.

Two new rices developed in these Thailand-IRRI cooperative deepwater research plots in Thailand were released to Thai farmers in 1979.

IRRI scientists discuss rapid generation advance, a procedure for speeding development of photoperiod-sensitive rices and testing them in national programs.

We seek to move rices quickly into national rice improvement programs and through them to widely diverse farm environments.

Rice disease problems in South American countries are surveyed by scientists during a monitoring tour.

IRRI and Indonesian scientists discuss plans for a cropping systems research site in southeastern Sulawesi, Indonesia – cooperation in national programs to bring research closer to the farmer.

A 1979 international rice workshop and monitoring tour, the first held in China, brought together scientists from 8 Asian countries.

The primary product of GEU teamwork is an improved rice variety — one that will grow well and yield high when planted in a farmer's field. Teams of biological and social scientists work closely with the GEU scientists to develop a technology that will get the best yields from the new rices.

Trials at IRRI measure the potential of the modern rices and the new technology — fertilizers, pesticides, improved water management, machinery — but the final test of how good the new rices and techniques are is acceptance, first by the farmer, then by the consumer.

To achieve acceptance, rices must move quickly into national rice improvement programs and, through them, to widely diverse farm environments. The mid-1970s — the start of the second decade after IR8 — marked an acceleration of efforts to get rices into national programs and to test rices in the areas where problems exist. The period that started in 1974 could well be called the decade of international cooperation in rice improvement.

As international cooperation increased, so did the focus on the farmer as the final key to a payoff from rice research. At IRRI that increase was seen in core research, in training and applied research, and in cooperation with national rice improvement programs.

Focus on the rice plant during the first decade after IR8 created a solid base for the intensification of rice production. The new rices required a shorter growing period and left time for more crops — one extra rice crop, two extra rice crops, or one extra rice crop followed by an upland crop. Only the rice farmer could put the intensification into practice. The research task was to help him develop cropping systems that made best use of the new varieties.

Cropping systems research from the start placed emphasis on the farmer and his family, and ultimately on their struggle for a better life. Teams of scientists at IRRI and in cooperating national programs developed components of the new technology in experiment station fields, but held off decisions on workability of the technology until it had been checked in the farmers' fields. The second decade results were twofold — the cropping systems research teams developed a research methodology that could be used around the world, and almost at the same time the farmer got workable technology that increased cropping intensity and profits on his farm.

In our on-farm trials, small farmers suddenly had rice production running as high as 10 t/ha per year — and a chance for a bonus upland crop on top of that.

Two outstanding examples of highly successful systems for intensifying crop production were seen in the 1970s.

- A continuous rice production system gave any farmer with assured irrigation a chance to greatly increase his income and to spread income and labor requirements evenly over the year. Rices that matured 90 days after transplanting were fitted into a weekly planting and harvesting scheme that moved many farmers from 2 or 3 crops to 4 a year and ran their annual rice yields from 12-15 to more than 25 t/ha.
- The second system centered on putting the new rices with short growth duration to work in the rainfed farmers' fields. By direct seeding the first crop, the farmer made the most of early rains. A second short-duration rice crop was transplanted at the height of the wet season. Then, with the second crop harvested early, an upland crop was grown in many areas.

Farmers trying the 2- or 3-crop rainfed system found that it worked. Not only did rice yields increase sharply as a result of the shift to the modern rice varieties for the first crop: they increased sharply again with the second crop. Small farmers who had worked hard for one-crop yields of 1-1.5 t/ha from their rainfed rice fields suddenly had yields running as high as 10 t/ha per year — and a chance for a bonus upland crop on top of that.

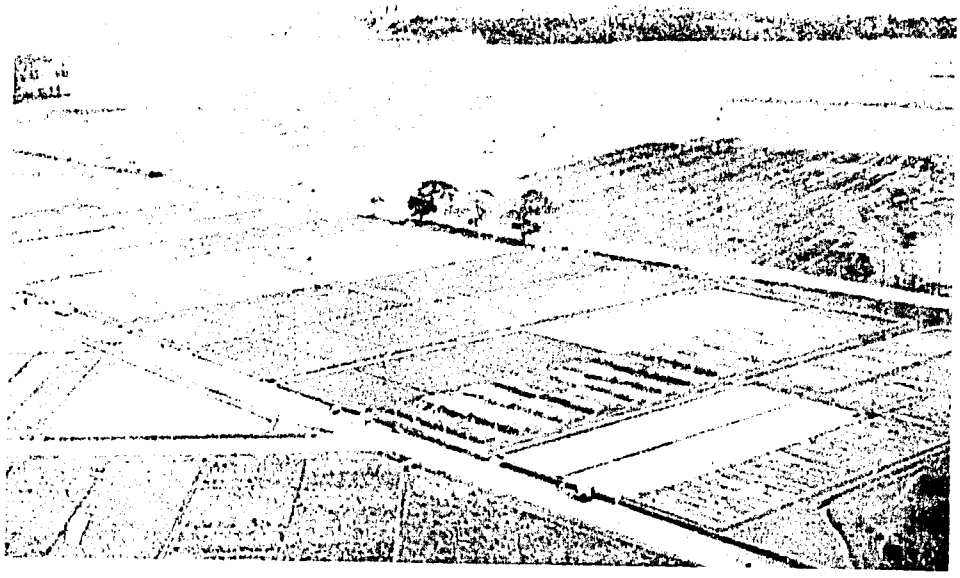
But even before researchers had moved to farmers' fields to test the methodology for cropping systems, questions were being raised about a yield gap — the difference between the farmers' yields and those that researchers got in farmers' fields. Again IRRI researchers developed a methodology to determine causes of the yield gaps. That methodology concentrated on identifying the constraints to higher yields in farmers' fields.

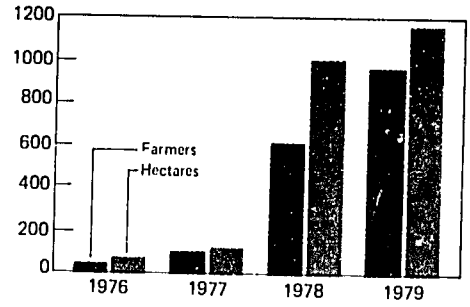
The constraints researchers, working mainly in the rice fields of Asia, identified inadequate use of fertilizer and faulty pest management as the main biological constraints to higher yields. But social and economic constraints were also found. Farmers hesitated to risk their cash to buy the inputs that the new technology required. In addition, the farmers lacked confidence in the technology and in their sources of information about it.

The consequences of the new rice technology also required attention, again directing researchers toward development of a research methodology. The research on consequences had to pinpoint those who had benefited — or had suffered — as a result of the technology. The farmer, the tenant, the landless laborer, and even the

A continuous rice production system, seen in plots at the center of the photograph (right), was tested in these IRRI fields starting in late 1976. Four men working on a hectare divided into 13 plots produced more than 23 tons of grain in 1978.

The rice in a farmer's direct-seeded field (top) was heading while his neighbor was still transplanting. Continuous cropping plots (bottom) show the weekly sequence of transplanting. With short-growth-duration IR rices, both systems have doubled, and even tripled, the income of many small farmers.



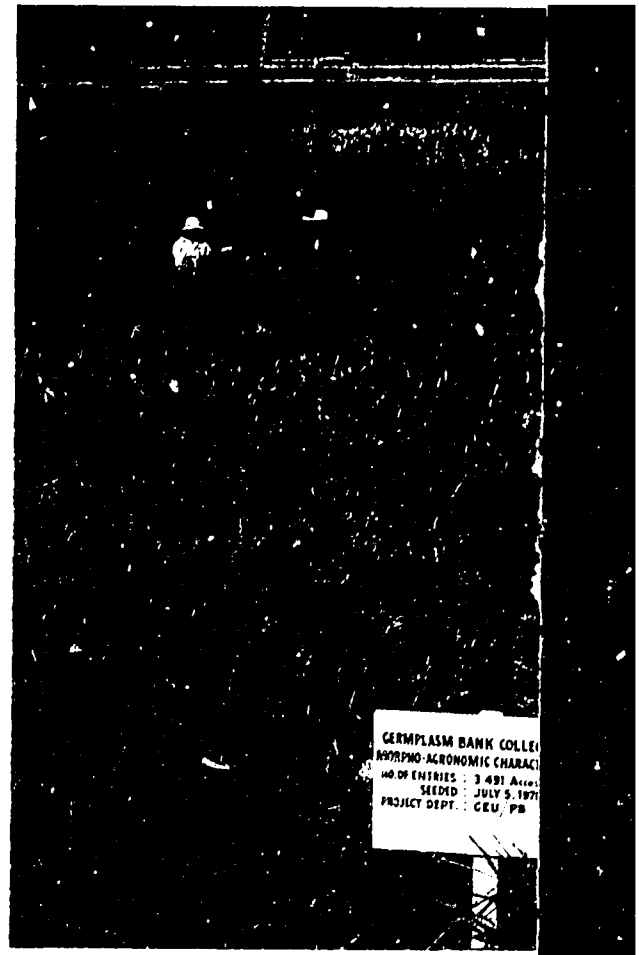


The adoption of early-maturing varieties and a two-rice-crop rainfed system by Iloilo farmers in two towns went beyond expectation. By 1980 the system had been adopted by more than 1,200 farms throughout the region.

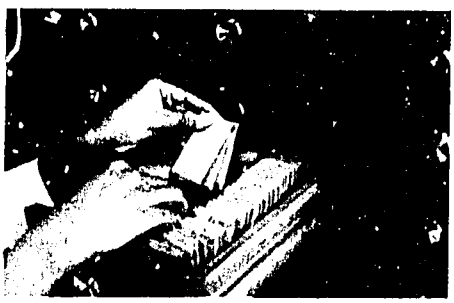
The success of research involving farmers requires getting together with them in on-site planning sessions.

With the advent of modern rices has come rapid disappearance of our genetic resources in areas formerly rich in diverse germplasm.

Materia from the world germplasm collection at IRRI is seen in research plots throughout the world.

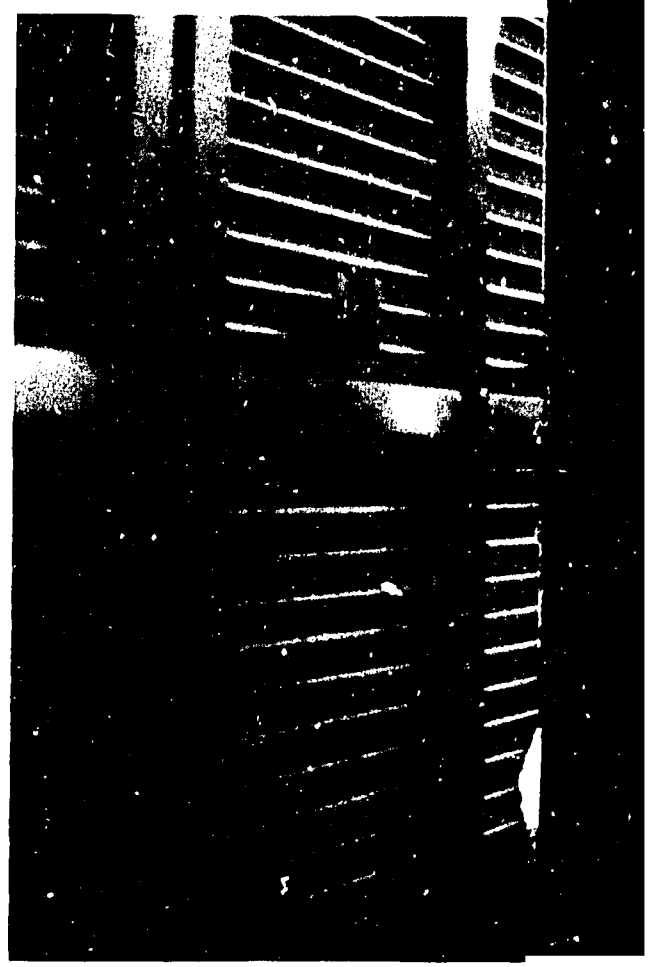


A germplasm collection team gathers panicles of a bulu rice from a farmer's harvest in Bali.



By the end of 1979 nearly 50,000 accessions had entered the files of the germplasm bank.

The characteristics of every accession are meticulously recorded during the germplasm bank's registration process.

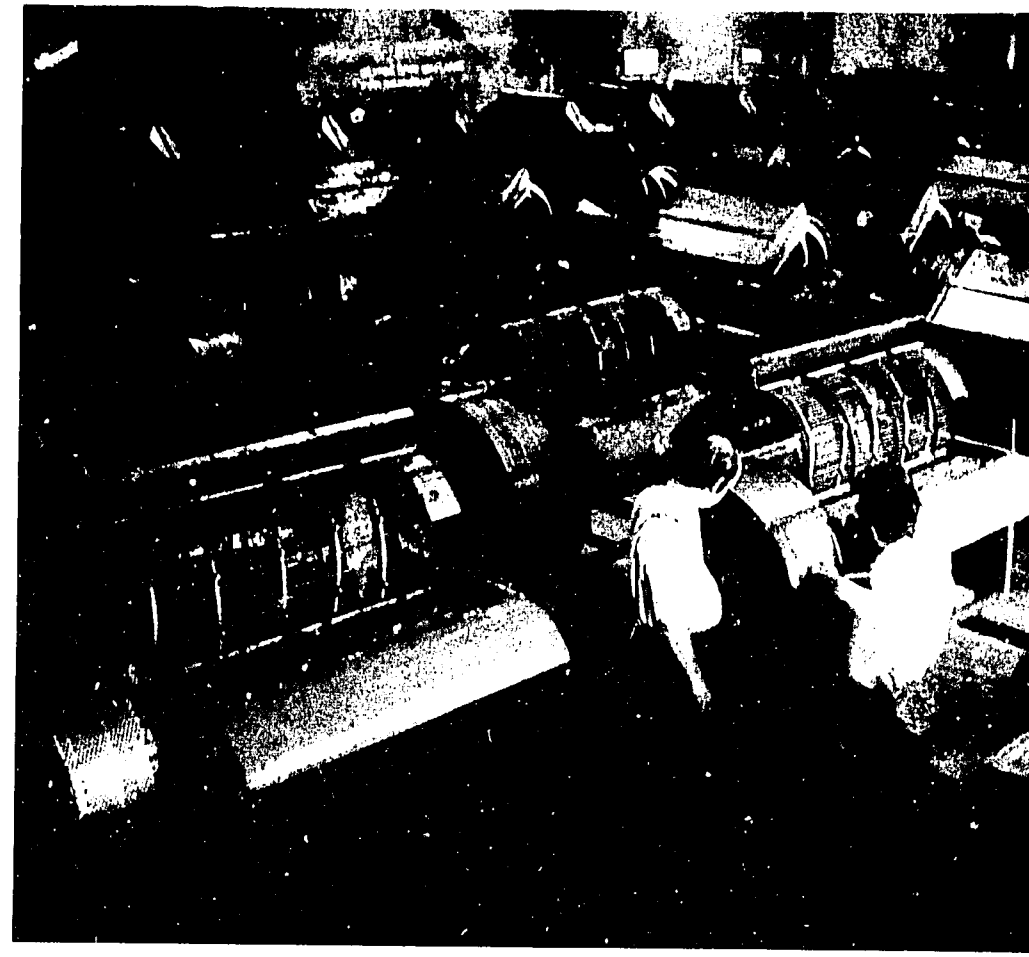


Each rice in the germplasm bank is grown at IRRI to obtain data on its agronomic characteristics and increase seed for distribution to the world's rice scientists.

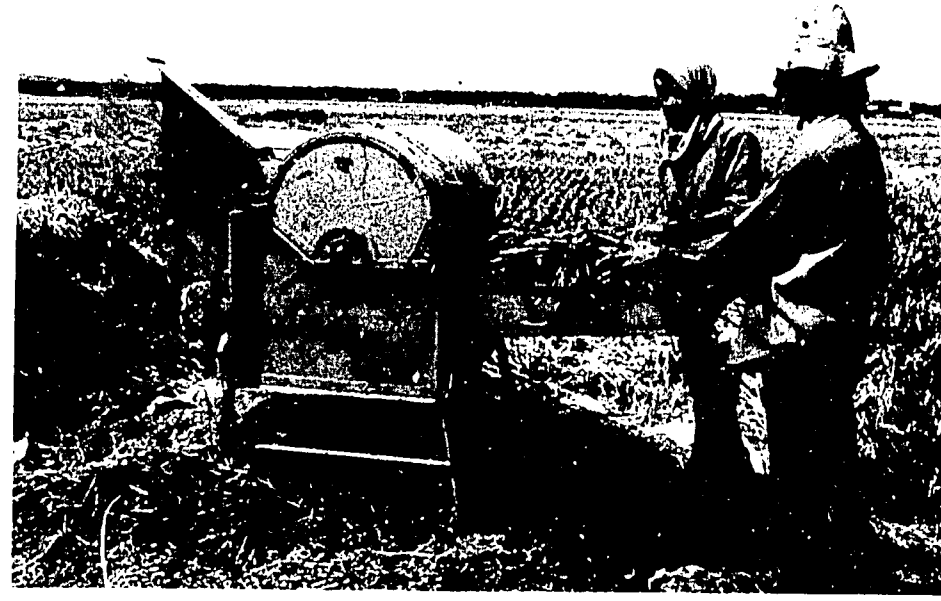
A canned sample of each germplasm bank accession goes to long-term storage at −10°C. The canned seeds are expected to remain viable for at least 50 years.

More than 60,000 seed samples moved through the germplasm bank's storage in 1979. The samples served the needs of rice scientists at IRRI and around the world.

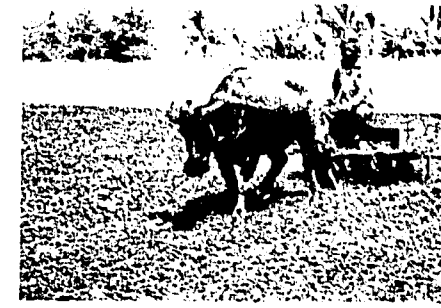
Small local manufacturers all over Asia have successfully fabricated and sold IRRI-designed machinery.



Much of Asia's rice crop is still transplanted and harvested by hand.

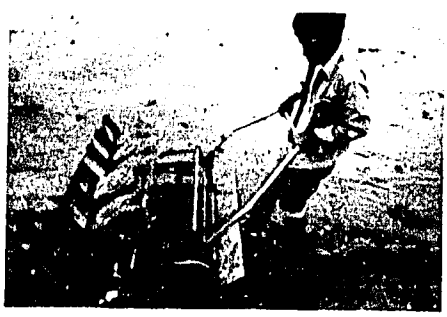


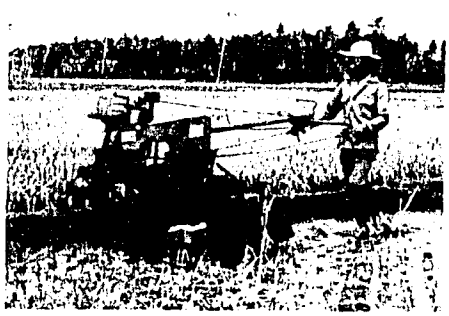
The IRRI-designed portable thresher has been a best seller among small farmers who have adopted the new rice technology.



A small 5-row seeder, pulled by a power tiller or by an animal, offers simple mechanization of planting for farmers who plant a dryland crop in addition to wetland rice.

A growing IRRI program for machinery development coincided with increased demands by farmers.





A hand-operated transplanter (top) that went into on-farm testing in 1979 promises to cut transplanting costs and get the rice crop into the paddy faster. The small IRRI-designed power tiller (bottom) has replaced the water buffalo on thousands of Asia's rice farms.

urban consumer were involved along the continuum of consequences; policymakers and politicians were not overlooked.

Results of the consequences research indicated that the benefits of the new rice technology are generally shared by all segments of a population and that no serious disadvantages exist. Increased cropping intensity and increased food production point to higher incomes and increased employment in the rural areas, to increased supplies of food at reasonable prices for the urban dweller, and to national development as a benefit for all.

The small farmer, however, remains the key to any gains in rice production and despite gains in production per hectare or per year, his farm will remain small. But, as crop technology removes production constraints, one consequence is that the small farmer will seek ways to relieve the drudgery imposed by hand labor. He will turn to small machines to relieve some of the burden.

In the decade after IR8 a growing IRRI program for machinery development coincided with an increase in demand by small farmers.

- Tens of thousands of small paddy tillers — based on a basic IRRI design — will have been sold in Asia as IRRI's third decade starts.
- High on the shopping list as small farmers increase incomes is a small grain thresher-cleaner. An IRRI design inspired the local manufacture of thousands of small portable threshers at the close of the 1970s.
- A hand-operated transplanter — designed to take the backbreaking drudgery out of transplanting and to speed getting the second rice crop in the field — went into on-farm tests late in 1979.
- A 5-row seeder was developed for planting dryland rice and other upland crops.
- A simple plow-sole applicator was designed to permit the farmer to apply fertilizer into the root zone where its efficiency is increased.

Such machines, designed specifically to fit the small farmer's needs, are an important component of increased cropping intensity and family income as IRRI enters its third decade.

The creation and coordination of multicountry networks are strongly indicative of IRRI's second-decade approach to rice research.

A key step as IRRI moved into the 1970s — into the decade of international cooperation in rice improvement — was the creation of a unique network for linking rice-growing countries to the world's best rice germplasm. At the same time, research started to move onto Asian farmers' fields through other IRRI-coordinated networks. The creation and coordination of multicountry networks are strongly indicative of the second-decade approach to rice research.

International rice testing

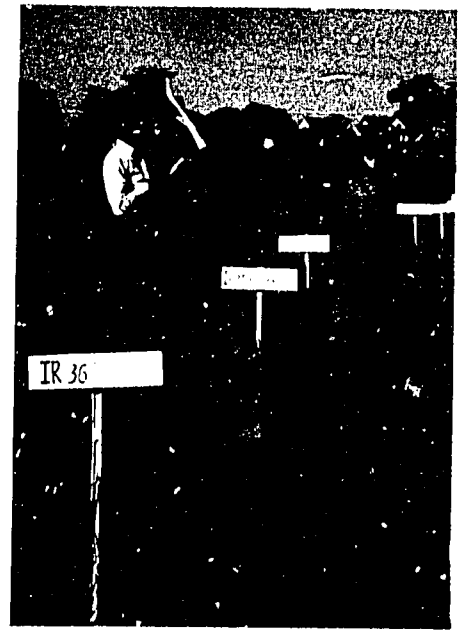
Cooperation and collaboration with rice scientists in national programs — basically an effort to build national rice improvement capabilities — started even before IR8 was released. In 1964 test nurseries were sent to 4 countries, breeding lines to 38, and seed packets to more than 50. Special nurseries were also developed. But it was in 1975 that a well-organized system for testing and reporting the performance of any new rice germplasm worldwide started through the International Rice Testing Program (IRTP). For the first time the testing of nurseries was internationally coordinated. More important, a two-way flow of rices was created — the best from all countries got into tests in all others and computer programs were developed for rapid analysis of IRTP data flowing from national tests to IRRI. IRTP also provided a chance for scientists to get together in monitoring tours for an on-the-spot look at nurseries and to ask, "So what?" and "Where do we go from here?"

By 1978, 60 rices from IRTP nurseries had been named as varieties and released to farmers in a dozen countries around the world. The IRTP nurseries were also a solid source of outstanding germplasm that national breeders could draw from.

The constraints network

The IRTP network identified suitable new rices. But yields from experiments in farmers' fields and those obtained by the farmer working alone in his field revealed gaps. The new technology lost its impact as it moved farther from the researchers' careful control. Some farmers did adopt the new ideas, but they obtained much lower yields than the scientists.

An IRRI-coordinated international rice agroeconomic network put agronomists, economists, and statisticians in farmers' fields in six countries in 1974. The scientists sought answers to why there was a difference between a rice's yield under careful researcher management and its yields when grown by a farmer.



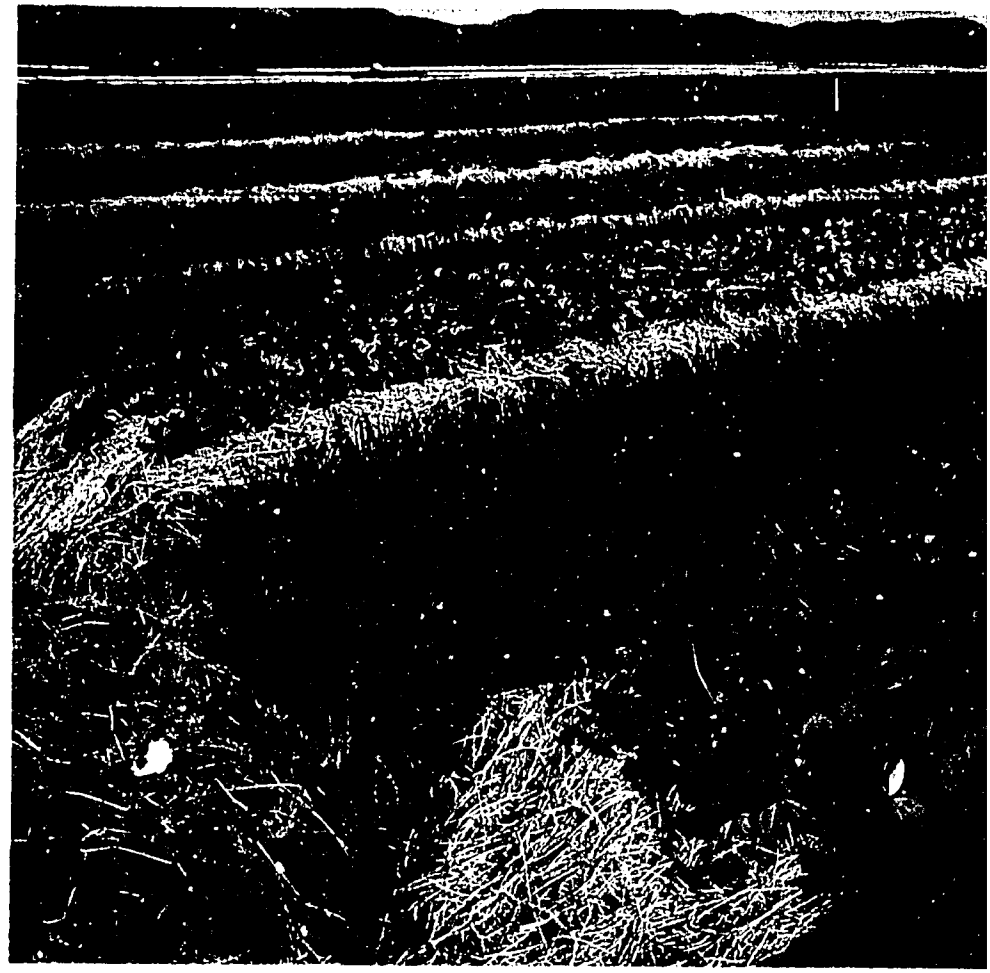
In 1979 IR varieties and breeding lines (top) were widely tested in China for the first time and IRTP monitoring tour participants were invited to take notes on those tests. During IRTP monitoring tours (bottom), IRRI and national program scientists discuss results on the spot and ask, "Where do we go from here?"

IR5853-118-5, an outstanding rice at IRRI, went into IRTP nurseries in 1978. Its worldwide performance as a drought-resistant rice in IRTP trials could result in its use as a rainfed wetland variety in several national programs.

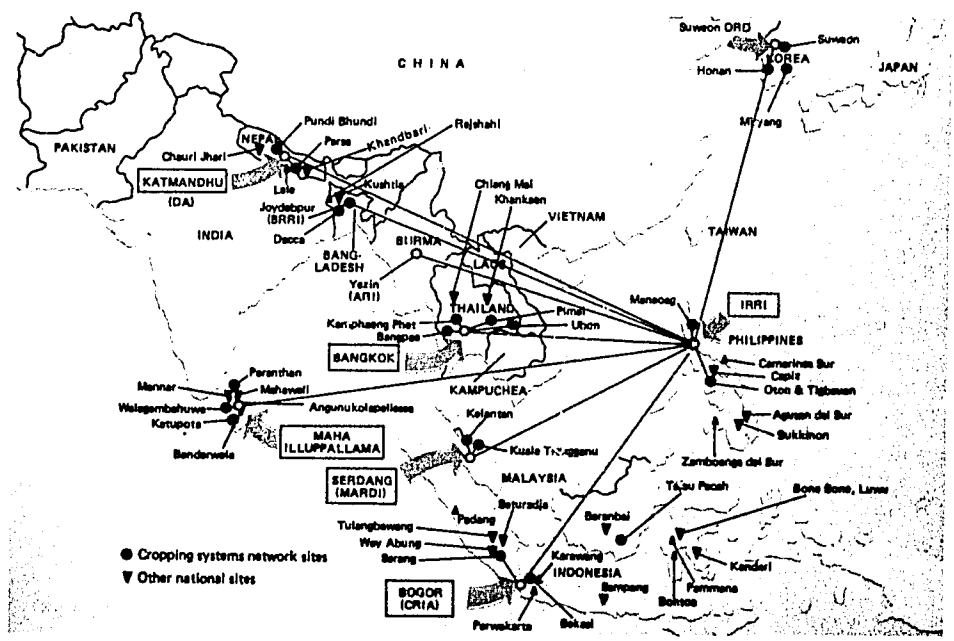
IRRI reports summarize the results of activities, strengthen research networks and encourage international cooperation.

Computer programs provide analysis of GEU and IRTP data to IRRI scientists and rapid feedback to national program scientists.

Many of the best ideas of research originate on small farms. Indonesian farmers have for centuries used a bedding system they call sorjan. *In 1979 IRRI scientists matched the proven practicality of* sorjan *with modern crop technology and attained spectacular yields of dryland crops in fields alongside wetland rice.*



Within the constraints and the cropping systems networks, there is continual survey of the risks and benefits from the new rice technology as it moves onto farms. The key to the system is working with farmers in their fields.



The cropping systems network in Asia tied together research on new cropping patterns with rice as the main crop in 8 countries in 1979.

A workable cropping systems methodology was rapidly developed because scientists held planning sessions in areas where the problems were throughout Asia

Our cropping systems methodology involves farmers in developing technology that fits their capacity.

The network surveys started with cooperative field investigations by IRRI scientists in Indonesia, the Philippines, and Thailand. Scientists in Bangladesh, Sri Lanka, and Taiwan joined the network in 1975, and by 1978 the collaborative research included India and Pakistan.

The cropping systems network

For centuries, most farmers who grow rainfed rice have grown only one rice crop a year, leaving their land fallow most of the time. But when they plant short-duration modern rice varieties, they gain the time — and enough remaining soil moisture — to grow another crop.

In close collaboration with national program scientists, cropping patterns and technologies that allow farmers to plant a second rice crop — or another food crop after harvest of the first crop of rainfed rice — were developed.

Throughout Southeast Asia the cropping systems methodology directly involves the farmers. Cropping systems scientists, by doing their research in the farmers' fields, make sure that the technology fits the farmers' management capacity. In 1975, a network approach was developed at six sites in three countries with collaborative testing of cropping patterns that could increase crop production and farmers' incomes. By 1979 the Cropping Systems Network covered 8 countries and research was in progress at more than 40 sites.

The fertilizer network

The mid-1970s marked the start of the worldwide energy crisis and rice farmers soon began to feel its effect. The initial impact was a sharp increase in fertilizer prices. Those higher prices called for research to increase the efficiency of fertilizer applied to the rice crop; possible fertilizer scarcity directed research toward biological sources of plant nutrients.

IRRI trials with slow-release nitrogen fertilizers for rice started in 1973. In 1974, work started on techniques to place fertilizers deep

Research has turned to the search for alternatives to purchased fertilizer for rice.

into the soil — into the rice plant's root zone where uptake would be more efficient and losses (as ammonia) to the atmosphere less. Those early tests produced yields of 8 t/ha when only 60 kg nitrogen was placed in the root zone. In the same field 100 kg nitrogen/ha applied by the farmers' usual method of topdressing on the soil surface produced yields of only 6.6 t/ha.

Attention also turned to the search for practical reliable alternatives to purchased nitrogen fertilizer for the rice crop. The atmosphere offers an unlimited nitrogen supply and some organisms can take nitrogen from the air and fix it into a form plants can use. The blue-green algae, often found in paddy water and in the azolla fern that grows on the paddies, play such a role for a rice crop.

An international focus on fertilizer problems was established by rice scientists at the 1976 International Rice Research Conference. They formed an 8-country network, now called the International Network on Soil Fertility and Fertilizer Evaluation for Rice (INSFFER). INSFFER covered 14 rice-growing countries by 1979, with research focused on increased fertilizer efficiency and biological nitrogen fixation for the rice crop.

The farm machinery network

The new rice technology flowing from IRRI's research plots often places an increased demand on the farmer's time — he must handle a larger harvest faster, do tillage faster, and apply fertilizer more precisely, for example. Sometimes more labor is a solution; often, a new or better machine is required.

By the end of 1974 more than 20,000 IRRI-designed machines had been commercially produced by small local manufacturers and were at work on farms of the rice-growing world. In 1975 the Farm Machinery Development Network was established to speed the transfer of machinery know-how to country programs and farmers' fields. The network, which started with single projects in 5 countries, had 12 projects in 9 countries by 1979.

Losses of nitrogen from the rice paddy soil greatly reduce the efficiency of nitrogen fertilizer applied by a farmer. These drums provided a measure of losses of nitrogen as ammonia.

Azolla will grow in the rice paddy and biologically provide more than enough nitrogen to grow a bumper rice crop. An international network is charged with the improvement of azolla's potential to fix nitrogen.

The adjustment of the plow on a new tiller attracts attention on an Indonesian rice farm. Hundreds of small machinery fabricators in Asia get active support from IRRI in producing machines that fit farmers' needs.

Hundreds of research scholars from all parts of the rice growing world, but mainly from Asia, have done research at IRRI as part of work for their advanced degrees.

The research scholar-IRRI scientist relationship is close and continuous. Many such relationships have endured and dozens of former IRRI scholars provide leadership in national rice improvement programs.

The ultimate measure of IRRI's success is the success of the new methods and techniques in national rice programs.

Experience in developing and using research techniques gained at IRRI serves training participants after they return to work in their national programs.

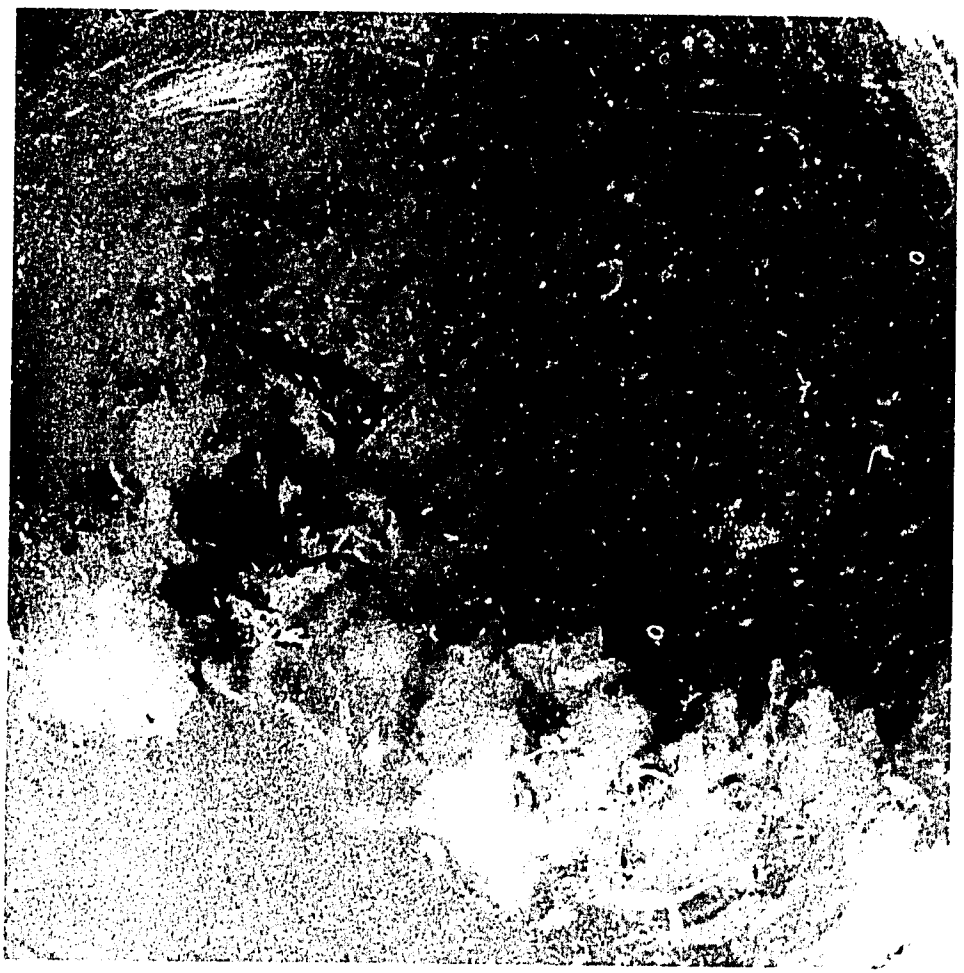
The ultimate measure of IRRI's success is the success of the new methods and techniques in national rice programs. And international activity is the mechanism by which a contribution to rice research in national programs is ensured.

Close links with national programs are seen in our training activity, in cooperative country projects, in the international networks, in collaborative research, in general services to national programs — workshops, conferences, symposia and distribution of rice literature. About one-third of the IRRI staff work directly with colleagues in national rice research programs in Bangladesh, Burma, Indonesia, India, Pakistan, the Philippines, Sri Lanka, and Thailand. Liaison scientists work in Africa and in Central and South America.

Properly trained and highly motivated people are essential to the success of national rice improvement programs. They are ultimately responsible for developing and adapting the technology needed to feed a hungry world. For that reason IRRI has made the training of scientists, educators, and extension specialists an integral part of its programs since 1962. To date we have provided the equivalent of more than 1,000 years — almost 200 years in 1979 alone — of training in rice research and rice production.

Most of the young rice scientists and extension specialists who participate in IRRI training spend at least half of their time in on-the-job *training.*

This rice seedling grows from a mass of cells in a laboratory dish. The cell mass was started from the anther of a rice flower. New techniques will open new horizons for rice breeders to improve the rice plant.



Making azolla, a water fern, more efficient in extracting nitrogen from the atmosphere will mean less costly fertilizer for farmers. A key factor will be development of a way to improve azolla through breeding.

This hybrid rice in an IRRI breeding plot is obviously more vigorous than its parents on either side.

IRRI emphasis will remain on the rice farmer and his needs as he works on his farm.

Biological control of rice pests has the potential to provide low-cost pest control for farmers and a healthier environment for mankind. The diseased insect pests on this rice plant provide an example; researchers must use the disease to kill more insect pests.

Talking to farmers about their needs as they work on their farm is essential to the effective flow of useful research information.

What about the future?

As IRRI faces its third decade of rice research, the emphasis clearly must remain on the rice farmer and his needs as he works on his farm. But more broadly it remains on the needs of mankind for an ever increasing food supply.

The success of our second-decade focus on the farmer, and the development of methodologies that quickly and clearly identified and served farmers' needs, point to the obvious. IRRI's third-decade research will move increasingly outward to seek greater cooperation and collaboration with national programs and to a definite expansion of the networks that served the second decade so well.

Closer collaboration with all national programs will be basic. The initiation of collaboration with Chinese rice scientists in the late 1970s can be expected to result in a vast expansion of cooperative work. Network activities will provide a key to that expansion. Increased collaboration will also move IRRI closer to national programs in Africa, Central and South America, and the Middle East.

The third-decade research will also seek an increasing payoff from core research:

- Attention will turn to hybrid rice production as a way to break current yield barriers.
- A continuing energy crisis will call for increased attention to biological nitrogen fixation as a lower-cost source of rice fertilizer.
- Innovative breeding techniques, such as tissue culture and mutations, will be used to develop rices that will grow and yield more in a wider range of environments.
- Integrated pest management methodologies will be developed to bring lower-cost, more effective pest management practices to the small farmer.
- Social research will play an increasing role in breaking down barriers to the flow of research information to farmers and others.
- The basic process through which solar energy is converted to grain will be studied as a way to increase the yield potential of rice.