Japan's role in tropical rice research

A summary report of a seminar jointly sponsored by
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and
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Japan is the only highly developed country whose agricultural industry is based on rice. Much Japanese research has focused on problems of rice in the temperate regions and can not be used directly in the tropics. But Japan’s experience in the application of science to solve rice production problems can be used everywhere. Furthermore, certain problems are common to the rice crops of both Japan and the tropical countries.

For example, planthoppers from Southeast Asia migrate to Japan yearly, damaging crops and spreading virus diseases. Japan’s experience in the conservation of fertility of submerged soils could be useful in tropical regions. The development of insect control measures using natural products of resistant plants require research facilities and techniques that are available in Japan, but not in most developing nations. The introduction of Japanese germplasm could diversify the genetic base of most tropical rice improvement programs.

Thus it is obvious that Japan has a key role in tropical rice research.

In 1976, Kyushu University established the Institute of Tropical Agriculture to promote Japanese participation in research and education to increase worldwide food production, particularly in developing nations of the tropics.

The Institute of Tropical Agriculture and the International Rice Research Institute cosponsored a seminar on Japan’s role in tropical rice research, held at Kyushu University in September 1980. The main purpose of the seminar was to plan strategies for the channeling of Japan’s accumulated rice research knowledge and pool of rice scientists toward the improvement of rice production in the tropics.

This volume contains summaries of major papers given and recommendations made at the seminar.

Marcos R. Vega
Acting Director General
Welcome address
Tsutomu Matsumoto

According to statistics of the Food and Agriculture Organization, cereals are grown on half of the world’s 1,470 million ha of arable land; rice is grown on 140 million ha — second only to the area planted to wheat. Although wheat is grown worldwide, 90% of all rice is grown in Asia. Thus, the location of the International Rice Research Institute (IRRI) in the Philippines is logical.

IRRI was initiated in 1960 and formally established in 1962. IRRI’s most significant early breakthrough was the 1967 release of IR8, the first high-yielding semi-dwarf rice cultivar to be widely grown in the tropics, IR8 and later research achievements have made IRRI a Mecca for tropical rice research.

Japan has a long history of rice research. The establishment of the Tropical Agriculture Research Center by the Ministry of Agriculture, Forestry and Fisheries promoted an exchange of rice scientists and specialists between tropical countries and Japan and has increased the number of students from developing nations who study in Japan. These exchanges have contributed to the improvement and stabilization of rice culture. In 1976, Kyushu University established the Institute of Tropical Agriculture to promote greater cooperation with, and the development of, tropical agriculture. Although only one scientist is with ITA, a number of professors and others help its research and communication activities.

I am greatly pleased and honored that we can hold this seminar, which is jointly sponsored by the International Rice Research Institute and the Institute of Tropical Agriculture of Kyushu University, with the cooperation of the Kyushu National Agricultural Experiment Station of the Ministry of Agriculture, Forestry, and Fisheries, the Faculty of Agriculture of Kyushu University, and the other organizations. I sincerely hope that such seminars will be held regularly in the future.

Director, Institute of Tropical Agriculture, Dean, Faculty of Agriculture, Kyushu University, Japan.
Opening remarks
Satoshi Wakimoto

This is the first joint seminar of the International Rice Research Institute (IRRI) and the Institute of Tropical Agriculture (ITA), Kyushu University. Participants in the seminar on “Japan’s Role in Tropical Rice Research” will discuss rice and rice culture research in the tropics, and study ways in which Japanese scientists can contribute to international projects.

Today, 60 scientists and 2,000 employees work at IRRI. Visiting scientists from around the world collaborate in research projects with IRRI staff members. Thus, IRRI has become one of the world's most famous and active international organizations. In 1967, IRRI released IR8, a new high yielding variety that gained rapid and wide-scale distribution throughout Asia, despite its high susceptibility to insects and diseases. IRRI has subsequently bred many improved rice varieties and distributed them to developing countries to help solve worldwide food problems.

ITA was established in 1976 to promote research and education in tropical agriculture. Its main functions include planning and execution of joint work on tropical agriculture, communication with foreign research organizations, and promotion of educational cooperation with tropical countries. All ITA staff members are actively involved in fundamental research.

The ITA staff wishes to contribute further to tropical agriculture — not only in fundamental research, but also in more practical fields through research collaboration with many institutions and in the education of students.

IRRI and ITA differ considerably in size, purpose, and historical background. The final objective of both organizations, however, is the same — to increase the world's food production. For rice, our emphasis is on problems in the tropics.

Japanese scientists with interest and expertise in tropical agriculture are needed in international organizations. I hope that this seminar will stimulate all participants, particularly the younger scientists, to develop an interest in tropical rice problems.

Finally, I would like to thank the officials and scientists who helped to make this seminar possible: Dr. N. C. Brady, IRRI director general and Mr. H. Akemine, representative of IRRI’s Japan Office, for financial support; Dr. T. Matsumoto, dean, Faculty, of Agriculture, Kyushu University, for providing the facilities; and

Professor, Faculty of Agriculture, Kyushu University, Japan.
Dr. R. Ito, director, Kyushu National Agricultural Experiment Station and other Station staff members for valuable help and suggestions in organizing the seminar. Thanks are also due to all speakers who presented papers, and to all commentators.
I hope the seminar will be successful and fruitful. Thank you.
For centuries, farmers in South and Southeast Asia were able to produce enough rice to support the region’s growing population using traditional cultivation methods. But by the mid-20th century, the scarcity of arable lands and rising populations had begun to make the future food supply of South and Southeast Asia appear precarious.

Rice is grown primarily for internal consumption. The international rice market is highly volatile, and involves only 2-3% of the total world production. Slight deficits or surpluses in major rice-consuming countries can affect international prices.

With population increasing at 2% or more per year, the demand and need for rice will continue to grow. Although rice production in many countries has increased substantially, in the past two decades, environmental hazards and socioeconomic problems have prevented the stabilization of production. Rice production is often affected by severe droughts, unpredictable floods, or disease and insect epidemics. Even in a favorable crop year, a small surplus often lowers the price of rice and discourages further investments for yield increase. A lack of local systems for rice storage and marketing further depresses farmers’ continued interest in rice cultivation. But steady progress in rice cultivation is important in the activation of local economies and, thereby, the development of sound national economies in South and Southeast Asia.

THE IMPROVEMENT OF RICE CULTIVATION IN THE 1960s: SUCCESS AND ITS CONSEQUENCES

In the early 1960s, potential rice yields under the best conditions in the tropics reached a ceiling of 2.5-3.0 t/ha. Attempts to further increase yields through improved cultivation practices were thwarted by the plant’s inability to support heavier grain loads. Higher rates of nitrogen fertilizer usually increased lodging and thus often decreased, rather than increased, yields.

IR8 resulted from the combining of the plant dwarfing character and sturdy stem
of the Chinese variety De-geo-woo-gen with the profuse tillering and partial disease resistance of Peta, an Indonesian variety. The new plant type of IR8 made it possible to raise the potential yield to 8-10 t/ha by applying more fertilizer.

Subsequent genetic improvements through breeding include the incorporation of an increasing number of built in characters such as a range of desired grain qualities, disease and insect resistance, and tolerance to cold temperature and adverse soils.

IRRl’s early success made a profound impact not only on farm-level practices but also on research and investment policies for agricultural development. People became convinced that investments in water reservoirs, irrigation canals, or transport networks could be paid off through doubled or tripled increments in output. Rural development projects were initiated. National development programs activated research and training in modern rice technology.

The intensification of rice cultivation has, thus far, supported the increasing population of the Asian tropics and contributed to the expansion of local markets. The most eloquent evidence of the soundness of the new rice technology is the self-sufficiency achieved by countries such as the Philippines that formerly had been chronically deficient in rice production. But the acceptance of the new technology is still limited and net per capita income has not increased significantly in many areas.

NEW HORIZONS IN RICE PRODUCTION RESEARCH

IRRl’s work (and most rice research in tropical Asia) initially focused on production increases in favorable soils and where water was not a seriously limiting factor. But it became clear that the new rice technology was not acceptable in the vast areas of bunded-rainfed, nonbunded-dryland, or deepwater areas. The sturdy, semidwarf rices often performed poorly on adverse soils. Local varieties continued to dominate rice cultivation in the highlands of the tropics and subtropics.

IRRl estimates that 28% of the rice area in South and Southeast Asia is under controlled irrigation, 48% is bunded rainfed, 8% deepwater, and 14% dryland (nonbunded-rainfed, including arid areas affected by high temperature). When water rices stress is present, regardless of whether due to an excess or deficit, socioeconomic problems accompany stagnant rice production.

Experience with high-yielding varieties and intensive cultivation has demonstrated that much further research will be needed to protect and stabilize achieved production levels and gains. Crop production in the tropics must intensify in the future. Coping with the consequences of intensification should be a focal point — and a new challenge — in rice research.

Intensification of rice cultivation changes the pest-pathogen-host relationship. The development and widespread use of a limited number of varieties that are resistant to prevailing biotypes or races of insects and diseases places new selection pressures on the population of the causal organisms. Organisms that survive a resistant variety may adapt to overcome the host’s resistance and multiply. Intensification of rice cultivation and the growing of two or three crops per year on the same land can profoundly affect the dynamics of disease organisms and pest populations.

Initial success has demonstrated that shortening the growth period of rice, even without a yield increase, is an important component for crop intensification.
Research in multiple cropping supported by the development of innovative practices to maintain soil fertility and to control diseases and insects may pay high returns. Multidisciplinary research to develop farm machines that are suited to the needs of small-scale farmers can open brighter prospects for rice-growing villages.

Vast rice-growing areas in Asia are hit by periodic flooding. In some places floodwater recedes within a few days, but in others, water 1–6 m deep may persist for weeks. Traditional varieties grow — but yield poorly — in both areas. One successful approach to develop improved varieties for such regions is to combine the elongation genes of traditional rice varieties with the desirable characters of modern rices.

The modern varieties produce well in rainfed fields during years of high, uniform rainfall. But drought-resistant rices are required for areas of average or below-average rainfall. Soil problems, as well as low fertility, limit yields in rainfed areas to below the levels that make additional inputs profitable. To explore and develop the full potential of the vast rainfed areas is perhaps the most exciting challenge of the coming decade. The success of rice double cropping with the use of short-duration varieties in rainfed villages is an encouraging indication that an innovative combination of existing technologies can drastically alter stagnant rice cultivation practices.

Dryland rice in Asia underscores the problems of low fertility, adverse soil conditions, drought, and weeds. The feasibility of improving dryland rice cultivation remains to be tested in collaboration with local farmers.

On millions of rice fields, yields are limited by soils that are saline, alkaline, or extremely acidic, and soils that are deficient in phosphorus, zinc, iron, and other essential elements. Surveys or characterization of such problem soils is a top priority task in the stabilization or improvement of such rice areas. After an initial survey, tolerant varieties should be selected and soil-amendment techniques applied.

Socioeconomic research to understand the complexities of the problems in the rice-growing villages is needed in breaking down barriers to the flow of research information to farmers and others.

**STRATEGIES AND EMPHASES OF FUTURE IRRI RESEARCH**

Strong national agricultural and extension programs are essential to the effectiveness and usefulness of IRRI’s programs to increase rice production. National and international efforts must be complementary.

As the national agricultural research programs gain strength, the programs of the international centers must necessarily change in character to maintain their appropriate complementary positions.

As an international center, IRRI is expected (in conformity with guidelines from the Consultative Group for International Agricultural Research) to play the following versatile roles:

- Collecting, conserving, cataloging, and distributing germplasm;
- Coordinating research to raise and stabilize yields;
- Developing improved research techniques;
- Organizing and conducting relevant training programs;
- Providing information and bibliographic services; and
• Organizing symposia, seminars, and monitoring tours.

IRRI’s current and future strategy is to focus greater attention on the major rice production constraints and to find means of removing such constraints. Attention to rainfed agriculture and to constraints such as pests and soil and climatic deficiencies will be increased. These changes in focus make it necessary for IRRI to increase its collaborative research with national programs.

IRRI emphasizes the multidisciplinary approach, which proved its effectiveness in the past decade, in solving the complex and diverse problems it faces in the future.

Basic research will receive greater emphasis in future IRRI research, so scientists can better understand factors such as the genetic basis of resistance to rice pests; the ecological and physiological factors that influence rice yield potential; and the basic processes through which solar energy is converted to grain. A continuing energy crisis will call for increased attention to biological nitrogen fixation as a low-cost source of rice fertilizer. Mobilization of scientific innovations in rice production will demand collaboration with scientists from universities and research institutions in developed countries, including Japan. Appropriate procedures to promote such collaboration must be developed.

Applied research will be done collaboratively with scientists in national programs. Such collaboration is essential as IRRI broadens its focus from the relatively well-controlled and highly productive environment of irrigated farms to the more extensive — and more erratic — environment of rainfed agriculture.

Emphasis on training, both formal and informal, will continue. Most of the training will be accomplished through the participation at IRRI headquarters of trainees, scholars, and fellows in organized research training programs. Other training will be given through IRRI scientists assigned to national programs through outreach projects.

In summary, IRRI’s role in future rice improvement will be increasingly that of as a catalyst for international cooperation among rice researchers. Joint research planning and implementation as well as the free interchange of genetic materials and research methodologies will continue to be emphasized through networks such as the International Rice Testing Program (IRTP), the International Cropping Systems Network (ICSN), the International Network on Soil Fertility and Fertilizer Evaluation for Rice (INSFFER), the International Rice Agro-Economic Network (IRAEN), and the International Farm Machinery Network (IFMN).
Professors Y. Yamada and S. Wakimoto conducted research to better understand the fundamental characteristics of paddy soils so they could evaluate soil fertility to increase rice production in tropical Asia.

The sites of field surveys and soil sampling for laboratory analyses included various soil groups, and included important soils of paddy fields in the main rice-growing areas. Twenty-five profiles in Thailand, 5 in Malaysia, and 23 in Indonesia were studied. Soil samples were collected from surface horizons of the profiles and sent to Japan for laboratory studies.

The samples were routinely analyzed for their fertility status as paddy soils. Following are analytical data for the surface-soil samples:

**TEXTURE**

More than half of Indonesian paddy soils were light clay or heavy clay. Thai and Malaysian soils were more clayey than Indonesian soils. Paddy soils in tropical Asia have heavy texture, partly because of the basic nature of their parent rocks and partly because they originate from marine and fresh-water swamps. Among the soil groups, the low humic gley soils are coarse.

**pH**

Malaysian paddy soils had the lowest mean pH value, 4.3. They were followed by Thailand soils (5.1). Japanese paddy soils had a mean pH of 5.4.

The acidity of Malaysian and Thai paddy soils was caused by severe weathering and intense leaching, reclamation of paddy soils from peaty swamps, and wide distribution of acid-sulfate soil areas. Indonesian paddy soils had a higher mean pH value, 5.8. High-pH soils are associated with either the climate or the calcareous parent material (such as limestone and basic igneous rocks) or with both. The result is small patches of high-pH soils, typically Rendzinas and Grumusols.
ORGANIC CARBON (OC)

Malaysian paddy soils had an exceptionally high mean OC value of 9.5%. They are primarily swampy lowland with peaty organic matter. Even excluding such peat soils, Malaysian soils had the highest mean OC value, 3.0%. Indonesian paddy soils, excluding 2 peat soils (whose mean OC was 12.8%) had a mean OC content of 1.9%. Thai paddy soils had the lowest mean OC value, 1.3%. Japanese soils contained higher OC (3.3%) than Indonesian and Thai soils.

TOTAL NITROGEN (TN) AND CARBON-NITROGEN RATIO

About 60% of Thai and Indonesian paddy soils contained less than 0.15% TN. Malaysian soils had high TN. Among soil groups, peat soils had the highest TN, and low humic gley soils the lowest. The mean TN values for Thai, Indonesian, and Malaysian soils were 0.11, 0.18, and 0.25%, respectively (excluding peat soils) — lower than the mean value of Japanese soils (0.29%). The most plausible explanation for this is a high annual temperature and, accordingly, a high turnover rate of organic nitrogen in tropical Asian soils. The overall mean carbon:nitrogen ratio was 12.3:1, which was comparable to the mean of 11.6:1 for Japanese soils.

AVAILABLE NITROGEN (AvN) AND PERCENTAGE OF NITROGEN MINERALIZATION (PNM)

The mean values of ammonia nitrogen (AvN) during a 4-week reductive incubation period were 4.0, 5.1, and 6.3 meq/100 g soil for Thai, Indonesian, and Malaysian soils, respectively. The PNM values for the same soils were 4.4, 2.8, and 2.5% TN, respectively. Those mean values were remarkably lower than values for Japanese soils (17.5 meq/100 g soil and 6.5% TN). The difference may be attributable to the low contents of, and high resistance to microbial decomposition of, organic nitrogen in tropical Asian paddy soils.

Low-humic gley soils and red-yellow Podzolic soils had characteristically low AvN values. But a Rendzina and some alluvial soils had high values. Peat soils, red-yellow Podzolic soils, and acid sulfate soils had low PNM.

AVAILABLE PHOSPHORUS (AvP)

The mean AvP values for Thai, Indonesian, and Malaysian paddy soils were 18.0, 39.2, and 41.2 ppm P$_2$O$_5$ — lower than the mean of 129 ppm for Japanese soils. AvP was relatively high in Andosols, Grumusols, and peat soils, and low in reddish-brown lateritic soils, Rendzinas, and humic gley soils.

CATION EXCHANGE CAPACITY (CEC)

Thai paddy soils had the lowest CEC mean, 14.2 meq/100 g soil. Malaysian and Indonesian soils had mean CEC values of 20.1 and 20.9 meq/100 g soil — almost the same as the mean for Japanese soils, 20.3 meq/100 g. The maximum values were those of Rendzinas, Grumusols, and peat soils.
EXCHANGEABLE POTASSIUM (ExK)

The mean ExK values for Thai and Indonesian paddy soils were 0.34 and 0.47 meq/100 g soil, comparable to the mean of Japanese soils, 0.40 meq/100 g soil. Malaysian soils had a relatively lower ExK mean of 0.17 meq/100 g soil, which may have been because of their acidic nature. ExK levels were higher in Rendzinas, Grumusols, and Andosols. Peat soils, reddish-brown lateritic soils, red-yellow Podzolic soils, and low humic gley soils had lower ExK levels. But irrigation water in Malaysia usually contains an adequate supply of potassium so crops seldom suffer from potassium deficiency.

EXCHANGEABLE CALCIUM (ExCa)

ExCa comprises a major portion of the total exchangeable cations. The mean ExCa value for Indonesian soils was 16.6 meq/100 g soil — markedly higher than the mean of 9.3 meq/100 g soil for Japanese soils. Malaysian and Thai soils had lower means of 5.4 and 7.6 meq/100 g soil, respectively. Grumusols and Rendzinas containing high ExCa, including free carbonates, are found widely in East and Central Java and some areas of Thailand. The low levels of ExCa in some peat soils, alluvial soils, acid-sulfate soils, low-humic gley soils, and red-yellow Podzolic soils reflected their acid nature.

EXCHANGEABLE MAGNESIUM (ExMg)

The mean ExMg values for Malaysian, Thai, and Indonesian paddy soils were 3.4, 3.8, and 4.7 meq/100 g soil — higher than the mean of 2.8 meq/100 g soil for Japanese soils. Soils containing relatively more ExMg than ExCa were considered as having originated from marine alluvia.

Grumusols contained a large amount of ExMg, but they contained even higher ExCa. The minimum ExMg levels were in low-humic gley soils, red-yellow Podzolic soils, and reddish-brown lateritic soils.

AVAILABLE MICRONUTRIENTS (IRON, MANGANESE, COPPER, AND ZINC)

Micronutrient deficiencies have recently been reported in tropical rice-growing areas. Extremely high levels of the soluble forms of micronutrients in soil cause toxicity disorders in rice plants.

To determine their availability to crops, iron (Fe) was extracted with $1\ N\ \text{NH}_4\text{OAC}$ (pH 4.8), manganese (Mn) with $1\ N\ \text{NH}_4\text{OAc}$ (neutral, containing 0.2% hydroquinone), and copper (Cu) and zinc (Zn) with $0.1\ N\ \text{HCl}$.

THAI PADDY SOILS

A low humic gley soil was low in AvMn, AvCu, and AvZn. An alluvial soil was low in AvZn.
MALAYSIAN SOILS

An acid-sulfate soil was low in AvMn; a peat soil, low in AvFe and AvMn.

INDONESIAN SOILS

The red-yellow Podzolic soil was low in ExK and AvFe, but extremely high in AvMn. An Andosol was low in ExK, AvMn, AvCu, and AvZn; a peat soil, low in AvMn and AvCu. The Rendzina was extremely low in AvFe, AvCu, AvZn, and AvP, and high in pH. A reddish-brown lateritic soil was high in AvFe and low in AvP.

Such soil nutrient conditions can cause nutritional disorders in rice plants.

CONCLUSION

Chemical analysis of 53 paddy soil samples collected from Thailand, Malaysia, and Indonesia showed that paddy soils in tropical Asia generally have a heavier texture and a higher level of ExMg than paddy soils in Japan. However, they have lower levels of OC, TN, AvN, PNM, and AvP.

The data also show that some tropical soils have extremely high levels of ExCa, AvFe, and Mn, and that others have exceptionally low levels of ExK, Ca, Mg, AvFe, Mn, Cu, and Zn. Excesses or deficiencies of one or more of the nutrients are common.
COMMENTS ON DR. KAI’S PAPER:

Mineralization of soil nitrogen in Thailand

Michio Araragi

The research presented by Dr. Hideaki Kai on the mineralization of soil nitrogen and results of the micronutrient analyses deserve notice. The mean values of available nitrogen mineralized during reductive incubation were 17.5, 4.0, 5.1, and 6.3 meq/100 g soil for Japanese, Thai, Indonesian, and Malaysian soils, respectively. Each value corresponds to the total nitrogen content. The values of percentage nitrogen mineralization (PNM) were 6.5, 4.4, 2.8, and 2.5% respectively. These values are not parallel to the total nitrogen content in the soils of each country. The reason lies in the difference in the quantity and quality of other elements, such as iron, that affect the mineralization of soil nitrogen.

In the general groups of microorganisms the largest difference between tropical (Thailand) and temperate (Japan) paddy soils was in the ratio of aerobic bacteria to actinomycetes. The value for the tropical soils was 1.6 in the rainy season, while that for the Japanese soils was 9.7 before irrigation in the spring. This difference was considered due to the absence of cultivation during the 6-month dry season, during which spore-forming actinomycetes survive.

The populations of microorganisms, except the cellulose decomposers, decreased in the dry season. The largest decrease was in the population of the nonspore-forming nitrite oxidizer. The populations of 12 groups of microorganisms, except the nitrite oxidizers and the purple nonsulfur bacteria, were highest in fresh-water alluvial soils that are heavy clay with a rather high organic-matter content. They were second-highest in low-humic gley soils, with low organic matter content. They were lowest in brackish-water alluvial soils, with low available phosphorus content and low pH value.

The number of nitrite oxidizers was highest in low-humic gley soils, which had the highest Eh value and the thickest oxidized layer among the three Great Soil Groups. In contrast, the number of nitrite oxidizers was small in fresh-water alluvial soils with low Eh value and a thin oxidized layer. Nitrite oxidizers were the least numerous in brackish-water alluvial soils. Their number seemed to correspond with the development of an oxidized layer.

The amount of molecular nitrogen released into the atmosphere from the control

Kyushu National Agricultural Experiment Station, Japan.
plot of low humic-gley soils was 7 times as high as that from the brackish-water alluvial soils. The amount of molecular nitrogen in soil gas increased after phosphate application, particularly in brackish-water alluvial soils. After the application of rice straw (6 t/ha) with nitrogen fertilizer, the amount of molecular nitrogen in soil gas increased, compared with that in corresponding plots without rice straw.

Methane gas was hardly detected before rice straw was applied to the plots with brackish-water alluvial soils. After application of rice straw, the amount of methane gas in both Great Soil Groups increased.

Following the application of rice straw with nitrogen fertilizer, the population of denitrifiers increased in both Great Soil Groups. Five weeks after transplanting, the population of nitrite oxidizers was lower in the topsoil (0–1 cm) of brackish-water alluvial soils than in the plot without rice straw.
Three rice virus diseases — rice dwarf virus, striped virus, and black-streaked dwarf virus—have been reported since ancient times in Japan as well as in Korea, China, and other East Asian countries. In the 1960s new virus diseases such as tungro, grassy stunt, and transitory yellowing were reported in Southeast Asia. Two new virus diseases have recently been reported: ragged stunt, first found in Indonesia and Philippines in 1976 and gall dwarf, first reported in Thailand in 1979.

Some of the rice virus diseases widely distributed in Southeast Asia have been found in paddy soils in Kyushu, Japan since 1970. For example, waika ("dwarf" in Japanese) virus disease appeared in 1970 along the coast of Ariake Bay in western Kyushu Island. The disease spread throughout Kyushu in 1972-73. The causal agent was not initially known but was later confirmed to be transmitted by a spherical virus identical to a causal agent of tungro virus.

Waika virus may invade Kyushu from Southeast Asia through its vector, the leafhopper *Nephotettix*. Its routes and mechanisms, however, are still unknown. The disease epidemics of 1972-73 were believed to be caused by the widespread cultivation of the variety Reiho, which is susceptible to waika virus.

Transitory yellowing virus disease has occurred in the double-cropped rice areas of Taiwan since 1960. In Japan, the disease was first reported in 1977 in Okinawa Prefecture. The leafhopper density was high in the Nansei Islands of Okinawa. The leafhoppers may have migrated from Taiwan to Okinawa.

Grassy stunt virus was first reported in Japan in Kyushu Island in 1978. Its spread throughout Kyushu was confirmed in 1979.

Ragged stunt was also reported in Kyushu in 1979. Ragged stunt was reported in Indonesia and the Philippines in 1976. A recent survey showed that the planthopper *Nilaparvata lugens*, a vector of both grassy stunt and ragged stunt, migrates to Japan in the wet season (Jun-Jul).

The outbreaks of grassy stunt and ragged stunt viruses and the 1970 occurrence of waika disease in Kyushu Island suggest that Kyushu is the area of Japan that is most closely related to, and influenced by, Southeast Asia’s natural environment.

The leafhopper *Nephotettix cincticeps* transmits the rice dwarf virus disease and

Table 1. Rice virus diseases in Japan.

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<th>Main vector</th>
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<td>Dwarf</td>
<td>Spherical 70</td>
<td><em>Nephotettix cincticeps</em> Uhler</td>
<td>Southern Japan Including Kyushu</td>
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<tr>
<td>Stripe</td>
<td>Branched filamentous 400 × 8</td>
<td><em>Laodelphax striatellus</em> Fallén</td>
<td>Southern Japan Including Kyushu, Hokkaido</td>
</tr>
<tr>
<td>Black–streaked dwarf</td>
<td>Spherical 75-80</td>
<td><em>L. striatellus</em> Fallén</td>
<td>Southern Japan including Kyushu</td>
</tr>
<tr>
<td>Necrosis mosaic</td>
<td>Rod–shaped 275 × 13</td>
<td><em>Polymyxa graminis</em></td>
<td>Southern Japan including Kyushu</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waika</td>
<td>Spherical 30</td>
<td><em>Nephotettix cincticeps</em> Uhler</td>
<td>Kyushu (1971) (tungro group)</td>
</tr>
<tr>
<td>Transitory yellowing</td>
<td>Rod–shaped 180-200 × 84</td>
<td><em>N. nigropictus</em> Stål</td>
<td>Ryukyu Islands (1977)</td>
</tr>
<tr>
<td>Grassy stunt</td>
<td>Spherical 20</td>
<td><em>Nilaparvata lugens</em> Stål</td>
<td>Kyushu (1978)</td>
</tr>
<tr>
<td>Ragged stunt</td>
<td>Spherical 60</td>
<td><em>N. lugens</em> Stål</td>
<td>Kyushu (1979)</td>
</tr>
</tbody>
</table>

Table 2. Rice virus diseases in Southeast Asia.

<table>
<thead>
<tr>
<th>Name of disease</th>
<th>Virus particle (nm)</th>
<th>Main vector</th>
<th>Distribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tungro</td>
<td>Spherical 30</td>
<td><em>Nephotettix virescens</em> Distant Bacilli form 31 × 100-160</td>
<td>Southeast Asia Philippines (1963)</td>
</tr>
<tr>
<td>Transitory yellowing</td>
<td>Bullet-shaped 180-200 × 84</td>
<td><em>N. nigropictus</em> Stål</td>
<td>Taiwan (1963) Thailand (1979)</td>
</tr>
<tr>
<td>Grassy stunt</td>
<td>Spherical 20</td>
<td><em>Nilaparvata lugens</em> Stål</td>
<td>Southeast Asia Philippines (1964)</td>
</tr>
<tr>
<td>Ragged stunt</td>
<td>Spherical 60</td>
<td><em>N. lugens</em> Stål</td>
<td>Southeast Asia Indonesia (1976)</td>
</tr>
<tr>
<td>Gall dwarf</td>
<td>Spherical 65</td>
<td><em>N. nigropictus</em> Stål</td>
<td>Thailand (1979)</td>
</tr>
</tbody>
</table>
Table 3. Area of rice waika incidence, 1970–76.

<table>
<thead>
<tr>
<th>Year</th>
<th>Area of incidence (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>23</td>
</tr>
<tr>
<td>1971</td>
<td>1,647</td>
</tr>
<tr>
<td>1972</td>
<td>11,924</td>
</tr>
<tr>
<td>1973</td>
<td>24,825</td>
</tr>
<tr>
<td>1974</td>
<td>612</td>
</tr>
<tr>
<td>1975</td>
<td>24</td>
</tr>
<tr>
<td>1976</td>
<td>17</td>
</tr>
</tbody>
</table>

the smaller brown planthopper *Laodelphax striatellus*, rice stripe virus disease. Those hoppers inhabit limited areas of East Asia, so practical measures to forecast and control virus diseases that they transmit should be relatively easy. The vectors of grassy stunt and ragged stunt diseases, however, are widely distributed in Southeast Asia and migrate with the summer monsoon. Countermeasures against such diseases and their vectors should be established from a global point of view.
COMMENTS ON DR. SHINKAI'S PAPER:

Occurrence of rice waika disease in Japan

Yasumichi Nishi

Since 1970, damaged plant masses of dwarfed rice have been observed in patch-like patterns in paddy fields in the coastal region surrounding Shimabara Bay, and in Fukuoka, Saga, Nagasaki, and Kumamoto Prefectures of Kyushu District. In Kyushu, where the variety Reiho has been widely grown, the damage amounted to 1,650 ha in 1971, 12,300 ha in 1972, and 25,000 in 1973. No damage was found in Oita and little damage was observed in Kagoshima and Miyazaki Prefectures in Kyushu. No damage was reported outside Kyushu.

SYMPTOMS

Clear symptoms of waika can be observed at the heading stage. Healthy and infected plants do not differ in the number of stems and panicles. But in infected plants, culm length decreases by 20%, panicle length by 10-20% and yield by 30%. Grain quality is also lowered.

Plant masses with dwarfed stems form sink-like patches. The size of the affected area is not fixed. Mixed stands of dwarfed and normal plants surround such patches. These are the only observable symptoms.

By 1973, a distinct symptom was observed in Kyushu. The leaf tip of the 2d and 3d leaves from the flag leaf turned light-yellow from early to mid-August.

Dwarfed plants were examined morphologically. The first plant parts to suffer from inhibited elongation were the 4th to 5th internodes from the panicle-based internode, the 5th leaf sheath from the flag leaf, and the 4th leaf blade from the flag leaf. The symptoms appeared 43 days before heading, or earlier. The plants suffer from disease in early growth stages after transplanting.

Symptoms of the virus disease were generally observed in the variety Reiho and, occasionally, in Nihonbare and Kinmaze.

CAUSES

Interdisciplinary research projects among plant breeders, agronomists, pathologists, and entomologists in Kyushu were conducted to determine the cause of the plant disease.
damage. In September 1973, the Fukuoka Agricultural Experiment Station proved that the symptoms were caused by an insect vector, the green leafhopper. By electron microscope scientists observed spherical particles, 30 nm in diameter, in infected plants. Similar particles were found in plants that were consequently infected through the hopper-infected plants. Another insect vector, the Taiwan green rice leafhopper, caused similar symptoms.

Those findings indicated that the symptom was induced by rice waika disease. In succeeding infection experiments, waika was found to require a shorter acquisition feeding time and transmission threshold period than other virus diseases. Waika virus has no latent period in the insect’s body, and transmission is nonpersistent because of the short transmission period.

**RELATION TO TUNGRO VIRUS**

Waika virus disease resembles tungro virus, which is common in Southeast Asia. Saito and others recognized spherical particles, 30 nm in diameter, and bacilli-form particles in tungro. They found no serological differences between the particles.

Further studies are needed to distinguish between rice waika virus and rice tungro virus, to determine why waika has occurred in Kyushu, and to determine its transmission cycle.
Rice virus diseases in Asia are transmitted by insects, particularly cicadellid leafhoppers and delphacid planthoppers. These hoppers also damage rice directly by sucking the plant juices.

Among cicadellids, the genus *Nephotettix* is important as a vector of viruses, including mycoplasma. *Nephotettix cincticeps*, *N. virescens*, *N. nigropictus*, *N. malayanus*, and *N. parvus* are distributed across Asia. Some of these species are considered virtually sibling species, showing different ranges of distribution and host-plant segregation. The first three transmit several viruses, *N. malayanus* and *N. parvus* also are vectors but are indigenous to gramineous grasses, primarily *Leersia hexandra* grown at watersides. These two species are not associated directly with the incidence of virus disease in rice.

*N. cincticeps* is distributed in the temperate and the subtropical areas. *N. virescens* and *N. nigropictus* are sympatric in the subtropics and the tropics. In contrast, *N. malayanus* and *N. parvus* are distributed in patches only in the tropics. The cicadellid *Recilia dorsalis* is also a vector of some viruses common to those transmitted by *Nephotettix* spp. *R. dorsalis* has a broader range of distribution, from the temperate area to the tropics, but is less important as a vector because of its inefficient transmission of all viruses except orange leaf mycoplasma in Thailand.

*Nilaparvata lugens* is the only delphacid that is important as a vector of virus diseases common in Asia. It transmits three viruses, including the newly found wilted

![Synoptic weather maps](image_url)

Synoptic weather maps on days when a mass of planthoppers immigrated southwest to Kyushu, Japan (21:00 h, 6-8 July 1980).

Kyushu National Agricultural Experiment Station, Japan.
stunt disease in Taiwan. The only host plant of *N. lugens* is the genus *Oryza*, including rice.

In recent years, close attention has been paid to *N. Lugens* as a vector of virus diseases because of its serious outbreaks throughout Asia. *N. lugens* is native to the tropics. Long-range migration to the subtropics and the temperate areas, where the planthopper cannot hibernate in winter because of a lack of diapause, helps spread virus diseases.

The movement of viruliferous insects offers many opportunities for insect-borne viruses to spread to new areas. But the range of virus spread depends on the insects’ flight (i.e. short- or long-distance migrations). *Nephotettix* spp. and *R. dorsalis* are short- or middle-distance migrants compared with *N. lugens*. The origin of *N. lugens* in Japan is unknown. It appears that their transoceanic, long-distance migrations from the southwest are associated with synoptic weather conditions. Immigration into Japan coincides with the inflow of warm and humid air masses from the south or southwest during the Bai-u period (Jun-Jul) in early summer. The inflow of air is associated with depressions along the frontal zone from central China. Seasonal patterns of *N. lugens* migrations in inland China were recently reported.

In addition to the recent invasion of *N. lugens*-borne virus diseases, the decrease in susceptibility of *N. lugens* to insecticides in Japan has caused complex problems. An international program on countermeasures to insect-borne diseases and the migration of their vector insects should be promoted.
Problems in intersubspecies hybridization in cultivated rice

Takeshi Omura

Cultivated rice consists of many ecotypes classified into two major subspecies, indica and japonica. Hybrids between the two subspecies show wider variation than hybrids within each subspecies.

SEGREGATION-DISTORTION

The segregation of some characters in intersubspecific hybrid progenies deviates significantly from the Mendelian expectation. Two hypotheses have been proposed on the genetic mechanism of this phenomenon. One holds that segregation is caused by complementary fertility genes while another proposes that it is caused by genic or chromosomal duplication. We found that gametophyte genes \(ga\), which are found in both indica and japonica varieties, can cause distortion. Pollen grains with \(ga\) have less pollinating ability than those with \(ga^+\). Linkage of a marker gene with \(ga\) reduces its frequency in the segregating generation. The degree of decrement depends on the pollinating ability of the pollen having \(ga\) and the intensity of linkage.

The gametophyte gene and complementary fertility genes prevent the free recombination of characters and thus act as barriers to reproductive isolation.

DIFFERENCE IN LINKAGE INTENSITY

Linkage prevents the free recombination of characters; its intensity determines the efficiency of breeding. The linkage intensity between genes was estimated in the \(F_2\) of hybrids made within subspecies and hybrids of subspecies. For example, the mean recombination value between \(d_6\) and \(g\) was estimated at 1.6% in the intersubspecific and 4.5% in the intrasubspecific hybrids—a highly significant difference. Explanations of the stronger linkage intensity in hybrids made within a subspecies are obscure. The reason may be minute differences, cytologically undetectable, in the chromosome structure of indicas and japonicas.

Faculty of Agriculture, Kyushu University, Japan. The full text of the paper appears in Bull. Inst. Trop. Agric. Kyushu Univ. 4:99-104.
When breeding rice varieties suitable to temperate regions by intersubspecies crosses, we should consider the existence of chlorosis genes because chlorosis may eliminate other characters linked to it.

When germinating seeds of some varieties are grown at temperatures lower than 20° C, the seedlings show chlorosis. The lower the temperature, the greater the degree of chlorosis. Seedlings recover from chlorosis when temperature rises, but wither when chlorosis is high and temperature does not rise. Depending on the differences in temperature and variety, the degree of chlorosis varies from a fine white stripe to complete whitening. Single recessive genes control chlorosis. More than four loci are found; one is located on the first chromosome. Indica varieties contain chlorosis-controlling genes but japonicas do not.

The frequency of varieties having ga is 75% in the Indian Subcontinent, only 15% in Indonesia, and none in the Philippines.
Sterility or close genetic linkage between the desirable and the undesirable traits in hybridization programs often causes difficulties in introducing Characteristics of indica rice into japonica rice. Because all undesirable traits should be removed during breeding, the procedure becomes extremely difficult. Some fatal defects that cannot be identified early are identified in the later steps of breeding.

We can understand how difficult it is to use indica rice as breeding material by looking at past breeding experiences. From 1951 to 1979, 6,162 crosses were made at 5 rice breeding stations — Tohoku, Hokuriku, Chugoku, Kyushu, and the Central National Agricultural Experiment Station. About 10% (623 crosses) involved indica rices as crossing parents. Only two of those crosses resulted in seven commercial cultivars through two parental lines. Most of those varieties were from the breeding program for introducing indica blast resistance into japonica rices. Recently some parental lines with resistance to planthoppers or leafhoppers and to dwarf disease have been bred. In the past, it took 11-14 years to develop a parental line; now it takes only 7-10 years. Three to five backcrosses are usual today; single crosses were common in the past when Chinese varieties were used as parents.

In the 1950s indica rices were used as breeding materials for blast resistance, for stiff straw, and for direct-seeding adaptability. In the 1970s indicas began to be used as parents for insect and virus disease resistance. In 1979, a new breeding project to develop high-yielding varieties for livestock feed was initiated using indica-type parents such as Milyang 23, Suweon 258, and IR24.
Two important rice breeding projects of indica-japonica hybridization have been launched outside of Japan. The first, in Taiwan, was initiated in 1931. The average yield of Taiwanese japonica varieties (called ponlais) from 1909 to 1912 was 27% higher than that of the native varieties. In 1926, Japanese varieties planted on 119,600 ha in Taiwan produced 186,700 t of brown rice. Their superior yield potential encouraged their use as parents in breeding programs.

The leading varieties developed from cross combinations involving japonica varieties were Taichung 65 (Kameji/Shinriki), Chianan 2 (O-luan-chu/Shinriki Aikoki/Taichung 65), and Chianan 8 (O-luan-chu Shinriki Aikoki Taichung 65). Taichung 65 remained the leading variety until 1959 when Chianan 8 surpassed it in area planted. Seventy-nine of 96 commercially grown ponlai varieties today are progeny of Taichung 65.

Chianung 242 (Hsinchu 4/Taichung 150//Taipei 7/Tainung 45) released in 1955, yielded high at many locations. In 1962 its highest yield for the first crop was 11.2 t rough rice/ha. Chianung 242 is a panicle-weight type with high fertilizer response. The first crop of Chianung 242 matures in about 125 days and is 110-120 cm tall. Tianan 5 (Kaohsing/Chianan 8) was released in Taiwan and by 1970 was planted on 302,000 ha (39% of the total rice area). Tianan 5 matures in about 120 days and is 100-110 cm tall. It has narrow leaf blades and its leaves remain green even at the ripening stage.

Taiwan's increased rice production (about 50% more than in the past decade) is largely attributable to the use of outstanding ponlai and semidwarf indica varieties as crossing materials.

The second and largest japonica-indica rice hybridization project was the post-World War II International Hybridization Scheme (IHS), sponsored by the International Rice Commission and funded by the Food and Agriculture Organization (FAO). The objective was to transfer the high yielding ability and fertilizer response of japonicas to indica varieties that are adapted to local cultural conditions, diseases, and insects.

Most tropical Asian countries participated in the project, sending seeds of their
best varieties for crossing with japonicas at the Central Rice Research Institute (CRRI), Cuttack, India. A parallel scheme of hybridization, with similar objectives, was initiated by the Indian Council of Agricultural Research (ICAR). These two projects used 192 improved indica varieties selected by the participating Asian countries and Indian states, and produced 710 japonica-indica hybrids. F1 seeds were distributed to the participating countries or states, who then grew the F2 and subsequent generations and crossed them to breed varieties better suited to local conditions. This project resulted in the release of only four commercial varieties — Malinja and Mahsuri in Malaysia; ADT27 in Madras, India; and Circna in Australia.

Gangadharan said in 1972 that these two projects failed because of the selection of tall japonica parents that were sensitive to both photoperiod and temperature. He also said the high yield potential and response to fertilizer of japonicas, which flowered in 35-40 days in India, could not be transferred into Indian varieties under Indian conditions. He concluded that the difference in yield potential of Indian and Japanese rice varieties was because solar radiation during India’s monsoon period was lower than that of Japan. In India ADT27, which is suitable for the early monsoon season, replaced the earlier varieties ADT3 and ADT4.

In West Malaysia, double cropping of rice began in 1942 when the Japanese introduced off-season varieties such as Ryushu, Taichung 65, and Pebifun from Taiwan. Pebifun was popular as an off-season variety until 1964.

The varietal improvement program for double-cropped rice in West Malaysia during the postwar period was limited to pureline selections among the indigenous varieties; it terminated in 1963. Breeding for double-cropping varieties began in 1951 when West Malaysia participated in the IHS. Selections from indica × indica crosses of local varieties had proved unsuitable for double cropping because of poor grain quality and sensitivity to photoperiod. The first double-cropping varieties, Malinja and Mahsuri, were selected from F2 materials from a group of 13 crosses received in 1956 from CRRI through the IHS. Malinja (Siam 29/Pebifun) was released in 1964 as an F17. Individual selection of that hybrid population was started from the F7, and 910 F8 pedigrees were tested. Mahsuri (Taichung 65/Mayang Ebos//Mayang Ebos) was released in 1965 in the F18 generation; 206 F7 pedigrees were selected from the F6 bulk population. These breeding programs were conducted through the cooperative effort of four Japanese scientists: Y. Yamakawa, K. Fujii, J. Kawakami, and S. Samoto.

Parthasarathy wrote in 1972 that the final promising strains in the indica-japonica hybridization program were from crosses involving the following japonica parents: in Burma — Norin 6, 8, 18, Rikuu 12, Asahi; India — Norin 6, 17, 18, 20, 36, Rikuu 132, Asahi; Philippines — Norin 1, 16; Thailand — Rikuu 132. (The project participants found Rikuu 132 promising as a parent.) The characters aimed at in this breeding program were nonshattering traits, high tillering, nonlodging
habit, good grain quality, early maturity, low sensitivity to photoperiod, and high response to intermediate levels of fertilization.

The first success of IRRI’s breeding program was IR8 (Peta/Dee-geo-woo-gen), a semidwarf indica variety suited to the tropics. The plant-type objectives for the IRRI breeding program were short, sturdy stems; moderate tillering; lodging resistance; erect leaves; and nitrogen responsiveness (a trait that certain japonica and U.S. varieties already possessed). Beachell said in 1972 that the tropical indica varieties had a distinct advantage over semidwarf japonica and U.S. varieties because of their vegetative vigor, high tillering ability, and high leaf-area index. He said that many of the segregates from crosses involving japonica and U.S. varieties tend to have an erect-tiller arrangement. Lines with open tillers, such as IR8, tended to yield more than those with erect tillers.

Today IRRI uses a number of varieties and lines of japonica or japonica-indica origin in crosses for improvement of gelatinization at high temperature and grain appearance; for intermediate amylose and high protein content; glabrousness; early maturity; short plant stature; slow senescence; nonshattering panicles; and for resistance to cold temperature, blast, and bacterial blight.

Some japonica varieties used in IRRI’s program are: Yukara, Wase Aikoku 3, Rikuto Norin 22 (Japan); Santo, Chow-sung, Chok-jye-bi-chal, Jinheung (Korea); Kaohsiung 68, Taichung 172, Chianan 8, Chianung 242, PI 215936 (Taiwan); Crythoceros Korn (Portugal); and Omirt 39 (Hungary).

U.S. varieties that IRRI uses as parents include: Century Patna 231, Dawn, Bluebelle, Belle Patna, B589A4-18, Zenith, Calrose, and Earlyrose.
A proposal for joint efforts to promote rice research in developing nations

Discussion Summary

The gap between developed and developing countries has widened despite the persistent efforts of national and international organizations to narrow it. Although agricultural production has increased substantially for the past two decades, the levels attained are still inadequate considering present per-capita income and tropical Asia’s population increase of 2.0-2.5%/year.

Agricultural production in developing countries is for two purposes: 1) to earn foreign currently through the export of raw materials such as sugar, rubber, natural fibers, or palm oil; and 2) for domestic consumption, with rice as the staple food. Some countries earn extra foreign revenue through the export of oil or tin. While rice is the major food crop in most tropical Asian countries, it is also important as an export crop in some countries.

Until the end of the 1950s, rice production was increased to meet growing domestic consumption needs through the expansion of rice-growing areas rather than through increased productivity. In the 1960s, the intensification of rice production emerged as top-priority projects in most national development strategies in tropical Asia. But the base for intensified rice production is precarious.

First, the crop has inadequate protection from natural hazards such as drought and flooding. Lack of funds and a scarcity of scientific management may cause the deterioration of the existing environmental integrity for rice cultivation (for example, the erosion of irrigation systems and severe zinc deficiency after continuous flooding).

Second, inadequate social infrastructures such as marketing systems are obstacles to the intensification of rice production. A slight surplus in rice production often leads to the “dumping” of rice on the market. Such tendencies discourage farmers from making further investments to increase rice yields.

The overall task of stabilization of rice production must be shared by government officials, policymakers, rice scientists, and rice farmers.

THE UNIQUE POSITION OF JAPANESE RICE SCIENCE

Japan is the only developed country in which rice is vitally important to the national economy. Therefore, Japan has more experience than other countries in the application of modern agricultural science to rice production.

Japan probably publishes more scientific papers on rice than any other rice-
growing country, even though rapid industrialization has decreased the relative importance of rice in Japan.

Japan’s achievements in rice science may not be universally applicable to tropical Asia until certain limitations are overcome. First, because of Japan’s geographic location, one crop of japonica rice is grown per year under relatively favorable growing conditions. Many Japanese cultivation practices are based on the availability of abundant industrial products although most of the irrigated lands are cultivated by small-scale farmers. Rarely do Japanese rice agronomists have a chance to open a new tract of rice fields.

Although many of Japan’s achievements in rice agronomy are not directly applicable in the tropics, Japanese experience in the use of science to solve rice problems is applicable. Furthermore, international cooperation in rice improvement will expose Japanese scientists to new and exotic experiences. The resulting enrichment of Japanese rice science should help solve future problems in domestic rice cultivation.

PERSPECTIVES IN INTERNATIONAL COOPERATION

Returns could be high if Japan’s accumulated knowledge and pool of rice scientists are properly channeled toward the improvement of rice cultivation in other areas.

**Breeding**
The international sharing of genetic materials and experiences has strengthened rice breeding both within and outside of Japan in the 1970s. For example the brown planthopper resistance of tropical rices has been incorporated into Japanese varieties. Also the success in Korea of high-yielding semidwarf varieties attracted the attention of Japanese breeders; Milyang 23 from Korea is now one of the most popular parents in Japanese breeding programs. Japanese experience in the use of screening facilities to test for cold tolerance has been extended internationally through Korean scientists. Rapid generation advance, a breeding technique developed in Japan, was transferred to IRRI.

**Disease management**
The strengthening of research on virus epidemics would benefit both Japan and tropical nations. Two viruses recently identified in Japan, for example, are also found in the tropics. Japan has developed sophisticated techniques to identify virus disease complexes. But more work is needed in the tropics, where virus diseases and resistance mechanisms often differ from those in Japan.

**Insect management**
Many insect species or biotypes migrate across international boundaries. Information on the biotype situation of the brown planthopper in one country is needed in forecasting biotype changes in another country. The development of reliable insect control measures using natural products of resistant host plants or hormone-like substances, rather than insecticides, requires more sophisticated research facilities.
and techniques than are available in most developing countries. Japanese universities express interest in participating in such research.

**Soil science**

Japan has a traditionally strong background in conserving the fertility of soils, particularly of submerged soils. For example, the application of nitrogen fertilizer to deeper soil layers has been recommended in Japan since the 1940s. Biological nitrogen fixation became a topic of widespread interest in Japan after the rise in prices of chemical fertilizers. Japanese rice scientists have screened the rice germplasm and identified a group of rices that seem symbiotic with nitrogen-fixing bacteria.

**PROBLEMS IN INTERNATIONAL COOPERATION**

There is no strong Japanese tradition of mission for less-favored countries. Japan has participated extensively in international aid and cooperation for only a few decades.

Communication is perhaps the most serious problem for Japanese scientists assigned to overseas programs. The Japanese have easy access to most available research knowledge in their own language. Many foreign publications, even in highly specialized fields, are available through translation. Thus, Japanese scientists are not highly motivated to learn foreign languages. Furthermore, the peculiarity of Japanese pronunciation and grammar makes learning a foreign language even more difficult.

The problems facing Japanese agriculture today cause many to feel that all research efforts should be directed to internal issues. Furthermore, among intellectuals there is a tacit but persistent skepticism regarding international aid; many consider it a tool for economic expansion.

Skepticism or misunderstanding regarding international cooperation can be remedied by providing critics information on facts, rather than by stirring up debates. A dialogue based on achievements would lead to a balanced recognition of the need for dynamic international cooperation, as well as its problems and limitations.

Institutional problems are serious hindrances to the participation of Japanese scientists in international programs. No quick or easy solutions are available. The “closed employment system” of Japan does not allow a scientist to undertake long-term assignments abroad. Children of scientists who opt to stay overseas cannot pursue education under the Japanese system and thus are isolated from their cultural community.

A compromise solution may be found in some flexible format of overseas services. The Tropical Agriculture Research Center (TARC), for example, dispatches its scientists to overseas assignments with 1 month of follow up research at TARC for 5 months abroad. Similarly, Japanese institutions might consider sending “visiting scientists” abroad on recurrent assignments with national program collaborators handling continuing projects in the interim. TARC has successfully developed such a system for its bilateral programs with other countries. Whatever modification is
adopted, the first step toward this format is an agreement between participating organizations, which have their own legal requirements.

Recognition of international programs merits further consideration. Some of the best programs of bilateral cooperation do not receive due recognition.

Although at least three Japanese ministries are concerned with international aid or cooperation in agriculture, many institutes have no mandates for international activities. The Ministry of Foreign Affairs (MFA) has an exclusive responsibility for all international activities in liaison with the Japan International Cooperation Agency. MFA has a strong budget, but it lacks professional workers in agriculture. The Ministry of Education (ME) and the Ministry of Agriculture, Forestry, and Fisheries (MAFF) are concerned with internal problems. ME is assigned to basic research and education of specialists, and MAFF to production-oriented research. Although both have minor sections for international affairs and a large pool of agricultural scientists, they have little room for joint endeavors. These administrative diversities complicate international cooperation and necessitate the creation of forums for the exchange of views and experiences.

ENCOURAGEMENT OF INTERNATIONAL COOPERATION

The addition of new institutes or sections to promote tropical agricultural research is a notable change in some universities in the past decade. Such sections should establish forums through which leading administrators and influential scientists can express their views on the problems of international agricultural research and help identify priority areas.

A review of international rice research including perspectives, problems, and possible solutions is needed. The IRRI-Japan Office may be able to help with such a review through its close cooperation with experienced scientists in other national programs. The report of the present symposium might serve as a preparatory guide for such a review.

There seems to be an “information gap” between Japanese universities with recently expanded sections for international agriculture and other international organizations involved in agricultural research. Therefore, Japanese university scientists must become acquainted with the agricultural research centers and organizations of the Consultative Group for International Agricultural Research (CGIAR). More efficient liaison is needed between those in charge of supporting CGIAR in MAFF and those in university sections oriented to international agriculture. If university professors recognize the roles and quality of the CGIAR institutes, joint CGIAR postgraduate training programs might be developed. Such training would simultaneously strengthen the staff of new international sections of universities and add to a pool of scientists who might work at international agricultural institutes.
RECOMMENDATIONS

1. The wealth of scientific knowledge accumulated by Japanese scientists in the last century must be made readily available to other countries.

2. Although Japanese technology is not always readily applicable in the tropics, Japanese scientists will benefit from the exposure to the diverse climates, soils, and human societies in other rice-growing areas. Such experiences will undoubtedly have domestic application in solving future Japanese agricultural problems.

3. Japanese research has been influenced by Japan's traditional society, civil culture, and scientific background. We believe that worldwide interaction among scientists will make rice culture and science itself more productive.

4. Problems discussed in this seminar include soil fertility, pathology, entomology, and plant breeding.

5. Although the agricultural research organizations established through the Consultative Group for International Agricultural Research have short histories, they lead in international research and will continue to do so. Japanese recognition and participation in their worldwide research and communication networks will help fully develop the ability and leadership of Japanese scientists, and will benefit the small-scale farmers and urban consumers in the developing nations.

6. The public and private agricultural research organizations of Japan have much to offer in the tropical agriculture because Japan is the only developed nation that grows and studies rice.

7. International and Japanese organizations that understand the need for participation of Japanese scientists should provide sufficient funding to enable the scientists to work freely without anxiety about family cares and future positions.

8. We aim to see a more dynamic international exchange of scientific information. We hope to promote greater international understanding of Japan's scientific achievements in relation to its socio-cultural history and, thus, ensure ready and unbiased acceptance of our local scientists by international organizations.

9. Internationalized Japanese scientists are urgently needed. We ask domestic organizations, as well as international ones, to give our junior scientists such as students pursuing M.S. or Ph.D. degrees the opportunity for international exchange of scientific experiences.

10. We recommend that international and responding Japanese organizations enter agreements on research collaboration in addition to bilateral agreements on a country basis.

11. We express our sincere respects and appreciation for the sponsors and supporters of this seminar, and our wishes to have similar meetings in the future.
Fifty scientists interested in rice culture and related problems on insects, diseases and virus-like diseases met at Kyushu University. The day-long event was the first of its type to be jointly sponsored by a Japanese institution and IRRI.

Key scientists in the organization and operation of the Seminar were (left) Dr. Takeshi Omura, Kyushu University, Dr. Satoshi Wakimoto, Kyushu University, and Mr. Hideo Akemine, part-time representative for IRRI.

Presentations followed by open discussion periods gave the seminar participants an opportunity to gain greater insight into the material presented.
Discussions of presentations continued on an informal basis during the coffee breaks.

Dr. Takeshi Omura, faculty of agriculture, Kyushu University, and Mr. Hideo Akemine, part-time representative in Japan for IRRI.

Dr. Satoshi Wakimoto, faculty of agriculture, Kyushu University (left) and Mr. Hideo Akemine, part-time representative in Japan for IRRI.
I thank the many scientists who participated in this important meeting, shared their knowledge and experiences, and discussed the problems of tropical rice. We have learned much today about rice in the tropics.

- We have been taught that high-yielding varieties such as IR8 could not expand into areas in Southeast Asia where irrigation and drainage are insufficient. But Dr. Ikehashi’s talk made me realize that the rice improvement is advancing into the regions of Southeast Asia that have thus, tar been “by passed” by the new rice technology.

- Dr. Kai and the commentator emphasized that paddy soils in Southeast Asia differ in fertility in terms of nitrogen and phosphate, and that mineral and nutrient deficiencies, although presently hidden by increasing fertilizer application, may become major problems in the future.

- Dr. Shinkai and the commentators pointed out that insects are transmitting rice virus diseases across international boundaries.

- Dr. Omura and two commentators reported on the difficulty of removal of undesirable genes from improved lines derived from japonica-indica hybridizations. Despite this difficulty, a number of new varieties with exotic genes for resistance to diseases and insects have been released in Japan and several improved tropical varieties carry japonica genes for desired traits.

My strongest impression from today’s talks is that for us to remain concerned only with Japan is nonsense if we seek to truly advance Japanese rice science. International cooperation is essential. The fact that pests do not recognize international borders (airborne rice planthoppers from Southeast Asia, for example, invade Japan through China) emphasizes that we, as scientists, must also have a world wide view.

Planthoppers come by air.
No country borders lie there!
Man cannot defeat planthoppers with country barriers.
We now see fast the fact that
No country border is in science
No country barriers should be in science!

Director, Kyushu National Agriculture Experiment Station, Japan.
I would like to emphasize the need for strengthening of our international cooperative projects with all countries and with international organizations that know no national boundaries!

I painfully heard Dr. Nagamatsu’s and Dr. Kajiwara’s appeal for improved language abilities and greater internationality. We Japanese are often frustrated at international meetings where we cannot explain our research because of our limited language ability.

Today, we appeal to international organizations to recognize the urgency of the need for research to advance tropical rice culture. Simultaneously, I say to Japanese nationals: we must increase both our language ability and our internationality.

Last, I express my gratitude for Dr. Matsumoto, Director of the Institute of Tropical Agriculture, Kyushu University, and Dr. Akemine, IRRI representative in Japan, and other cooperators who have made this seminar possible.