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Woman *Peladang Jaya* in Selangor is operating a coffee shop for farm workers near the fields (Photo by K. Yasunobu)

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JIRCAS
JAPAN INTERNATIONAL RESEARCH CENTER FOR AGRICULTURAL SCIENCES

≪Project Report≫

Comprehensive Studies on Soybean Improvement, Production and Utilization in South America

Makie Kokubun

Soybean, *Glycine max*, is considered to be one of the major crops for human life, especially as oil resource for human consumption and as protein resource for livestock feed. The increase of soybean production has been very rapid compared with that of other major crops for the last three decades (Table 1) and the continuous growth is considered to be very important for the stabilization of the world food supply.

Soybean production in South America, mainly in the MERCOSUR countries such as Brazil, Argentina and Paraguay, accounts for approximately one-third of the total world production (Table 2), and thus the MERCOSUR countries play a major role as leading soybean export countries. However, soybean production in South America has been mostly carried out under environmentally vulnerable conditions such as arid, acid soils with low fertility level. Also, the history of soybean production in these countries is relatively short since cultivation was initiated on a large scale only in the 1960s. It is anticipated that in future growth retardation due to continuous cropping, outbreaks of diseases and pests and soil erosion may adversely affect soybean production in this area. Therefore, research efforts focused on the development of sustainable and more efficient systems of soybean production in South America should be promoted to address these constraints.

Photo 1: Soybean field in Paraguay (January, 1997).

Japan has a long history of soybean cultivation and its use as material of traditional foods. Until now, soybean research in Japan had played an important role worldwide along with the results stemming from research applied in several collaborative research projects implemented by JIRCAS and JICA (Japan International Cooperation Agency). In Brazil, JIRCAS initiated in 1996 a research project entitled "Comprehensive Studies on the Development of Sustainable Agro-Pastoral Systems in the Subtropical Zone of Brazil" in which soybean will be the main crop for the development of mixed, multiple-cropping systems. Also, the Centro Tecnologico Agropecuario en Paraguay (JICA-CETAPAR), which was established in 1962 for extending technical assistance to the Japanese immigrant farmers in Paraguay, is now engaged in studies for the dissemination of no-tillage cultivation system of soybean in the fertile area covered with Terras Roxas soils in Paraguay and neighboring countries for sustainable production.

The JIRCAS's new research project entitled "Soybean Improvement, Production and Utilization in South America" places emphasis on the following characteristics,

(1) Multidisciplinary studies on soybean production and utilization in South America through the collaboration of researchers from Japan and South American countries.
(2) Promotion of collaboration with JICA, and selection of CETAPAR as one of the research sites of the project.

Research areas for implementation include,

1) Genetics and breeding,
2) Soil management and pest control,
3) Crop management and production,
4) Postharvest technology,
5) Socioeconomic aspects.

Research organizations expected to participate in the project are institutes affiliated to EMBRAPA (Empresa Brasileira de Pesquisa Agropecuaria, Brazil), MAG (Ministerio de Agricultura y Ganaderia, Paraguay) and to INTA (Instituto Nacional de Tecnologia Agropecuaria, Argentina), and CETAPAR. The project will be implemented during the period 1997-2006.

Table 1. Cultivated acreage, yield and production of major crops in the 1962-1992 period

	Planted acreage (million ha)		Yield (tons/ha)		Production (million tons)		
Crop	1962	1992	1962	1992	1962	1992	ratio ('92/'62)
Rice	119	147	2.0	3.6	242	525	217%
Wheat	203	220	1.2	2.6	237	564	238
Corn	103	132	2.1	4.0	214	526	246
Soybeans	27	55	1.2	2.1	31	114	368

Source: FAO Production Yearbook, 1963, 1993

Table 2. World soybean production (10,000 tons) by region

Year	World	Asia	North/Central America	South America	Africa	Europe
1979-81	8,607	1,034	5,620	1,801	33	62
1994	13,673	2,237	7,238	3,898	60	146

Source: FAO Production Yearbook, 1994

Cryopreservation of Germplasm of Tropical Crops

Hiroko Takagi, Nguyen Tien Thinh and Pius M. Kyesmu

Conservation of plant genetic resources has become an issue of common global concern. With increasing numbers of accessions requiring *ex situ* conservation through recent intensive collecting activities, it is important to develop reliable techniques for long-term conservation, especially for vegetatively propagated species that are mainly preserved in field gene banks.

Cryopreservation, storage in liquid nitrogen (LN_2) at a temperature of (-196˚), is the only current method that could provide ideal conditions for base collection of vegetatively propagated plant germplasm. In recent years, remarkable progress was made in the field of cryopreservation techniques and different plant materials (cells, protoplasts, meristems, embryos, etc.) from more than 110 plant species were reported to be adequately stored in LN_2. Consequently, cryopreservation was recognized as a practical, efficient and economical tool for long-term storage of vegetatively propagated plant germplasm. There is a growing interest in cryopreservation of crop germplasm in the tropics where species that require clonal maintenance are prevalent. Since tropical species are known to be more sensitive to chilling, low temperature and desiccation than cold-hardy or temperate species, cryopreservation of tropical species has not been studied extensively.

In view of the significance of cryopreservation for plant genetic resources activities, a project on the development of techniques for the long-term conservation of vegetatively propagated tropical crops was set up at the Japan International Research Center for Agricultural Sciences (JIRCAS). This project aims to develop simple techniques for the efficient and stable cryopreservation of shoot tips of several tropical crops i.e. taro, yams and banana.

Recent progress in cryopreservation has provided potentially valuable cryogenic procedures such as slow freezing, desiccation, encapsulation/dehydration, and vitrification. We focused on the vitrification method because the handling of explants by this method is relatively simple and the method has been reported to be successful with complex tissues such as meristems rather than cells. The principle of the vitrification method is as follows: dehydration of a specimen by exposure to a vitrification solution containing a high osmoticum and changes in the conditions of intracellular water as well as penetration of antifreeze substances (such as sucrose, ethylene glycol, dimethyl sulfoxide (DMSO), glycerol) in the vitrification solution to promote the vitrification of the specimen by rapid cooling in LN_2.

Through detailed investigations of the conditions of each procedure of the vitrification method, a protocol for shoot tips of taro (*Colocasia esculenta* (L.) Schott) was eventually optimized (Table 1). The keys for the success were as follows: 1) conditioning culture of shoot tip donor plants with high concentration of sucrose (120g/l), 2) selection of shoot tips with proper size and developmental stage, 3) preculture of dissected shoot tips with 0.3M sucrose prior to the cryogenic procedure, and 4) loading treatment by cryoprotectants at lower concentrations than vitrification solutions. Vitrified and warmed shoot tips obtained by this method resumed growth within 7days, developed shoots directly without intermediate callus formation and almost all the shoot tips that survived were easily transferred to soil in pots. No morphological abnormalities were detected in the plants developed from the cryopreserved shoot tips (Photo 1). The protocol developed was applied to various triploid and diploid taro cultivars and post-thaw survival rates of 67-100% were obtained for the different genotypes.

The protocol for taro was also successfully applied to tannia (*Xanthosoma* spp.), banana (*Musa* spp.), yams (*Dioscorea rotundata* and *alata*), pineapple (*Ananas comosas*), orchid (*Cymbidium*) with some modifications depending on the level of sensitivity of each species to sucrose and vitrification solution.

Our study demonstrated that cryopreservation of shoot tips by vitrification can be useful for the long-term conservation of vegetatively propagated tropical crops.

Photo 1: A) Taro shoots formed from cryopreserved shoot tips by vitrification. Dead shoot tips turned white whereas those which survived showed a green color.
B) Taro plants developed from cryopreserved shoot tips by vitrification.

Table 1. Protocol developed for cryopreservation of shoot tips of taro by vitrification

Step 1:	Culture the shoot tip donor plants on Murashige and Skoog medium (MS) supplemented with 120g/l sucrose for three weeks (conditioning culture)
Step 2:	Dissect shoot tips (0.5-0.8mm in length, apical dome + 1-2 leaf primordia)
Step 3:	Preculture the shoot tips on MS containing 0.3M sucrose for 1 night at 25˚C
Step 4:	Treat the precultured shoot tips with a loading solution [2M glycerol + 0.4M sucrose] for 20min at 25˚C
Step 5:	Expose the loaded shoot tips to PVS2 [30%(w/v) glycerol + 15%(w/v) ethylene glycol +15%(w/v) DMSO + 0.4M sucrose] for 10min at 25˚C
Step 6:	Directly immerse the shoot tips into LN_2 and store
Step 7:	Rapidly rewarm the cryopreserved shoot tips in a 40˚C water bath
Step 8:	Soak the shoot tips into 1.2M sucrose for 10min at 25˚C
Step 9:	Reculture the shoot tips on two layers of blotting paper over MS supplemented with 0.3M sucrose
Step10:	Transfer the shoot tips to MS containing 0.1M sucrose for regrowth of plantlets

Entrepreneur Farmers in Peninsular Malaysia: Profile of *Peladang Jaya*

Kumi Yasunobu, Wong Foong Yee and Laily Paim

The new National Agricultural Policy (1992-2010) sealed a new era for the small-holder farmers in Malaysia. The emphasis of the new policy is on the commercialization of the small-holder and the small "unorganized farmers" sub-sector. To achieve the above objectives, the traditional farmers need to become entrepreneur farmers. In our study, we focus on a special exclusive group of farmers, who have won the annual title of "*Peladang Jaya*"or "Successful Farmers", awarded by the Ministry of Agriculture as respondents. They were chosen to become role model of modern, innovative, resourceful farmers, for others to emulate. They are outstanding individuals when compared to other farmers, nationwide. In our evaluation, they are one step nearer to the "entrepreneur farmer" types as envisioned by the policy makers, to transform the agricultural sector into a modern commercialized entity.

The main purpose of the study is to explore the characteristics of a group of leader farmers, who stood above the rest of their counterparts nationwide, for which they won the title of "*Peladang Jaya*" in annual competition. From the year 1987 to 1993, out of a total 88 farmers listed, 71 *peladang jaya* were selected; 40 male and 31 female farmers. They were purposely selected to represent all the states in Peninsular Malaysia. The respondents were personally interviewed by the researchers. The data collection lasted from November 1993 to July 1994.

In Malaysia, encouraged by the market demand, the enterprising farmers began to diversify their crops and farming activities, which include livestock raising and aquaculture. The survey found that the *peladang jaya* were mostly engaged in mixed cropping, except for 20% who were involved in mono-cropping paddy cultivation. In paddy cultivation, 14 people were mainly engaged in mono-cropping. Others combined the cultivation of paddy rice with other field crops-mostly a combination with industrial, and/or with short-term cash crops, and fruit orchards.

The average income of the respondents in the sample was RM42,791 per year. The income was derived from earnings from farming and non-farming activities. The proportion earned from farming activities was high at 73%. Judging from the average annual income earned, this group

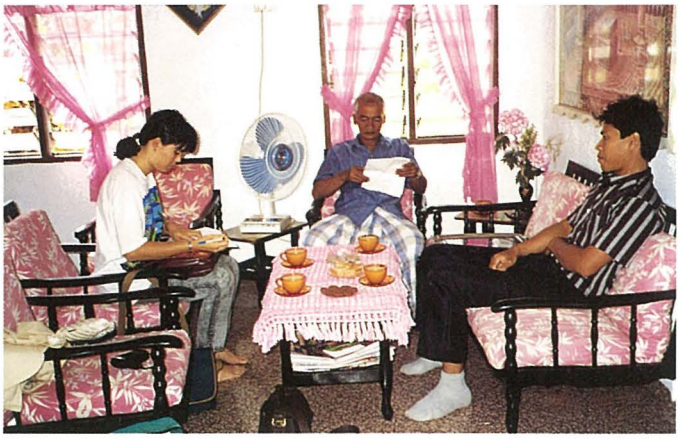

Photo 1: Interview of Peladang Jaya *in Pahang.*

of *peladang jaya* can be categorized as middle income group, and a few can be classified as upper middle income group.

As for the farm and household equipment, the standard of living of *peladang jaya* was higher than the Malaysian average in Agricultural Census. All the farmers owned houses, some of them being relatively large and comfortable, fully equipped with the basic necessities and utilities such as piped indoor water and toilets, when compared to the farmers in their respective villages. Almost all the respondents owned basic electric appliances such as fan (98.6%), refrigerator (97.1%), television set (100%) and radio (95.7%). All except 2 of the respondents used a LPG stove for cooking and 88.6% owned sewing machines. Seventy nine percent of the farmers' households owned washing machines while slightly more than two-thirds had telephones. It is noteworthy to observe that almost one-third (32.9%) owned Kubota/2 wheel tractors, while another 10% big tractors.

By applying principal component analysis, seven factors that represent the attitude of the *peladang jaya* were identified as follows:

Factor 1: "work eagerness"

The respondents were diligent in conducting farming job. Once they faced a problem, they attempted to solve it.

Factor 2: "good planning"

They recognized the importance of planning and realized

Table 1. Characteristics of agricultural performance of *peladang jaya*

Average age:	Male Female	53 50
Average household size:		5.3 people
Source of income:	Farm activities only Farm + non-farm activities	45% 55%
Average size of land-holding:		7.6 ha (range: 2.3 – 17.4 ha)
Range of land rented-in		0.3 – 8.2 ha
Average farm size of *peladang jaya* (Average farm size of Malaysia)		9.3 ha (1.5 ha)

that their effort leads to success. In other words, they attributed their success mainly to proper planning.

Factor 3: "challenging"

They realized the importance of recording and they showed challenging spirits. They knew what action should be taken to resolve a difficulty without other people's help.

Factor 4: "self-confidence"

They considered that the ability to manage is much more important than physical involvement. They also carried out the project because they had a great deal of knowledge and experience.

Factor 5: "cautiousness"

The respondents were able to consider risk.

Factor 6: "resourcefulness"

The respondents knew where and how to seize the opportunities required to improve their farming.

Factor 7: "information seeker"

In summary, they were not only eager to collect information but also did not hesitate to ask people to get more information. These 7 factors accounted for approximately 75% of the variance.

Based on the analysis and interview observations, following three major characteristics can be pointed out for the leading farmers:

1) They made utmost efforts to increase their income. Besides farming they held various side-jobs in small industry or were engaged in large-scale business.
2) They were interested in the new technologies including machinery, chemicals and new varieties. They planted the crops which other farmers in the area did not use. They easily adopted new projects.
3) They had acquired a knowledge and/or experience of farm management practices. Almost all the respondents participated in courses and seminars.

It is noteworthy that even though their educational background was not high, they were eager to gain useful information pertaining to farm management as much as possible. Their formal educational attainment varied from none to 6 years (elementary school level). Some of the respondents who did not have formal education attended "*pondok*" (religious school) in the village.

Fig. 1. Map of Peninsular Malaysia and location of the respondents' house.

Besides being actively involved in farm and non-farm activities, the respondents were also engaged in social activities, such as group farming projects, agricultural associations, religious groups, village committees, etc. They joined not only as members, but held important positions like head, deputy and committee member, implying that they are playing an important role as leaders in their community.

Photo 2: A woman peladang jaya *who has a retail lot in the market besides the production of vegetables (Pahang).*

Photo 3: Peladang Jaya *involved in food processing (chilli sauce) after working in the field (Johor).*

"Sugarcane Stalk" Can Be a Good Roughage for Dairy Cattle in the Dry Season

Tomoyuki Kawashima

Dairy production has been developed in the temperate and cool zones. The feeding system adopted in this area is generally based on preserved roughage such as hay and silage. This system requires large machinery with a large scale of operation. On the other hand, dairy production has been newly introduced into monsoon and savanna zones in the tropics. Generally speaking, dairy production in this region is characterized by a small scale of operation and manpower system. In this system, hay or silage making has not yet been practically implemented. Farmers are very much relying on rice straw as a roughage in the dry season (Photo 1). Low nutritive value of rice straw limits further improvement of production. And collection of rice straw is a labor/time-consuming work, which is another constraint. On the other hand, sugarcane has unique characteristics. It can produce a large amount of biomass and stand until the end of the dry season without withering, which allows farmers to cut it when necessary without the need for preservation. The use of sugarcane stalks (Photos 2 and 3) as a roughage for cattle has been examined in Northeast Thailand.

A metabolic trial by using Brahman cattle was carried out in order to determine the content of metabolizable energy in sugarcane stalks, which amounted to 9.05 MJ/kg. It was estimated that sugarcane can supply nearly 3 times the level of metabolizable energy per ha than that that by ruzi grass which is the major grass produced in the region.

Sugarcane stalk can be divided into an easily soluble fraction, i.e. sugar, and hardly degradable fraction, i.e. bagasses. The turnover rate of digesta from the rumen was compared between the cattle given either ruzi grass hay or sugarcane stalks. While the liquid phase outflow was faster in the cattle given sugarcane stalks than in those given ruzi grass hay, the solid phase outflow was slower in the cattle given sugarcane stalks (Table 1). It was considered that bagasses remained in the rumen for a long period of time without degradation, which would suppress feed intake. Although sugarcane stalks have a relatively high metabolizable energy content, cattle can not consume a sufficient amount of sugarcane stalks to satisfy their energy requirement. Therefore, cattle must be given concentrate feed to fulfill not only the protein but also the energy requirement.

Feeding trial was carried out using milking cows owned by a private dairy farmer in order to examine the use of sugarcane as a roughage for milking cows. Milking cows were given either only rice straw *ad libitum* or chopped sugarcane stalks plus rice straw *ad libitum*. Both groups were also given commercial concentrate feed whose amount was determined by the farmer based on the cow's body condition as well as milk yield. Milk production tended to be higher in the cows given sugarcane stalks than those given only rice straw in spite of the lower total DM consumption. Protein content in the milk of the cows which received sugarcane stalks was significantly higher than that in the milk of cows given rice straw. It was considered that the energy supply was increased by supplying sugarcane stalks, which affects the improvement of the protein content in the milk, while energy supply was not sufficient when only rice straw was given to cows.

Sugarcane stalks can be a good roughage for milking cows in the dry season provided that they are supplemented with proper protein and energy sources.

Table 1. Turnover rate of liquid and solid phase in rumen, and liquid volume of cattle given ruzi grass hay and sugarcane stalks

Feed	Turnover rate of		Liquid volume
	Liquid % hour	Solid % hour	$1/BW^{0.75}$
Ruzi grass hay	10.8	4.17	0.557
Sugarcane stalks	16.3*	2.61*	0.335
MSE	1.7	0.50	0.091

* Significant difference ($p<0.05$)

Photo 1: Popular feeding system characterized by the use of dry season rice straw.

Photo 2: Cattle are fond of chopped sugarcane stalks which should, however, be supplemented with energy and protein sources.

Photo 3: Chopped sugarcane stalks.

JIRCAS Fellows in Okinawa

Dr. Hussein M. El-Khawas

Department of Microbiology, Faculty of Agriculture, Cairo University, Giza, ***Egypt***

Response of Lowland Rice to Inoculation with Plant Growth-Promoting Rhizobacteria (PGPR) and Their Culture Supernatants

Cereal crops are the most important sources of food. In particular, rice is the major food for more than one-third of the world population. Many plant growth-promoting rhizobacteria (PGPR) have been isolated from cereal crops and demonstrate the ability to promote plant growth under different growth conditions. Various free-living nitrogen-fixing bacteria are considered to be PGPR, including *Azospirillum* and *Klebsiella* species. These nitrogen-fixing microorganisms also produce growth regulators such as auxins, several gibberellins and cytokinins. Therefore, the aim of my study at the JIRCAS International Collaboration Research Section (ICRS) is to identify and quantify auxins, gibberellins, and cytokinins in culture medium of *Azospirillum* and *Klebsiella* strains and to determine their effect on the development of rice roots. In addition, the study will also focus on the response of rice seedlings to inoculation with different PGPR strains. The practical use of such PGPR bacteria may enable to save chemical fertilizers.

Dr. Safdar Hussain Shah

Agricultural Research Station Dhodial Mansehra, NWFP, ***Pakistan***

Physiological, Biochemical and Genetic Characterization of Salinity Tolerance in Rice

Generally plants experience some kind of stress during the various stages of growth. Salinity is a widespread stress occurring worldwide which limits the yield on 30% of the total land. The ever-increasing salinity-affected area coupled with the decreasing soil resources, dwindling fresh water availability and increasing demand for food requires that plant scientists develop a biological strategy (breeding crops for saline areas) to complement the technological strategy (reclamation and drainage, etc.) for intensive and extensive agriculture. Salinity exerts diverse effects (osmotic, toxic and ionic imbalance) on plants/cells and tolerant genotypes are expected to have more than a single adaptation simultaneously.

My collaboration at JIRCAS Okinawa Subtropical Station aims to identify and characterize the salinity markers in rice that are associated with the osmotic component (cytosolute accumulation) and toxic component (modifications of membranes) of salt tolerance by studying the cation co-tolerance phenomenon through the selection of cell lines tolerant to LiCl (toxic effect), PEG (osmotic effect) and NaCl (osmotic+toxic effects). This may lead to the elucidation of the components of salinity tolerance in rice that could contribute to the characterization of salt tolerance and development of salt-resistant plants by biotechnological procedures in conjunction with classical breeding methodology.

Li Chengyun

Yunnan Academy of Agricultural Sciences, ***People's Republic of China***

Studies on the Relationship between Salinity Tolerance and Cold Tolerance at the Booting Stage of Rice (*Oryza sativa* L.)

Drought, cold, heat and salt stress all induce dehydration in plants and it is well known that the panicle initiation stage is a very sensitive stage both to cold and salt stress in rice. It has been reported in the literature that a number of genes respond to dehydration as well as to low temperature and high salt stress at the transcriptional level. These results indicate that there may be some common physiological characteristics between salinity and cold tolerance, especially at the booting stage. Although tolerance of rice varieties to salinity and cold has been studied by many researchers, salt tolerance was mainly studied at the seedling stage and cold tolerance at the booting stage. Therefore, 30 rice varieties showing a wider variation in cold tolerance will be utilized in this study for the development of salinity tolerance. The effect of salinity on the percentage of seed setting, mean grain weight, grain yield, protein and amylose content in brown rice, *in vitro* pollen germination, Na^+ accumulation in roots, old leaves and flag leaves will be investigated. The results may enable to clarify the mechanism of cold and salt tolerance in rice plant.

Workshop on Heat Tolerance of Crops

— October 7 & 8, 1997 JIRCAS Okinawa Subtropical Station —

Takaharu Hayashi

JIRCAS is expected to contribute to the development of agricultural technology for developing countries. One of the divisions of JIRCAS, Okinawa Subtropical Station (OSS) was established to promote agricultural research under a subtropical environment. Thus, heat tolerance of crops is a major research activity at OSS. The Workshop on Heat Tolerance of Crops held at OSS aimed at two objectives. One was to review previous research output from OSS and the other was to devise new strategies for developing techniques for improving heat tolerance of crops including mitigation of heat stress and heat tolerance.

The workshop was held for two days from Oct. 7 to Oct. 8, 1997 at OSS under the sponsorship of JIRCAS. Prof. Anthony Hall from the Department of Botany & Plant Science, University of California and Dr. George Kuo from the Asian Vegetable Research and Development Center were invited as keynote speakers. Dr. Ishige from JIRCAS Headquarters was also invited as commentator and chairman of the general discussion. A total of 28 researchers including OSS staff members participated in the workshop.

Photo 1: Participants in the workshop.

On the day first, Dr. Kuo, Director of Crop Improvement Program, gave a presentation on "Vegetable improvement of heat tolerance under tropical conditions" and Prof. Hall gave a presentation on "Positive and potential negative effects on crop of Heat Tolerance Genes". Following the keynote speeches, six researchers from OSS including three visiting scientists from JIRCAS Visiting Research Fellowship Program '97 presented their research outcome. On the second day, five researchers outlined future strategies for studies of heat tolerance of crops at OSS. Participants exchanged views on the progress of heat tolerance studies and confirmed the importance of such studies. In the last part of the workshop, Dr. Ishige, chaired the general discussion. During the workshop, questions, were raised and discussions and comments took place. The workshop may enable OSS to devise new strategies for developing techniques for improving heat tolerance of crops in the future.

Preliminary Notice for The 5th JIRCAS International Symposium "Postharvest Technology in Asia — For a Stable Supply of Food Products —"

The symposium on "Postharvest Technology in Asia – For a Stable Supply of Food Products –" organized by the Japan International Research Center for Agricultural Sciences (JIRCAS) will be held in Tsukuba, Japan during the period of September 9-11, 1998.

In Asia, agricultural research so far has been mainly centered on the improvement of crop production itself to achieve self-sufficiency in food in order to support the growing population of the respective countries. It is anticipated that, in the near future, the food supply problems will become more complex as patterns of food consumption become more diversified in the region along with the increase of income and societal development.

"Postharvest technology", which encompasses issues ranging from harvesting methods in farmers' fields to food processing, should be more emphasized to prevent crop losses, to utilize agricultural products efficiently and to meet the changes in the food demand.

Recognizing the importance of "Postharvest technology", this symposium will attempt to highlight the main priorities, constraints and perspectives in the field of postharvest technology. Three sessions with invited speakers will cover the following themes:

Session 1: Main priorities and constraints relating to postharvest technology in Asia

Session 2: Perspective of technology for grain storage and preservation in the tropics

Session 3: Development and orientation of technology for food industries in Asia

For detailed information

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PEOPLE

Tadao Hamazaki, a soil scientist, became Director of JIRCAS's Environmental Resources Division on October 1, succeeding Dr. Katsuyuki Minami who was transferred to the National Institute of Agro-Environmental Sciences (NIAES) to assume the post of Director of the Research Planning and Coordination Department. Dr. Hamazaki worked as Laboratory Head at NIAES on soil genesis and classification (1990-1997) after carrying out collaborative studies on soil genesis and properties at the University of the Philippines at Los Banõs (UPLB) as a staff member of the Tropical Agriculture Research Center (TARC) (1986-1990).

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