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Soil salinity due to inadequate water management with waterlogging (Photo by Y. Shinogi)

CONTENTS

JIRCAS
JAPAN INTERNATIONAL RESEARCH CENTER FOR AGRICULTURAL SCIENCES

Animal Production in Developing Regions: Importance of the Conservation of Genetic Resources

Mitsugu Shimizu
Director, Animal Production and Grassland Division, JIRCAS

Farm animals contribute to more than 30% of agricultural products and supply food rich in protein, hide, fiber, fertilizer for crops, and draught power. In the developing regions, animal production may enable smallholders to upgrade their living conditions through the improvement of their diet and health conditions and the increase of farm household income, alleviation of poverty, and diversification of resources to reduce risks. In addition, animal production is an important component of sustainable agricultural systems in these areas, because animals can use agricultural by-products and residues as feed resources, animal excreta and wastes can be utilized as a source of household energy and fertilizer for crops, while draught power is used for plowing land and for transportation. However, animal productivity is reduced by many constraints in developing regions. The major factors involved in the low animal productivity are the deficiency in feed in terms of quantity and quality and low nutrition level, inappropriate management practices, and the depletion of grassland resources, which result in poor growth of the animals. The other serious problem is related to animal health. Farm animals in developing regions, especially in tropical and subtropical countries are often reared in unsanitary and stressful environments, and are frequently exposed to various pathogens, including viruses, bacteria, and parasites and to harsh climatic conditions that cause considerable damage to the animals. Economic losses of animal production due to sanitary problems in the developing regions have been estimated at more than 40% of total production.

Therefore, the Animal Production and Grassland Division (APGD), Japan International Research Center for Agricultural Sciences (JIRCAS), has promoted collaborative research with various countries, placing emphasis on securing feed resources by either identifying new feedstuffs or utilizing agricultural by-products and residues along with the improvement of grassland and animal management, and implementation of measures for disease control. For instance, oil-palm fronds and sugarcane stalks have been successfully used as ruminant feeds through collaborative research with Malaysian and Thai scientists, respectively, and the project entitled "Development of Agro-pastoral Systems in the Subtropical Area of Brazil" is being carried out to develop a sustainable technology for grass production in Brazil. APGD, JIRCAS intends to continue these research activities in order to achieve a sustainable increase of animal production compatible with the preservation of natural resources and environmental conditions in the respective regions.

To increase livestock production in developing regions, research on genetic characterization and conservation of indigenous breeds of farm animals, and their effective utilization for animal raising is important. In the past 12,000 years, human beings developed about 4,500 breeds of domestic animals from approximately 40 animal species, and most countries, depending on the geographic and climatic conditions, have their own unique animal breeds with various traits. Only a few breeds of important domestic animals have been successfully developed to improve some traits in relation to production in developed regions, mostly in northern countries. These breeds consume nutritious feeds and live in favorable environments. As a result, they produce more meat, milk, eggs, etc, when they are fed with sufficient quantities of high quality feeds, and reared under well controlled environments. However, they may not be adapted to the conditions prevailing in the developing regions where animals are usually reared with poor quality feeds, and always exposed to harsh climatic conditions, various pathogens, diseases, insect bites, and other environmental stresses. On the other hand, many indigenous breeds that are well adapted to the harsh conditions of the respective regions are distributed in the developing regions. Although these locally adapted breeds harbor valuable traits for adaptation to harsh climatic conditions, low quality feeds and various diseases, many of them are now becoming endangered species. These indigenous breeds appear to be valuable, and essential for further enhancement of sustainable animal production that does not depend upon high inputs and skillful management in the developing regions. The genetic characterization of indigenous breeds, and the conservation and utilization of useful genetic resources, particularly genes controlling heat and drought tolerance, adaptability to low quality feeds, disease resistance, and so on, should be promoted to improve animal production in the developing regions.

Although JIRCAS is not currently involved in such activities, in future, research along these lines should be considered.

Photo 1: Native pig in the Philippines

Photo 2: Nelore cattle in Brazil

Photo 3: Sustainable agro-pastoral systems in Brazil

Suppression of Nitrification in Soil by a Tropical Grass

Takayuki Ishikawa
Environmental Resources Division, JIRCAS

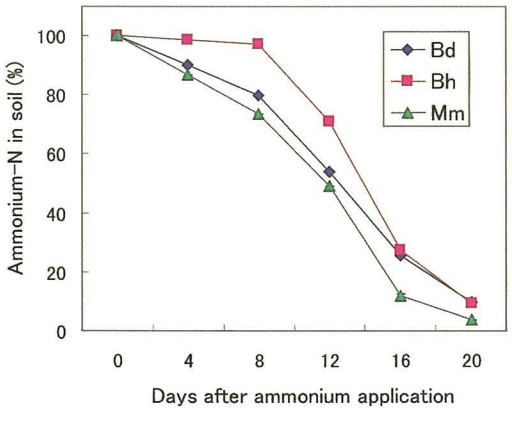
Nitrogen in fertilizers and organic components is transformed into ammonium-N in soil by microorganisms. In the nitrification process, ammonium-N is converted into nitrite-N by ammonium-oxidizing bacteria and nitrite-N is converted into nitrate-N by nitrite-oxidizing bacteria. Since plants can absorb only ammonium-N and nitrate-N, nitrification markedly influences the nitrogen absorption efficiency by plants. Nitrate-N that is not absorbed by plants easily leaches down from the rhizosphere to the deeper layers of soil and pollutes the underground water. During the process of nitrification, nitrous oxide, one of the greenhouse gasses, is emitted from the soil to the atmosphere. By controlling nitrification, it is possible not only to increase the nitrogen absorption efficiency by plants but also to minimize the nitrogen loss by leaching and volatilization. In order to decrease the nitrogen loss, chemical fertilizers with nitrification inhibitors have been developed but their application is very limited in developing countries because of their high cost. If plants could inhibit the nitrification process, their nitrogen absorption efficiency would be considerably enhanced. It was reported that the amount of nitrate-N accumulated in the soil where a tropical grass grew seemed to be smaller than that in the soil where other tropical grasses grew. The objective of this study was to demonstrate the ability of this tropical grass to suppress nitrification and to identify the relation between nitrification suppression and nitrous oxide emission to the atmosphere.

Three tropical grasses (*Brachiaria decumbens* (Bd), *B. humidicola* (Bh), *Melinis minutiflora* (Mm)) supplied by CIAT were grown for 6 weeks in Wagner pots and soils were sampled. Ammonium-N was applied to the sampled soils and the nitrification process was observed. In soils with Bd and Mm, the content of ammonium-N decreased 4 days after ammonium-N application and nitrification started rapidly (Fig. 1). However, the content of ammonium-N in the soil with Bh did not change until the 8th day and there was a lag period before the onset of nitrification. The results indicate that only *B. humidicola* suppressed nitrification in soil.

In order to study the effect of nitrification suppression on nitrous oxide emission, Bd, Bh and Mm were grown for 4 weeks in Wagner pots and ammonium-N was applied to the soil. From soils without plants (No Plants), and with Bd and Mm treatments, nitrous oxide was emitted at a rate of 3 μ g-N/m^{2}hr one day after ammonium application (Fig. 2). From the No Plants soil, nitrous oxide emission increased from the twelfth day. In the case of the Bd and Mm treatments, nitrous oxide emission continued for more than 4 days and then began to decrease because nitrogen in soils was absorbed by the plants. However, nitrous oxide emission from the soil with the Bh treatment was low throughout the experimental period. The amount of nitrous oxide emitted from the soil with the Bh treatment was 1/4 smaller than that from the Bd and Mm treatments.

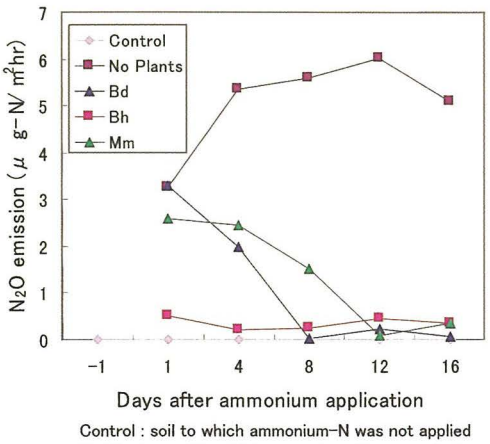
In another experiment, it appeared that *Brachiaria humidicola* suppressed the multiplication of ammonium-oxidizing bacteria specifically but had no effect on the nitrite-oxidizing bacteria. Of the two nitrification processes, it is assumed that the process in which ammonium-N is changed into nitrite-N is a rate-determining process. By the suppression of multiplication of ammonium-oxidizing bacteria, *Brachiaria humidicola* suppresses nitrification in soil and nitrous oxide emission to the atmosphere. Generally it is considered that tropical grasses preferentially use nitrate-N compared to ammonium-N. Among the *Brachiaria* species, it is assumed that only *B. humidicola* can utilize both forms of nitrate-N and ammonium-N and that this function of *B. humidicola* may lead to an efficient use of nitrogen in soil.

Native pastures are widely distributed in various countries of the tropical zone but their productivity is very low. In order to increase livestock production, if *Brachiaria humidicola* could be introduced, it would be possible to decrease the nitrogen input for agriculture in addition to preserving the environment and ecosystems.



Ammonium-N in soil was taken as 100% at 0 days.

Fig. 1. Content of ammonium-N in soil



Control : soil to which ammonium-N was not applied
No Plants : soil to which ammonium-N was applied

Fig. 2. Nitrous oxide emission from soil

Compound Resistance Mechanisms to the Whitebacked Planthopper in Chinese Japonica Rice Variety "Chenjiang 06"

Kazushige Sogawa
Crop Production and Postharvest Technology Division, JIRCAS

Rice agriculture in China is characterized by the wide adoption of high-yielding F1 hybrid rice. Since its introduction in 1976, the cultivation of hybrid rice has expanded rapidly and hybrid rice was planted to about half of the total rice area in China in the 1990s. The remarkable increase in rice production in the 1980s was largely dependent on hybrid rice. However, Chinese hybrid rice has caused a new pest problem, namely outbreaks of the whitebacked planthopper, *Sogatella furcifera*, because of its high susceptibility to the pest. Subsequent increase of insecticide applications has resulted in the development of resistance of insect pests to pesticides in paddy fields, and increased the risk of pest resurgence due to the destruction of natural enemies in the paddy ecosystem. Growing pest and pesticide problems in rice agriculture in China drew our attention to varietal resistance to insect pests in Chinese rice as an effective component of the ecologically based pest management (EBPM) system. In the course of the JIRCAS-CNRRI Collaborative Research Project on EBPM for rice planthoppers in China, we demonstrated the mechanism of varietal resistance to *S. furcifera* in Chinese japonica rice "Chenjang 06 (CJ-06)".

S. furcifera resistance of CJ-06 was investigated in comparison with that of a susceptible indica hybrid rice cultivar "Shanyou 63 (SY-63." Field experiments revealed the high field resistance of CJ-06 to *S. furcifera*. The *S. furcifera* immigrants did not land and failed to establish populations on CJ-06. They preferred to settle on SY-63 on which they could well reproduce. Under a free choice condition, significantly fewer *S. furcifera* individuals alighted on CJ-06 than on SY-63. The significantly smaller amount of honeydew excreted by *S. furcifera* females on CJ-06 than on SY-63 indicated a low sucking activity on CJ-06. Both fecundity and egg hatchability were markedly reduced on CJ-06, when newly emerged *S. furcifera* females continuously fed and were allowed to oviposit on it. Consequently, the number of nymphs hatched on CJ-06 amounted to only about one-tenth of that on SY-63. *S. furcifera* eggs showed a high mortality in watery lesions at oviposition sites of CJ-06. The watery lesions rapidly led to the formation of conspicuous necrotic symptoms before the eggs hatched. The egg mortality in the watery lesions occurred within 1-2 days after oviposition (Fig. 1). Such watery lesions seldom occurred in SY-63, where the eggs hatched normally.

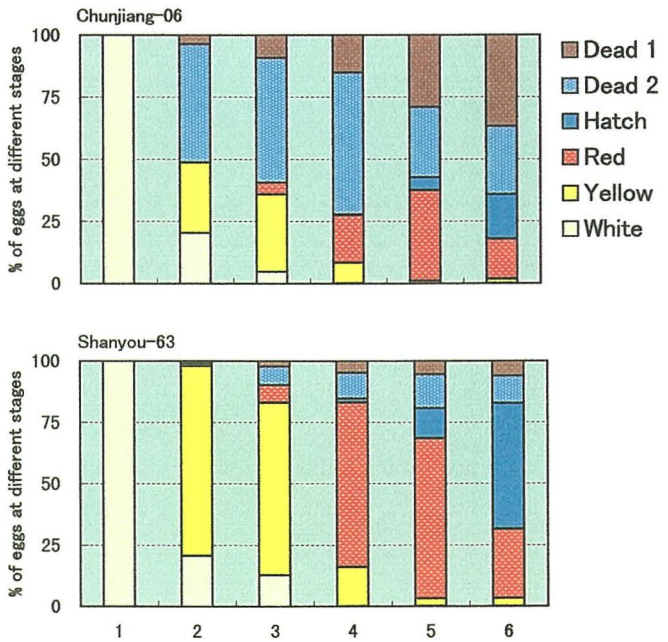


Fig. 1. Embryonic development of *S. furcifera* eggs in resistant CJ-06 and susceptible SY-63.
White = newly deposited eggs
Yellow = eggs at yellow spot stage
Red = eggs at eye-spot stage
Hatch = hatched eggs
Dead 2 = opaque dead eggs
Dead 1 = discolored dead eggs

Based on the above findings, we concluded that sucking suppression and ovicidal reaction were critical factors for the *S. furcifera* resistance in CJ-06. These functions are associated with the antixenosis mechanism against *S. furcifera* immigrants, as well as the antibiosis mechanism whereby fecundity and egg hatchability of inhabitants are reduced, respectively. Such dual mechanisms of varietal resistance may result in a stable and durable field resistance to *S. furcifera* in Chinese japonica rice CJ-06 (Fig. 2). It would be important to identify the chemical components responsible for the sucking inhibition and ovicidal reaction associated with the resistance of CJ-06 to *S. furcifera*, compared to the susceptibility of SY-63 and to analyse the genetic basis of the resistance for subsequent breeding work.

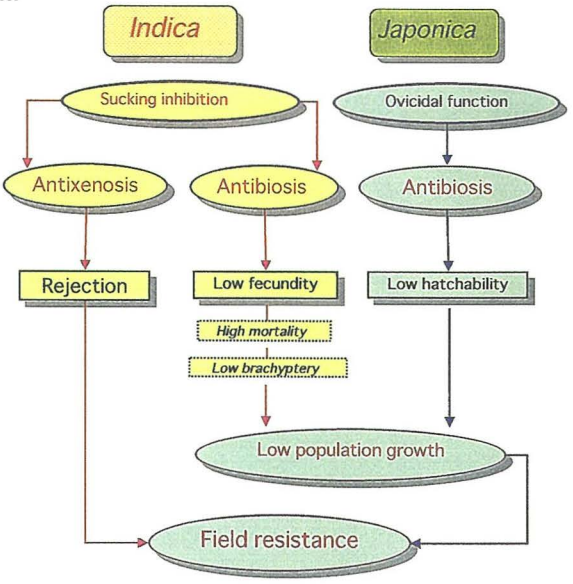


Fig. 2. Antixenotic and antibiotics resistance to *S. furcifera* in Chinese japonica rice, CJ-06.

Analysis of Chitinolytic Enzyme Genes of a Mycoparasitic Bacterium *Flexibacter* sp. FL824A

Yasuo Ando
Animal Production and Grassland Division, JIRCAS

The purpose of this study is to develop disease control utilizing lytic microorganisms. We detected a lytic activity in a mycoparasite *Flexibacter* sp. FL824A toward several plant pathogenic fungi, consisting of the secretion of lytic enzymes, chitinolytic enzymes (chitinases and *N*-acetylglucosaminidases), β-1,3-glucanases and proteases. Chitinolytic enzymes are considered to play an important role in the mycoparasitic process, because chitin, poly-β-1,4-*N*-acetyglucosamine [$(GlcNAc)_n$], is a major structural component of cell walls of fungi. In the first step of our study, we analyzed the genes of chitinolytic enzymes from *Flexibacter* sp. FL824A.

A genomic library of *Flexibacter* sp. FL824A using pUC19 and *Escherichia coli* was constructed. Hydrolysis activity of the crude protein of the transformants was determined by using analogs of chitin derivatives, 4-methylumbelliferyl-β-D-*N*, *N*´-diacetylchitobioside [4-MU-$(GlcNAc)_2$] or 4-methylumbelliferyl-β-D-*N*,*N*´,*N*˝-triacetylchitotriose [4-MU-$(GlcNAc)_3$] as substrates. Among 6,000 transformants tested, four clones showed a positive activity. They fell into two groups according to their specificity to the substrates (Table 1). We selected two clones CHF1149 and CHF1351, based on the activity level, specificity to the substrates, size of DNA-inserted fragment, and digestion pattern of the insert with restriction endonucleases.

An open reading frame (ORF) of 4236 bp was found to code for a chitinase with 1412 amino acids based on the nucleotide sequence and deduced amino acid sequencing of an 8.7-kbp insert of pCHF1149. Homology analysis of the deduced amino acid sequence of this protein revealed that the enzyme has a multiple domain structure consisting of at least seven domains (Fig. 1). The most interesting property is that the enzyme has two catalytic domains, one homologous to the catalytic domain of chitinase A1 of *Bacillus circulans* WL-12 on the N-terminal side of the protein and the other homologous to that of chitinase D of the same bacterium on the C-terminal side.

The DNA sequence of 5.0 kbp of the DNA-inserted fragment of pCHF1351 was determined after subcloning. An open reading frame (ORF) of 1962 bp was found to code for a putative protein with 654 amino acids. The protein shared a 25% homology with endo-β-*N*-acetylglucosaminidase of *Clostridium perfringens*.

Strong lytic activity of *Flexibacter* sp. FL824A may be due to the presence of a unique chitinase with two catalytic domains. Further studies on the chitinase should be carried out to analyse the chitin degradation of this mycoparasitic bacterium.

Table 1. Enzymatic activity of positive clone using 4-MU-*N*-acetylchitooligoside as substrate

Clone	Enzymatic activity (μUnit/ml)[1]		Ratio of activity (dimer/trimer)
	dimer[2]	trimer	
Group A			
CHF2778	7.63	10.36	0.74
CHF2601	15.81	26.16	0.60
CHF1149	232.19	446.39	0.52
Group B			
CHF1351	768.50	40.33	19.06

1) 1 Unit of enzymatic activity was defined as 1μmol of 4-MU/min at 37°C.
2) dimer, 4-MU-$(GlcNAc)_2$; trimer, 4-MU-$(GlcNAc)_3$.

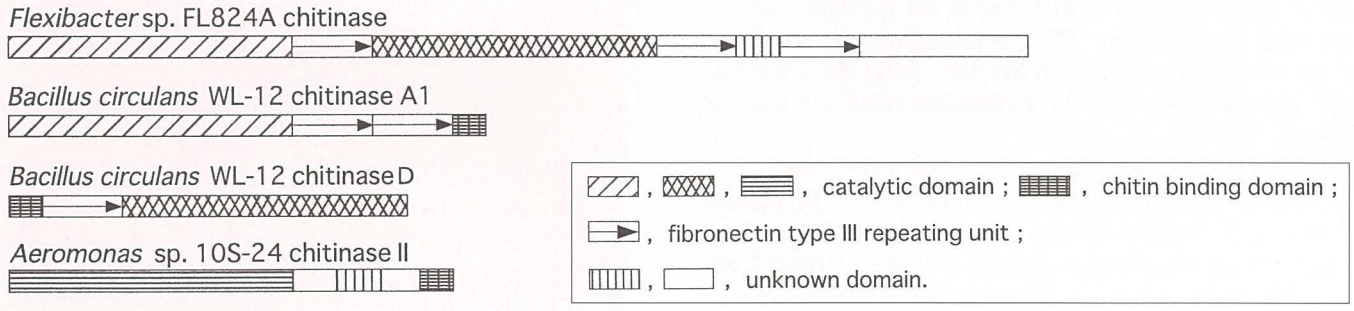


Fig. 1. Schematic representation of the domain structures of chitinases from several bacteria

Seminar on "High Value Timber Species for Plantation Establishment – Teak and Mahogany Species –"

Disappearance of the natural forests has prompted the Southeast Asian nations to establish and develop artificial forest plantations. The trees selected for this purpose have been mostly fast-growing species for pulp and/or light use timber. Recently, however, in Malaysia, including Sabah State, there has been a growing interest in planting high value timber species with longer rotation periods. Not only the foresters, from either governmental organizations or the private sector, but also estate plantation holders and farmers are interested in planting teak (*Tectona grandis*) in their plantation or farm areas, and more recently some of them have also started to plant mahogany species (American mahogany, *Swietenia macrophylla*, and African mahogany, *Khaya ivorensis*). Malaysian experience with these species is, however, rather limited.

To fill this gap, JIRCAS, INNOPRISE (Sabah Foundation) and Sabah Forestry Department decided to jointly organize a Seminar on "High Value Timber Species for Plantation Establishment" with emphasis placed on teak and mahogany species. The seminar was held at the Auditorium of Sabah State Library, Tawau, Sabah on December 1, 1998. Following the opening addresses by Datuk Musa Haji Aman (Chief Executive of INNOPRISE), Dr. Kiyoshi Tanaka (Director of Forestry Division, JIRCAS) and Mr. Herman Anjin (Deputy Forestry Director of Sabah Forestry Department), Dato' Dr. Salleh Mohd. Nor (Executive Director of TROPBIO Research) gave a keynote address and 14 experts from five countries presented nine papers

Photo: Participants leaving for field trip

related to silviculture, propagation, protection, wood utilization and marketing in three sessions. More than 130 participants, including forestry scientists, foresters and many plantation holders from Sabah, Sarawak and Peninsular Malaysia, held animated discussions and exchanged information. More than 50 participants also joined a field trip to the Luasong Forestry Centre, about 100 km from Tawau to observe demonstration/experimental stands of teak and mahogany on the next day. This seminar was very timely and successfully promoted the establishment of plantations of teak and mahogany species in Malaysia, especially in Sabah.

(Kazuma Matsumoto)

4th Seminar on "Brackish Water Project" Held in Malaysia

On December 8-9, 1998, the 4th "Brackish Water Project" seminar was held in the Conference Room of the Hotel Equatorial Penang, in Penang Island, Malaysia. This project on "Productivity and Sustainable Utilization of Tropical and Subtropical Brackish Water Mangrove Ecosystems" aims to evaluate the productivity of the above areas and identify the criteria for sustainable utilization of resources. The West coast of Peninsular Malaysia has been selected as the study area due to the presence of various types of mangrove forests differing in the level of management and exploitation. The counterpart organizations include the Fisheries Research Institute (FRI), the University of Malaya (UM) and the Forest Research Institute of Malaysia (FRIM).

Subjects addressed in the seminar were as follows:
1) Forest and litter fall, 2) Benthic communities, 3) Aquatic organisms, 4) Socio-economic aspects, 5) Environmental aspects. About 40 scientists and government officials from Japan, Malaysia, and Australia participated in the seminar, and fourteen papers were presented.

During the 4th seminar, Mr. Hashim Ahmad, Deputy Director General of the Department of Fisheries Malaysia gave an opening address, and Dr. Shiro Uno of JIRCAS presented closing remarks.

During the two days' seminar, it was concluded that the surveys conducted in 1997-1998 in the mangrove forest and waters had been completed. At that stage, it is necessary to analyse the structure of the mangrove ecosystems and to ensure that economic activities in these areas are sustainable.

(Katsuhiro Kiso)

Photo: Survey in the Merbok Mangrove Estuary

Topics

Current Status of Collaborative Research Activities between IWMI and JIRCAS

The International Irrigation Management Institute (IIMI), one of the sixteen organizations supported by the CGIAR , was established by an Act of Parliament in Sri Lanka. The Act is currently under amendment to rename the Institute as International Water Management Institute (IWMI).

IWMI implements four global research programs to improve water resources and irrigation management as follows: 1) Performance and Impact Assessment, 2) Design and Operation of Irrigation Systems, 3) Policy, Institutions and Management, and 4) Health and Environment. Collaborative research activities between IWMI and JIRCAS cover the Design and Operation of Irrigation Systems Program.

Two studies are being carried out as follows:"Optimal Water Management under Water Deficit Conditions" and "Soil Salinity Problems."

The site for the "Optimal Water Management" study is located in the North-Central province of Sri Lanka. Irrigation water is used not only for agriculture but also for bathing, washing, as drinking water, etc. Although rainfall is usually abundant in this area, due to the lack of effective water management, the amount of water available for agriculture and daily life is sometimes insufficient. Many small tanks (ponds) are connected to one another (tank cascade system) in the area and they comprise the main water reservoirs. At first, it is necessary to analyse the water balance in these systems for identifying optimum cropping patterns based on traditional systems and more advanced technology in order to improve water management. As a result, crop productivity could be enhanced and maintained during the dry season, also. These practices could be adopted in other areas in Sri Lanka and in other countries.

Soil salinity is one of the most severe problems in arid and semiarid environments. Sometimes, it is caused by inadequate water management practices such as waterlogging, which is associated with excessive irrigation and

Photo: In rural areas, irrigation water is used for many purposes (Sri Lanka)

which induces soil salinity. Soil salinity is a complex phenomenon which is region-specific. Productivity can be improved in the affected areas and it is important to determine the main causes of salinity so as to reduce it. The main factors can be determined by statistical methods, and one prediction model could be constructed with these parameters to predict the areas that may experience soil salinity.

"Soil slotting" is considered to be a useful technique to improve salinized (sodic) land. In this technique, some slots are cut and filled with soil and chemical substances or organic matter. It is important to analyse the soil-water and solute movement in this technique to identify suitable specifications (slot width, depth, space, etc.). These parameters can be simulated using a solute movement model under different water management conditions. Such a technology may enable to promote sustainable agriculture and raise the productivity of crops. The results could be applied to other salinized areas.

(Yoshiyuki Shinogi)

JIRCAS Symposium

The 6th JIRCAS International Symposium

GIS Applications for Agro-environmental Issues in Developing Regions

The symposium on "GIS Applications for Agro-environmental Issues in Developing Regions" will be held in Tsukuba, Japan during the period of September 7 – 9, 1999.

The greatest challenge for mankind today is to develop agricultural systems that would enable to utilize biological and natural resources adequately to feed the global human population and preserve the resources simultaneously. To meet this objective, quantitative and temporal evaluation of the resources in a given environment is required. However, geographic information to be used for this purpose has been lacking in many developing regions, which has hindered the precise evaluation. Geographic Information Systems (GIS) are now expected to become an effective tool to produce various kinds of evaluation maps on the environment by overlaying multiple geographic data. These data include not only drawn map sheets and written statistics but also digital remote sensing data, which have been accumulated for a quarter of a century and should be effective for quantitative and temporal analyses of various agro-environmental issues, including deforestation, desertification, soil

erosion and salinity, etc.

JIRCAS is actively implementing GIS-related research in collaboration with various countries in different geographic environments. This symposium offers a unique opportunity to review the studies carried out in this field by JIRCAS and other institutes, evaluate the current status of research and plan for the future. About 200 participants will attend the symposium and JIRCAS welcomes their active participation.

The symposium consists of two keynote speeches and three sessions as follows:

Keynote Speech: Application of GIS and remote sensing technology for agro-enviromental issues in developing regions

Dr. Andrew K. Skidmore, ITC, Netherlands

Dr. Tsuyoshi Akiyama, Gifu University, Japan

Session 1: Development of global dataset and models for agro-environmental sciences

Six presentations from representative institutes of USA and Japan

Session 2: Applications of GIS for agro-environmental issues in various developing regions

Nine presentations covering different geographic environments (Nepal, Indonesia, China, Pakistan, Colombia, Thailand and Japan)

Session 3: Education and training in the field of GIS

Presentations from AIT (Thailand), PUSDATA (Indonesia) and JIRCAS (Japan)

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(Makie Kokubun)

Visitor

President of Tanzania Visited JIRCAS

The President of the United Republic of Tanzania, Benjamin William Mkapa visited Japan in December, 1998. It was the first visit by an African head of state since the Second Tokyo International Conference on African Development (ITCAD II) held in Tokyo in October. Since gaining its independence, Tanzania has maintained close ties with Japan and Japan continues to extend technical and economic assistance for development in many areas such as agriculture, health, telecommunications and human resources development.

During his stay in Japan, President Mkapa visited JIRCAS on December 15. After the welcome-ceremony and the briefing of the center's activities by Dr. Nobuyoshi Maeno, Director General of JIRCAS, (Photo, left) President Mkapa (Photo, center) and his group observed the Biotechnology Laboratory where research on "Improving Plant Tolerance to Environmental Stress by Gene Transfer" is being carried out.

PEOPLE

Masachika MAEDA, a microbiologist (and protozoologist), became Director of the Fisheries Division on January 1, succeeding Dr. Shiro Uno who was transferred to the National Research Institute of Fisheries Sciences (NRIFS). Before joining JIRCAS, Dr. Maeda was Director, Physiology and Molecular Biology Section, NRIFS. Dr. Maeda was a visiting research fellow at the Royal Society and British Museum, England from 1980 to 1983.

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