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Secondary forest of *Acacia mangium* five years after the occurence of a forest fire, Sabah, Malaysia (Photo by T. Suzuki)

CONTENTS

JIRCAS
JAPAN INTERNATIONAL RESEARCH CENTER FOR AGRICULTURAL SCIENCES

Development of Agroforestry Technology for the Rehabilitation of Tropical Forests

— JIRCAS New Agroforestry Project —

Terunobu Suzuki
Director, Forestry Division, JIRCAS

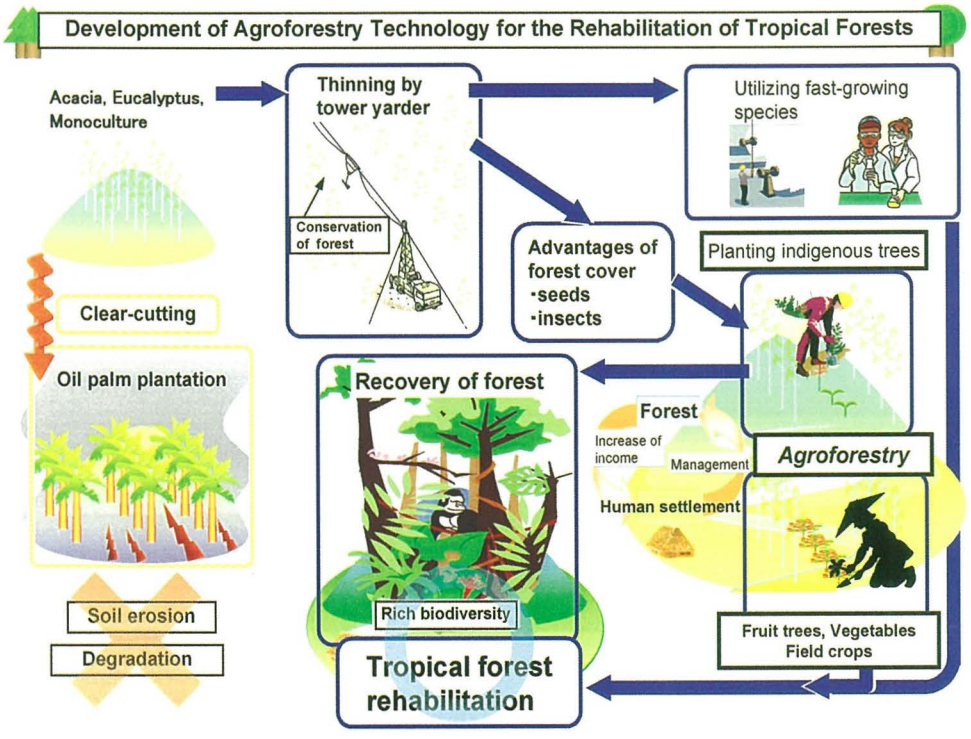
With excessive logging and indiscriminate cutting of trees for fuel as well as with the increasing exploitation of arable land associated with the high demand for food, the deterioration and clearing of natural forest areas have been rapidly progressing, particularly in developing regions. This is bringing about serious economic and environmental problems not only at the local level but also on a global scale. Therefore, the rehabilitation and sustainable management of these forests are urgent issues. Development of forest production systems and postharvest technologies for local communities can be considered to be essential means for the reduction of forest degradation.

Forest rehabilitation and enrichment of denuded and degraded areas are the first steps in developing sustainable management of forest areas. JIRCAS has played a significant role in alleviating forest degradation by focusing its efforts on methods of reforestation and ways to motivate local inhabitants to participate in reforestation activities.

Research on methods for the establishment of fast-growing species as shelter wood for the promotion of growth of valuable indigenous trees such as Dipterocarps in logged-over tropical forests is being conducted in collaboration with the researchers of the College of Forestry, University of the Philippines at Los Baños (Philippines). Studies on the regeneration and growth of *Shorea* species seedlings on logging roads in Malaysia are conducted in collaboration with the researchers of the Forest Institute of Malaysia (FRIM), where joint investigations on the improvement of logging techniques for the selective management system applied in Malaysia, including the improvement of harvesting methods using a mobile tower yarder, are also in progress.

Malaysia is one example of several countries with which JIRCAS has been working closely on deforestation issues. In Malaysia, forests are logged on a large scale and the enrichment of remaining secondary forests is a major task for the government. Compared to other Southeast Asian nations, Malaysia's standard of living is higher and its forest management programs have been more effectively carried out, particularly in the state of Sabah. Nevertheless, in Sabah alone, several hundred thousand local inhabitants, over 10% of the state's population, still practice shifting cultivation. Their activities, which include unsustainable forest harvesting, slash and burn agriculture, repeated cultivation and wildfires have had a considerable impact on the forest ecosystems and resulted in losses of flora and fauna, erosion, flooding, decrease of forest resources and general soil degradation.

However, this situation may be improved by introducing agroforestry systems which encourage people to settle in a certain residential area, cultivate cash crops and participate in intercropping, afforestation and reforestation activities. Along with initiating the development of cultivation and farming technology, local authorities and scientists have been engaged in the assessment and analysis of social and economic factors in order to develop sustainable management systems for forest resources. In the 1970s, for example, agroforestry was first introduced to Sabah with a certain amount of success through the intercropping of cacao. On the whole, however, agroforestry techniques are essentially site-specific and for any given program to be successful, acceptance by the local community is indispensable. Given these conditions, we therefore proposed a more flexible research project titled: "Development of agroforestry technology for the rehabilitation of tropical forests." This project which will be implemented mainly in collaboration with the Forest Research Centre, Forestry Department, Sabah, Malaysia, aims at balancing out the effects of secondary forests, burnt



forests, monoculture plantations and grasslands by introducing a cropping system consisting of cash crops including vegetables, fruit trees as well as indigenous trees. Our final objective is to establish a technological base for the ongoing development of biodiversity-rich forests, high-value timber forests, forests that perform critical environmental functions and fruit tree orchards where soil fertility has been improved or is well maintained. These studies will contribute to the mitigation of agriculture-forestry conflicts while promoting environmental conservation and sustainable forest resource management.

Over the seven-year (2000-2006) duration of the project, specific objectives will include a socio-economic evaluation of agroforestry, the re-establishment of a productive environment for agroforestry and the development of agroforestry techniques with the utilization of shade trees. Individual targets for the program include the development of technology for the re-establishment of a productive environment for agroforestry and development of techniques for growing non-arboreal crops under shade trees.

Finally, it is indispensable to promote close relations between forestry researchers and agriculture researchers in order to promote the project and obtain good results.

JIRCAS Research Highlights

Nitrogen Cycling in Agro-Pastoral Systems in the Cerrados

Kenichi Kanda
Environmental Resources Division, JIRCAS

In Brazil, grasslands have been developed over large areas originally covered by savannas (Cerrados). However, problems of declining productivity have arisen in recent years because of the low soil fertility. Agro-pastoral systems that combine soybeans and grasses in rotation have been proposed for sustaining grassland productivity. One of the primary advantages of these systems is that lime and P fertilizer are used for crop cultivation and that the succeeding grasses can benefit from the remaining P. Since N is added to the system through the N_2 fixation of soybeans, the grasses grow well. On the other hand, the organic matter content of the soil decreases steadily under soybean cultivation. To evaluate the agro-pastoral systems in terms of N budget, N flow into the systems, N_2 fixation by soybean, input from rain, removal associated with harvest of soybean grains, gaseous losses from animal excreta and denitrification* as well as leaching were studied.

A long-term field experiment has been carried out at the National Beef Cattle Research Center (CNPGC), National Corporation of Agricultural Research (EMBRAPA), Campo Grande, MS, Brazil. The soil is classified as Purple Red Latosol. In a grassland with grazing beef cattle, NPK fertilizer (14 kg N/ha, 70 kg P_2O_5/ha and 70 kg K_2O/ha) was applied and *Brachiaria decumbens* cv. Basilisk was sown in November 1993. Soybeans were sown in November and harvested in April of the next year. PK fertilizer (80 kg P_2O_5/ha and 80 kg K_2O/ha) was applied at the time of seeding.

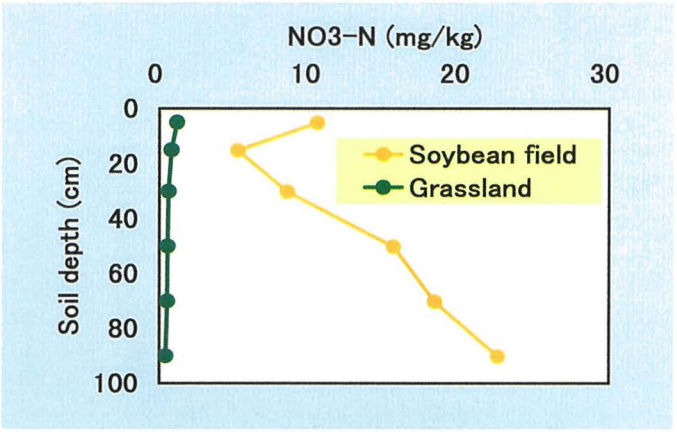


Fig. 1. Concentration of NO_3-N (mg/kg) in soil.

The rate of N_2 fixation of soybeans was determined using a non-nodulating isoline, T201, as a control. The rate ranged from 23 to 51% of the total plant N. Most of the plant N was removed after harvest of the grains, resulting in a negative N balance in the field. It was shown that the amount of N entering the system through rainwater was small. Nitrate accumulation from the surface to a depth of 100 cm in soil under soybeans indicated the potential leaching of nitrate (Fig. 1). The estimated amount of leaching from the soybean field was large compared with that from the grassland. A large negative N balance was observed in the soybean field, whereas there was a small negative N balance in the grassland (Fig. 2).

The nitrate that accumulated in the subsoil can be absorbed by grasses grown subsequently. Thus, rotational grassland may be more sustainable. On the other hand, both soybean field and grassland showed a negative N balance. It is concluded that in order to sustain N fertility in agro-pastoral systems, some application of N fertilizer may be necessary over time.

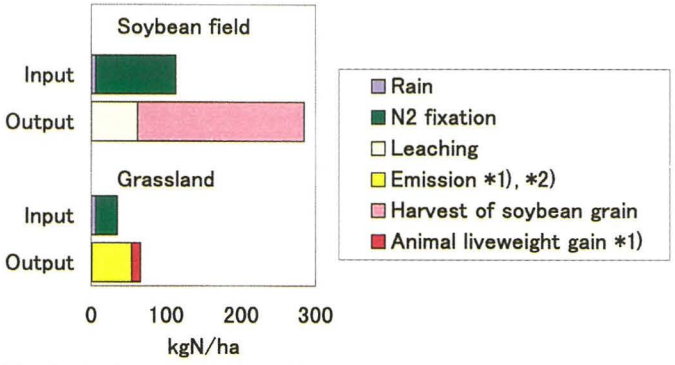


Fig. 2. N balance for soybean field and grassland.
*1) Cadisch, G. *et al.*, 1994
*2) Gaseous losses from animal excreta (ammonia volatilization and denitrification)

*Data relating to gaseous losses from animal excreta (ammonia volatilization and denitrification) were cited from Cadisch, G. *et al.*, Tropical Grasslands (1994), 28, 43-52.

Evaluation of Heat Tolerance of Snap Bean Based on Pollen Stainability

Katsumi Suzuki, Tadashi Tsukaguchi, Hiroyuki Takeda and Yoshinobu Egawa
Okinawa Subtropical Station, JIRCAS

Yield of temperate vegetables decreases at high temperatures in tropical and subtropical areas. Heat tolerance is one of the most important characters for the promotion and increase of vegetable production in these areas. It remained to be determined why heat-tolerant varieties show a superior yield under high temperature conditions. Simple methods of evaluation of heat tolerance are necessary for developing heat-tolerant varieties efficiently and introducing new crops suitable for high temperature conditions. JIRCAS Okinawa Subtropical Station is located on Ishigaki Island (lat. 24°20'N) under subtropical conditions in Japan. At this station, a heat-tolerant variety of snap bean (*Phaseolus vulgaris*), 'Haibushi', was developed from an accession collected in Southeast Asia by screening about 350 breeding lines and varieties. However, the mechanism controlling heat tolerance in 'Haibushi' compared with other varieties has not been elucidated. We investigated the pollen stainability of 'Haibushi' during cultivation in summer and compared it with that of other varieties under high temperature conditions.

The young pod yield, mean air temperature and pollen stainability changed during the cultivation of snap bean as shown in Table 1. Mean air temperature during the harvest period of the first, second and third croppings was 25.7, 27.9 and 29.8°C, respectively. Young pod yield of all the varieties decreased when the mean temperature rose. As the mean air temperature during the flowering period in each cropping rose, pollen stainability decreased. In the first cropping, each variety showed a pollen stainability above 80%. While the pollen stainability of 'Okinawa Local' and 'Kentucky Wonder' decreased to 55 and to 65% in the second cropping, respectively, that of 'Haibushi' was still higher than 75%. In the third cropping, though the pollen stainability of the three cultivars decreased to less than 20%, that of 'Haibushi' was higher than 60% .

When the plants were exposed to a high temperature (32°C/28°C, day/night) for 24 hours and then returned back to optimum conditions (25°C/25°C) in a greenhouse, the pollen stainability of the flowers which opened 8 to 11 days after the treatment decreased. Pollen stainability thus decreased by exposure to high air temperature 8 to 11 days before flowering. Pollen stainability also decreased when the mean air temperature during this period exceeded 28°C under field conditions. The heat-tolerant variety 'Haibushi', however, showed a higher pollen stainability than the heat-sensitive variety 'Kentucky Wonder' under high temperature conditions.

Fig. 1. Sterile pollen grains (a) of heat-sensitive variety 'Kentucky Wonder' (A) and normal pollen grains (b) of heat-tolerant variety 'Haibushi' (B) cultivated under high temperature conditions.

Reduction of young pod yield was ascribed to the decrease in pollen stainability, since a high correlation was observed between the pollen stainability and pod set. We concluded that the decrease of pollen stainability by high temperature led to a failure of fertilization and abscission of flowers, resulting in yield reduction in snap bean.

As mentioned above, yield reduction was accompanied by a lower pollen stainability. A heat-tolerant variety 'Haibushi' showed a high young pod yield and high pollen stainability under high temperature conditions. We suggest that examination of pollen stainability is one of the effective methods for evaluating heat tolerance.

Table 1. Yield of young pods and average pollen stainability (PS) of snap bean during each period of cultivation

Seeding date	27 Feb.		10 Apr.		13 May	
Harvest period	14 Apr.~12 May		26 May~25 June		25 June~3 Aug.	
Mean air temperature during harvest period (°C)	25.7		27.9		29.8	
Cultivar	Yield ($t \cdot ha^{-1}$)	PS (%)	Yield ($t \cdot ha^{-1}$)	PS (%)	Yield ($t \cdot ha^{-1}$)	PS (%)
Haibushi	11.4	90.7	6.6	75.2	2.8	61.3
Okinawa Local	—	—	5.5	55.8	0	8.0
Oregon	8.0	96.0	5.1	73.0	0	19.5
Kentucky Wonder	10.5	83.0	1.4	65.1	0	14.3

—: no data

Digestion Characteristics and Energy Requirements for Maintenance of Native Ruminants in Northeast Thailand

Tomoyuki Kawashima
National Institute of Animal Industry

Animal production in Northeast Thailand plays an important role in nutrient cycling for the development of sustainable agricultural systems. While exotic breeds have been introduced in the region to increase the production of meat and milk, the number of native ruminants, such as swamp buffalo and Thai native cattle, has been decreasing. Consequently, low quality roughages such as rice straw are not well utilized and some are burnt in the fields while the consumption of concentrate feed has been increasing. Although it is generally recognized that native ruminants have an inherent ability to digest low quality diet better than exotic breeds, the mode of digestion and nutrient requirements of native breeds developed in the tropics have not yet been fully elucidated.

Metabolism trials were conducted in sheep, Brahman cattle, swamp buffalo and Thai native cattle given Ruzi grass hay with different levels of soybean meal in order to examine the effect of protein levels on fiber digestion. The quality of hay used in each trial was slightly different and the crude protein (CP) contents in four dietary treatments ranged from about 3, 6.5, 10 and 13.5%. The outline of the results is shown in Fig. 1. In sheep, fiber digestibility was improved by the supplementation of soybean meal until the dietary CP content reached 10%. Beyond this level, the positive effect of supplements was not observed. In Brahman cattle, the fiber digestibility without protein supplements was lower than that with supplements (CP 6.5%). But there was no improvement by additional protein supplements to a level above 6.5%. On the other hand, in swamp buffalo and Thai native cattle, fiber digestibility without supplements was not different from that with supplements. And the fiber digestibility in Thai native cattle was generally higher than in the other animals. It was considered, therefore, that these native ruminants, especially Thai native cattle, have a superior ability to digest fiber without protein supplements.

A total of 44, 27 and 20 metabolism-trial data, in Brahman cattle, swamp buffalo and Thai native cattle, respectively, were examined in order to compare metabolizable energy (ME) requirements for maintenance. The ME requirements for maintenance were obtained by regression analysis of energy retention against ME intake based on the metabolic body size. The values were 377, 334 and 245 KJ/BWkg$^{0.75}$ in Brahman cattle, swamp buffalo and Thai native cattle, respectively, which corresponded to 86, 76 and 56% of the value of Japanese Black Cattle. These findings clearly showed that native ruminants, such as Thai native cattle and swamp buffalo, require less energy to maintain their body weight compared with high performance breeds.

Thai native cattle (Northeastern group)

The ability to efficiently utilize low quality roughage and the lower energy requirements in native ruminants enable them to survive under a severe feeding environment. It was considered that such animals have been selected for their characteristics by farmers, which led to the development of a breed or a group adapted to the local conditions. The soil in Northeast Thailand, where the largest population of these native ruminants can be found, is characterized by low organic matter and nutrient contents. Re-construction of a system utilizing native ruminants in order to exploit available low quality feed may contribute to the sustainable development of agriculture and animal production in Thailand.

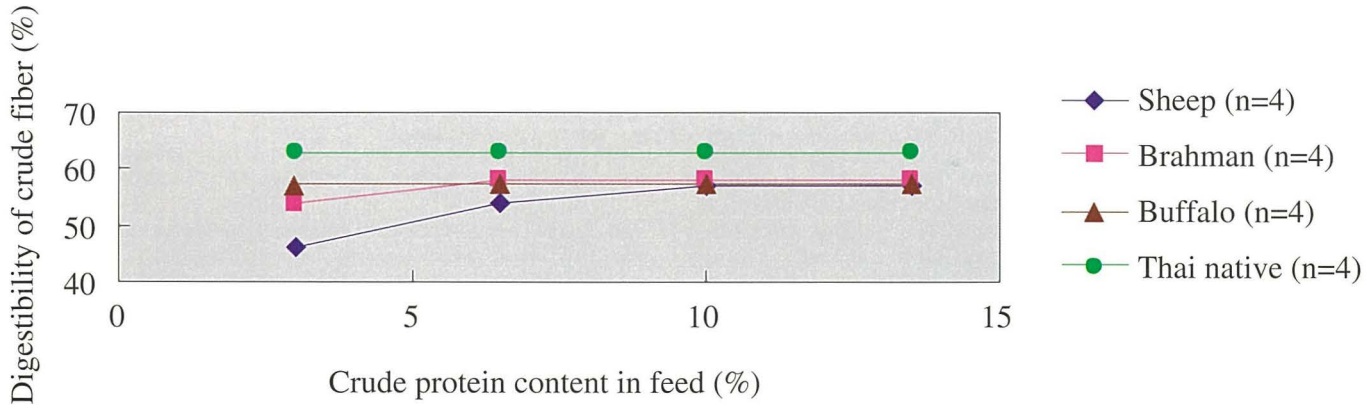


Fig. 1. Changes in crude fiber digestibility depending on the supplementation of soybean meal.

Development of Sustainable Agricultural Systems in Northeast Thailand

— Toward the end of the project —

Osamu Ito
Director, Environmental Resources Division, JIRCAS

The northeastern part of Thailand is a region with an unfavorable production environment characterized by infertile sandy soils and a long dry season. About half of the total land area in the region used to be covered with tropical rainforest which drastically decreased to 14% by deforestation. Intensive upland farming that reduces soil fertility and expansion of the arid land area have further accelerated the deterioration of croplands. Under such unfavorable conditions, rice, cassava, sugarcane and legumes are cultivated as cash crops, but they bring an insufficient income to the farmers (family income being only 40% of the national average). Regional development through agricultural technology improvement has become the highest priority in the Northeast.

In order to further develop agriculture in the region, it is necessary to shift the agricultural systems from those that depend heavily on a few cash crops to more sustainable systems in which diverse cropping options are combined with more efficient utilization of local resources. The project titled: "Comprehensive studies on sustainable agricultural systems in Northeast Thailand" was initiated in 1995 for a seven-year period in order to promote the technological development of rice, upland crops, vegetables, livestock and the sericulture industry, as well as to develop sustainable agricultural systems combining various types of farming and animal husbandry. The project has been implemented in close collaboration with Thai partners, including researchers from the Department of Agriculture (DOA), Department of Livestock Development (DLD), Land Development Department (LDD), International Training Center for Agricultural Development (ITCAD) and Khon Kaen University (KKU).

The project is composed of five main themes (Table 1). Until half of the project period, much focus had been placed on rather fundamental aspects within each research theme. Some of the outputs from fundamental research (Table 1) are now being integrated to develop sustainable agricultural systems suitable for the biophysical and socio-economic environment in the region. Main targets in the latter half of the project are as follows: (1) development of a rainfed lowland rice production system with more profitable farming operations and (2) crop-livestock integration in upland cropping systems with year-round feed supply and more efficient nutrient cycling. Farm mechanization for rice production in the transition from transplanting to direct seeding and utilization of locally available organic materials to sustain the soil fertility in upland fields are the central issues toward the end of the project.

In future, it may become important to maximize the use of water resources through the establishment of irrigation facilities compatible with the local hydrogeological characteristics, in order to further enhance the sustainability of agriculture in the region along with improving the socio-economic conditions of the rural communities.

Table 1. Main research themes and activities/outputs of the project

Research themes	Activities/outputs
I. Evaluation and effective utilization of environmental and biological resources in the region	•Effective recycling systems of organic materials were proposed through the analysis of nutrient cycling of organic and inorganic components in present farmlands. •The salt-affected area was characterized using GIS and remote sensing. •For the development of water resources, the construction of sub-surface dams was proposed based on hydrogeological studies. •Sugarcane and pineapple were found to fix atmospheric nitrogen, indicating future possibility to cultivate these crops by reduced N application.
II. Development of sustainable crop production systems	•The proper planting interval of leguminous trees for alley cropping was determined in order to develop an integrated system of trees and crops. •The agronomical factors for the introduction of direct seeding on dried paddy fields were thoroughly examined, particularly in relation to non-tillage operations and farm mechanization.
III. Improvement of feeding management using local feed resources	•For feed supply during the dry season, leguminous pasture, fodder trees and sugarcane were examined for their growth under limited moisture conditions. •For the nutritional characterization of grass pastures, their nutritive value and digestion physiology were analyzed. •Metabolizable energy and protein requirements for the maintenance of local ruminants were clarified.
IV. Development of postharvest technologies for local agricultural products	•The main flavor component of Khao Dawk Mali 105 was identified as 2-acetyl-1-pyrroline. The analytical method for its quantification was established. A technique to identify the rice variety using DNA was developed, which makes it possible to detect mixing of non-Khao Dawk Mali 105 varieties. •High-quality silk could be obtained through the use of cocoons after crossbreeding of polyvoltine and bivoltine silkworm strains.
V. Economic evaluation of multiple cropping and livestock farming systems	•The economic and managerial evaluation of the current agricultural systems shows that (1) mechanization of rice production could improve farmer's income under certain conditions and (2) profitability of dairy farming is relatively high, but further technological improvement is still required.

Workshop

Workshop on Weather-Based Information Systems for Risk Reduction in West African Cropping Systems

On July 18, 2000, JIRCAS held an introductory workshop to start a new three-year project titled: "Development of Risk-Reducing Technologies for West African Cereal-Based Cropping Systems Based on Advanced Weather Modeling." This project seeks to respond to the global call made recently by the CGIAR to apply advanced technology to address the need to reduce poverty among those parts of the developing world that have benefited least from previous agricultural research. The objective of this project is to provide farmers with information that will enable them to make better choices among crops, production practices, and land use based on the analysis of farmer behavior and crop performance in response to weather variability. By combining results of advanced weather analysis, crop response, and understanding of farmer behavior, the project seeks to establish the criteria for more accurate and productive production choices in the face of rainfall variability. Information technology will enable the project to gather information on land use and farmer behavior at precise locations in small areas, as well as to develop a system in which it can be shared visually with farmers in a participatory way.

Twenty scientists from seven institutes and organizations representing a diversity of disciplines participated in the workshop. The workshop was organized around six topic areas: West African agriculture; soil and crop conditions; weather analysis and water use; information processing; risk management; and linkages to research in related on-going projects. After opening remarks by T. Ishitani and K. Tsurumi, Division Directors, JIRCAS, the workshop started with the first topic area, with two presentations on West African agriculture. J. Caldwell, JIRCAS, presented slides and data on rainfed cereal production in Mali, and T. Sakurai, JIRCAS, presented slides and data on rice production in several West African countries. The second topic area included presentations by K. Okada, JIRCAS, on soil fertility and its improvement in West Africa, and H. Hasegawa, Tohoku National Agricultural Experiment Station, on quantitative modeling of crop growth parameters. In the third topic area, H. Kanno, Tohoku National Agricultural Experiment Station, provided an introduction to weather analysis used in the Tohoku region of Japan, and possibilities for application of analysis methods in West Africa. K. Ozawa, JIRCAS Okinawa Subtropical Station, followed with a presentation on water use-efficient technologies for semi-arid regions. This was followed by two presentations in the fourth topic area. K. Takezawa, Hokuriku National Agricultural Experiment Station, presented information on decision support systems using pattern recognition. T. Hayashi, JIRCAS, described new portable information loggers appropriate for land use surveys. Next, in the fifth topic area, T. Nanseki, National Agriculture Research Center, provided an introduction to risk modeling. T. Sakurai presented results of research on household budgets and risk in semi-arid West Africa. In the last topic area, S. Asanuma, JIRCAS, described the studies carried out within the framework of the anti-desertification project, and H. Takagi, JIRCAS, explained the research being conducted within the framework of the West Africa rice improvement project. The workshop closed with a general discussion on how to implement the project plan, with a focus on the linkages among the project components of farmer production decision-making criteria, weather modeling, and risk management.

(John S. Caldwell)

7th JIRCAS International Symposium

"Agricultural Technology Research for Sustainable Development in Developing Regions"

At the dawn of the new millennium, the Japan International Research Center for Agricultural Sciences (JIRCAS, formerly TARC, Tropical Agriculture Research Center), celebrates its 30th anniversary. TARC was established in 1970, just as the Green Revolution was reaching its peak. The major impetus to the Green Revolution at that time was the need to address the chronic food shortages in developing countries, especially Southeast and South Asia. These efforts enabled most countries to become self-sufficient in basic foods.

Today, at the start of a new century, agricultural research faces many more challenges. Increased food production continues to be a high priority in the face of continued world population increase. This needs to be achieved through the development of production systems in better harmony with the environment. Technology development targeted towards environments with marginal soil and water resources, where still over half of the farmers of developing countries make a living from agriculture characterized by unstable production, is a critical need. Advances in research and application of biotechnology, information technology, and other new technologies are needed to help solve these problems. In addition to such discipline-based research, strengthening farmer participation and linkages with other stakeholders in research and extension is essential to achieve new production and resource management systems with high sustainability.

This symposium will address four themes, with the objective of assessing future directions for sustainable agricultural development in developing regions, drawing from the experience of all symposium participants, including public institutions, non-governmental organizations and the private sector in each country, and international research institutions, with a focus on JIRCAS:

1. Accomplishments, needs, and potential for technology development for increased production
2. Concepts and approaches for agro-ecological sustainability
3. Farmer-researcher-extension-private sector partnerships for technology development and dissemination
4. Past achievements and future orientation of JIRCAS and partners in the development of sustainable agriculture, forestry and fisheries

Program

Date: 1 and 2 November 2000
Venue: Epochal Tsukuba

Day 1

Keynote addresses

(1) An assessment of technology development from the Green Revolution to today
Dr. William D. Dar, Director General, ICRISAT
(2) Key characteristics of agricultural sustainability
Dr. Pedro A. Sanchez, Director General, ICRAF
(3) Evolution and new directions using information systems for enhanced farmer partnership in NARS agricultural research
Dr. Stein W. Bie, Director General, ISNAR

SESSION 1 TECHNOLOGY DEVELOPMENT FOR INCREASED PRODUCTION: ACCOMPLISHMENTS, NEEDS, AND POTENTIAL

(1) Developing new crop varieties for stress and low-input conditions
Prof. Kazuyoshi Takeda, Okayama University
(2) Contribution of molecular biology to breeding and issues associated with its application in developing countries
Dr. Ronald P. Cantrell, Director General, IRRI
(3) Distribution and processing systems for stable supply of products from agriculture, forestry and fisheries
Dr. Greg Johnson, Program Manager, Postharvest Technology, ACIAR

SESSION 2 CONCEPTS, NEEDS, AND APPROACHES FOR AGRO-ECOLOGICAL SUSTAINABILITY

(1) Sustainable land management for crop production
Dr. Eric T. Craswell, Director General, IBSRAM
(2) Sustainable water management for crop production
Dr. S. A. Prathapar, Director, IWMI Pakistan
(3) Sustainable aquaculture production and fisheries management
Dr. Meryl J. Williams, Director General, ICLARM

Day 2

SESSION 3 EVOLUTION OF FARMER-RESEARCHER-EXTENSION-PRIVATE SECTOR PARTNERSHIPS FOR TECHNOLOGY DEVELOPMENT AND DISSEMINATION

(1) Evolution of concepts and approaches of systems-oriented, farmer participatory agricultural research
Dr. John S. Caldwell, International Research Coordinator, JIRCAS
(2) Contributions of farmer knowledge to agricultural technology development
Prof. Harold J. McArthur, University of Hawaii
(3) Institutionalization of technology development
Prof. David W. Norman, Kansas State University
(4) Developing sustainable agricultural systems: case study examples, determinants, future approaches, and roles of different partners, as viewed from the cooperation agency
Mr. Nobuyuki Samejima, Managing Director, JICA
(5) Developing sustainable agricultural systems: case study examples, determinants, future approaches, and roles of different partners, as viewed from the national agricultural research system
Dr. Ananta Dalodom, Director General, DOA, Thailand

Poster session

SESSION 4 DISCUSSION AND SYNTHESIS OF SYMPOSIUM THEMES: Past achievements and future orientation of JIRCAS and partners in the development of sustainable agriculture, forestry and fisheries

(1) Research output and future direction of JIRCAS
Dr. Takasuke Ishitani, Director, Research Planning and Coordination Division, JIRCAS
(2) Questions, comments, and discussion
(3) Synthesis and conclusions

For further information, please contact:
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