Japan International Research Center for Agricultural Sciences

Annual Report 2016

(April 2016-March 2017)

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Message from the President

President
Dr. Masa Iwanaga
(FY2011-)

Recent events around the world – hot summers, droughts, land rush (investing in foreign farmlands), and shocks in energy supplies and prices – underline the scarcity of resources we depend on to produce the world's food supply. According to a recent FAO estimate, we will have 9.6 billion people by 2050 – an increase of 2.6 billion people from 2013. It has become increasingly clear that sustainably feeding an ever-increasing number of people requires a much more careful and integrated approach to the use of land, water, and energy than we currently apply. Which is why it is an absolute must that we start now to produce more food using fewer resources and to use the harvest more efficiently. Demographic changes, rising incomes (and associated consumption patterns), and unstable climatic conditions, alongside persistent poverty and inadequate policies and institutions, are all placing serious pressure on the natural resource base that supports current and future societies. This presents a 'perfect storm' scenario, especially in light of recent climate trends and increased likelihood of extreme weather events. Not surprisingly, the World Economic Forum's Global Risks Report 2016 named (1) water crises, (2) failure of climate change mitigation and adaptation, (3) extreme weather events, and (4) food crisis as the top four global risks of the highest concern for the next ten years.

To end poverty and protect the planet, countries around the world adopted the 2030 Agenda for Sustainable Development. They officially began implementing the United Nations' 17 Sustainable Development Goals (SDGs) on January 1, 2016, hoping to achieve its 169 associated targets by 2030, and even by 2020 in some cases. The OECD-FAO, in its Agricultural Outlook Report for 2016-2025, aptly summarized the significance of agriculture vis-à-vis the 2030 Agenda. In it, **Goal # 2 (End hunger, achieve food security and improved nutrition, and promote sustainable agriculture)**, which highlights global targets on hunger, malnutrition, productivity and incomes, sustainability and resilience, biodiversity, investment, trade and commodity markets, was viewed to be the most important among the 17 SDGs. It also recognized **Goal #1 (End poverty in all its forms everywhere)** to be highly relevant, linking the many aspects of food security to poverty and noting that poverty has driven most of the world's poor to become chronically hungry. It emphasized the significance of agricultural development toward alleviating the plight of three-quarters of the world's poor, who rely heavily on agriculture as food and income sources, and how it can be harnessed into ending extreme poverty and feeding 9.6 billion people by 2050.

The year 2016 was highly significant for JIRCAS because it was the first year of the Fourth Medium to Long-term Plan for FY 2016-2020. We had carried out the Third Medium-Term Plan for FY 2011-2015 with verifiable evidence of successful implementation of the Projects and delivery of expected outputs under our four Programs. We have reformulated our project portfolio in response to changing priorities, placing more emphasis on nutrition and strategic research. This annual report describes how JIRCAS has carried out its major activities under the new medium to long-term plan for FY 2016-2020.

Let me recap the main points of our program-based management and strategy:

Introducing the four Programs

We have retained the same overall structure of program-based management with some modification of the project level components. The number of projects has been reduced from 19 to 14.

The four Programs developed using the mission-based principles are as follows:

1) Program A: Development of agricultural technologies for sustainable management of the environment and natural resources in developing regions
2) Program B: Technology development for stable production of agricultural products in the tropics and other adverse environments
3) Program C: Development of high value-adding technologies and utilization of local resources in developing regions
4) Program D: Collection, analysis and dissemination of information for grasping trends of international agriculture, forestry and fisheries

Program-based management

For FY 2016-2020, we have 14 "Projects" that are placed under "Programs" (see Fig. 1).

The programs enable us to clarify our overall goals that need to be achieved and the manner by which we attempt to accomplish our research. Especially assigned Program Directors are in charge of budget, personnel, goal achievement management, and evaluation. Programs A to C have their own so-called flagship projects, representing the most important activity in each program. Projects under each program collectively and coherently contribute to the major goal of their respective programs.

Partnership is the center of our activities

Most of our activities are carried out together with our partner institutions around the world. Effective partnership makes it possible for us to conduct joint research activities that would be of value for social impact for our target beneficiaries in developing regions. The map (Fig. 2) shows locations of our current activities based on formal institutional Memorandums of Understanding. We value such partnerships and place it as our organization's core value. We consulted our partners for their feedback on our research activities, and we made the necessary adjustments in our planned research, accommodating our partners' suggestions and our own reflections. This was needed as a mid-course adjustment for better impact delivery. JIRCAS's operational cycle (Fig. 3) illustrates our focus towards impact-oriented research for development. Consequently, we were able to develop a clear impact pathway for the delivery of our research outputs to the respective target beneficiaries of each project.

Strive for impacts

By introducing the program-based system for output development and delivery, JIRCAS was able to depict more succinctly, not only to taxpayers and Japanese citizens but also to people in developing countries, what it essentially does and for whom. Promotion of more efficient and accountable research will further be feasible. Accordingly, it is important for every researcher, manager, and support staff to work together to produce well-considered outputs that will be deemed suitable, acceptable, and adaptable for users. We will keep striving to take advantage of this new structure with the undying passion of our 46-year-old "research for development" tradition, hoping to produce deliverables that will be used by our target beneficiaries, resulting in significant positive social impacts.

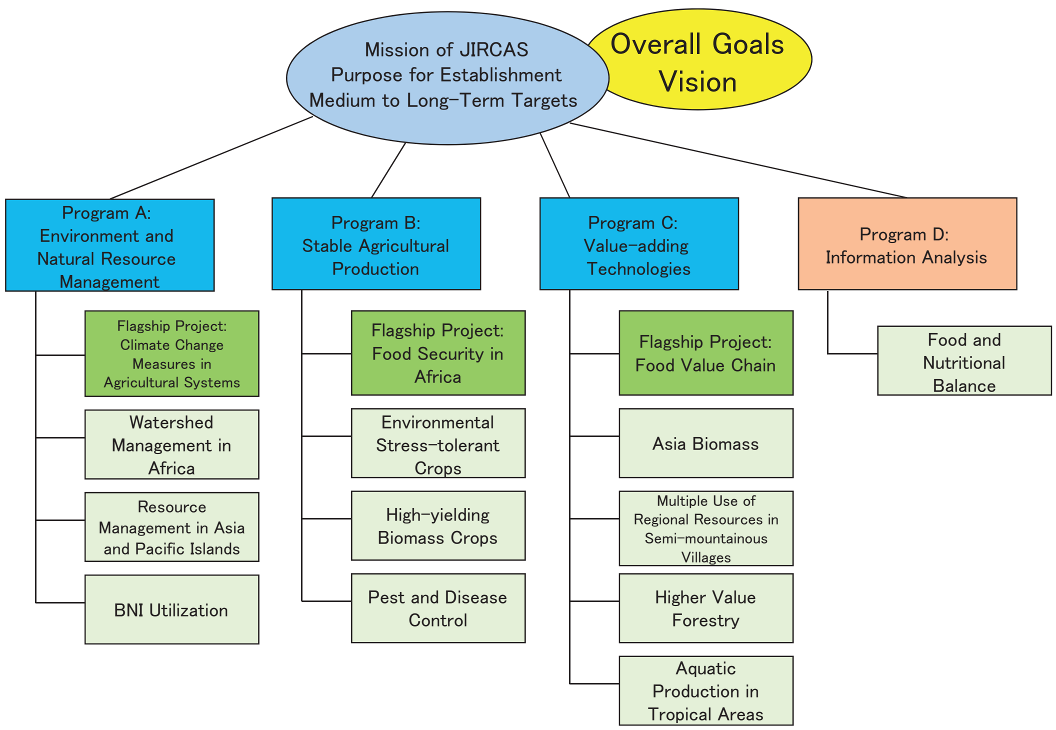


Fig. 1. Program-Project Research Framework

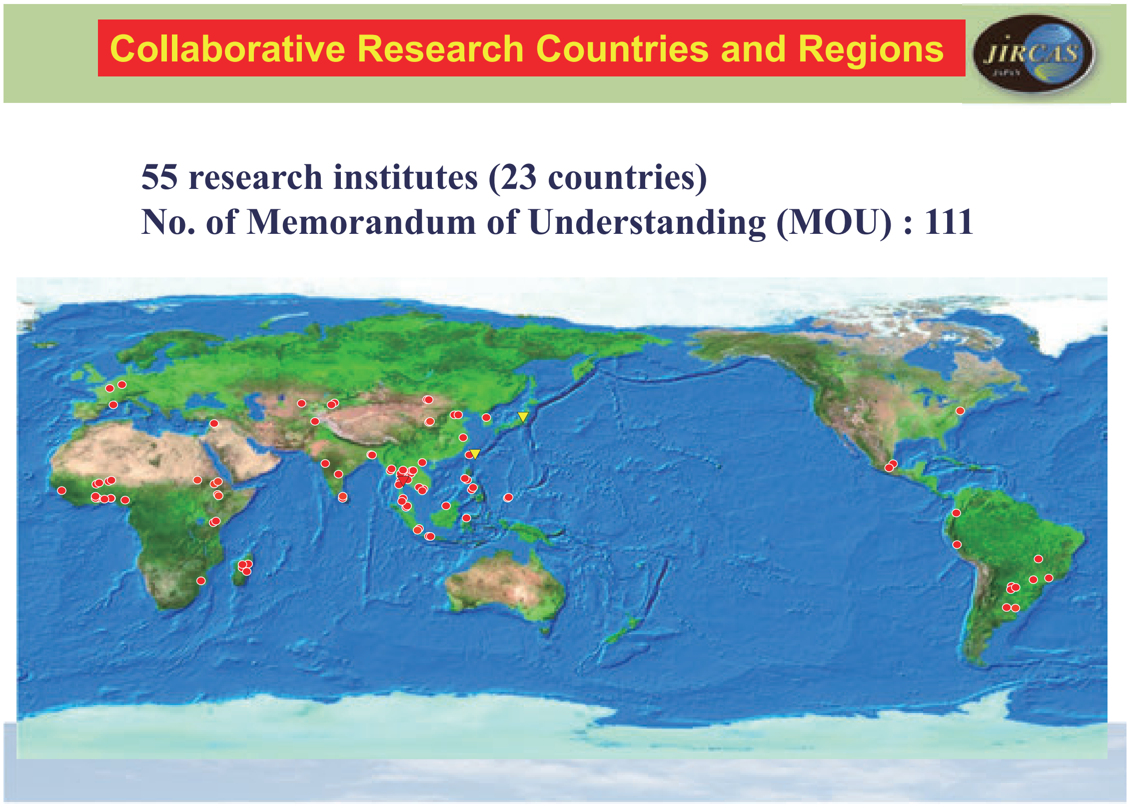


Fig. 2. Locations of our current activities based on 111 MOUs with partner institutions

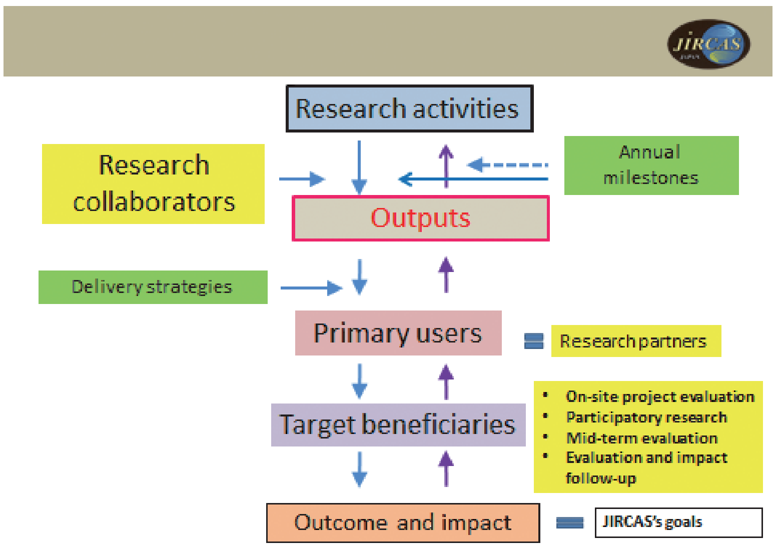


Fig. 3. Impact-oriented research for development (Operational Cycle)

HIGHLIGHTS FROM 2016

JIRCAS International Symposium 2016

JIRCAS International Symposium 2016, titled "Legumes Improve Our Livelihood!" was held on December 2 in Tokyo. It was co-organized by the United Nations University - Institute for the Advanced Study of Sustainability (UNU-IAS), with great support from the Research Council Secretariat of the Ministry of Agriculture, Forestry and Fisheries (MAFF, Japan), the National Agriculture and Food Research Organization (NARO, Japan), Japan Pulse Foundation, the Japan Liaison Office of the Food and Agriculture Organization (FAO) of the United Nations, as well as the Japan Forum on International Agricultural Research for Sustainable Development (J-FARD).

The importance and significance of leguminous crops in world agriculture, food, and nutrient security is widely recognized. Legumes are highly nutritious and economically accessible, and they contribute to food security and human health. They are cultivated all over the world in various cropping systems, and they sustain the biodiversity of the systems. They promote sustainability of agricultural lands with their ability to fix nitrogen from the air. Agricultural products made from legumes have been effectively involved in international and local economies and bring benefits to various sectors through value addition chains. Recognizing that legumes/pulses play an important role in both food security and nutrition improvement, the United Nations declared 2016 as the "International Year of Pulses."

Internationally, soybean and peanut (groundnut) are excluded from the group of pulses, and are recognized instead as oil crops. However, in this symposium, we discussed leguminous crops in broader terms to include soybean and groundnut, as they are the most popular leguminous grain commodities in Japan and Asia.

The first keynote speech was delivered by Dr. David Bergvinson, director general of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). He presented ongoing research projects on legumes worldwide and the steps being taken to achieve sustainable development. The second keynote speaker was Dr. Kazumi Maeda, professor emeritus at Kochi University. He explained the relationship between beans and people and traced the etymology of beans (or the history of words used to name or describe beans).

Three sessions were held on the following topics, namely, "Legumes in agriculture: Sustainability, environment and development," "Legumes over the world: Diversity for improvement," and "Livelihood with Legumes: Value addition and nutrition," with speakers from Japan, India, USA, Malawi, and Ghana. Japanese sweet sponge cakes stuffed with adzuki bean jam, courtesy of the Japan Pulse Foundation, were served during coffee/tea breaks, making the interactions and talks more active than usual.

In the panel discussion, Dr. Bergvinson was joined by Dr. Gretchen Neisler, director of the Center for Global Connections in Food, Agriculture and Natural Resources, Michigan State University, USA, and Dr. Robert Abaidoo, a professor of Kwame Nkrumah University of Science and Technology, Ghana. They talked about 'the future and way forward' toward further utilization of legumes and pulses for world development, and exchanged opinions on how research on legumes and pulses can contribute to the UN Sustainable Development Goals (SDGs).

Symposium on "BNI (Biological Nitrification Inhibition) - Potential impacts on nitrogen-cycling in global agricultural systems"

The BNI international symposium, titled "BNI (Biological Nitrification Inhibition) - Potential impacts on nitrogen-cycling in global agricultural systems," was held on September 14 and 15, 2016 at Tsukuba International Congress Center (EPOCHAL TSUKUBA) in Tsukuba, Japan. It was organized by Japan International Research Center for Agricultural Sciences (JIRCAS).

In March 2015, JIRCAS, as the lead agency in Japan supporting BNI research, organized the first international conference on BNI and launched the "BNI International Consortium." This most recent symposium, therefore, was held to strengthen the consortium activities, build the international network, and further develop research on BNI.

The symposium was made open to the public on September 14 so that those interested in nitrogen circulation and agricultural environment studies could participate widely and deepen their understanding of BNI and its usefulness. The number of participants was about 80. The opening remarks were delivered by Dr. Iwanaga, president of JIRCAS, and Mr. Masamichi Saigo, secretary general of the Agriculture, Forestry and Fisheries Technology Council of the Ministry of Agriculture, Forestry and Fisheries. A keynote speech, entitled "BNI-technology - Potential implications to reduce N_2O emissions and improve NUE from agricultural system," was given by Dr. Guntur Subbarao, a senior researcher of JIRCAS. The symposium was followed by four themed sessions, namely, Nitrogen-fertilization impacts on global environment (3 subjects), BNI in natural ecosystem (4 subjects), Method for analysis of BNI (3 subjects), and Challenge for BNI utilization in agricultural production (4 subjects). All presentations encouraged active discussion, and there were many questions and comments.

On September 15, the meeting was limited only to domestic and foreign researchers involved in BNI studies. First, activity reports on BNI research at JIRCAS were presented, followed by presentations of the latest results obtained by three CGIAR research institutes (CIMMYT, CIAT, ICRISAT) in collaboration with JIRCAS. In addition, overseas research institutions, which could become partner institutions for new collaborative research, expressed their views toward future development. Finally, there was an exchange of opinions on how to proceed with BNI research in the future and on further research developments.

International symposium on "Dairy Cattle Beef Up Beef Industry in Asia: Improving Productivity and Environmental Sustainability"

Dairy farms have the potential to play an important role as beef cattle supplier through effective management of their dairy bulls. Additionally, the utilization of dairy bull for beef production could be effective in mitigating greenhouse gas emissions because of its contribution to reducing the number of beef cows for beef calf production. Fattening of dairy bulls is still not very popular in Southeast Asia compared with developed countries. Therefore, to create an opportunity to exchange opinions and discuss the possibility of a successful dairy beef production system in Southeast Asia, the Thailand Research Fund (TRF) and JIRCAS held the international symposium, titled "Dairy Cattle Beef Up Beef Industry in Asia: Improving Productivity and

Environmental Sustainability," on 19 August at Hotel Swissôtel Le Concorde, Bangkok, Thailand. About 30 participants from Southeast Asia attended the symposium.

Symposium presenters first introduced the current situation of dairy beef industries in Japan and Thailand. This was followed by reports on the supply chain of dairy beef, dairy bull fattening trials in Thailand, and environmental impact evaluation of dairy beef production systems. There was a productive exchange of views, with the participants recognizing the necessity of investigating suitable feeding management strategies for dairy bull fattening to maximize benefits to the farmers while minimizing environmental load.

Opening address by Dr. Jutarat Sethakul of TRF

Presentation by Dr. Tomoyuki Suzuki of JIRCAS

IRRI-JIRCAS-NARO Joint Symposium "Towards Achieving Sustainable Rice Production in Asia"

JIRCAS, the International Rice Research Institute (IRRI), and the National Agriculture and Food Research Organization (NARO) organized a joint symposium under the auspices of the Global Rice Science Partnership (GRiSP) on September 7 and 8, 2016 at the Tsukuba International Congress Center (Epochal Tsukuba) in Tsukuba, Ibaraki, Japan. The symposium aimed to provide an overview of the current situation in rice research focusing on high temperature tolerance, yield physiology, and pest management.

In his welcome address, JIRCAS President Masa Iwanaga emphasized the importance of technological development for high temperature tolerance by mentioning that rice is one of the most susceptible crops to global warming.

In Session III (Insect Pest Management), a speech titled 'Network collaboration on rice blast disease' was delivered by JIRCAS Senior Researcher Yoshimichi Fukuta. He summarized the history of Japan-IRRI collaboration dating back to 1986 and introduced the achievements of the international rice blast network led by JIRCAS. Before the symposium, five IRRI researchers, including Deputy Director General Jacqueline Hughes, visited JIRCAS. They paid a courtesy call on Dr. Iwanaga and exchanged opinions about rice research with JIRCAS researchers.

Participants of the IRRI-JIRCAS-NARO Joint Symposium

2016 Japan International Award for Young Agricultural Researchers

JIRCAS, in cooperation with the Agriculture, Forestry and Fisheries Research Council (AFFRC) Secretariat, presented the Japan International Award for Young Agricultural Researchers for the 10th consecutive year. The award recognizes and honors young foreign researchers (citizens of developing countries and under 40 years of age) who are highly recommended by their institutes, and whose outstanding achievements promote research and development of agricultural, forestry, fishery and other related industries in developing regions. The 2016 commendation ceremony was held last December 1 at the U Thant International Conference Hall of the United Nations University (UNU) in Tokyo.

AFFRC Chairman Yoshio Kobayashi welcomed the awardees and guests. Congratulatory remarks were delivered by Mr. Hiroshi Chishima, director for Industrial Technology and Nanotechnology, Bureau of Science Technology and Innovation, Cabinet Office; Dr. Kazuhiko Takemoto, director of the Institute for the Advanced Study of Sustainability, UNU; and Mr. Hiroto Mitsugi, director general of the Rural Development Department, Japan International Cooperation Agency (JICA). Selection Committee Chair Mutsuo Iwamoto explained the selection process.

The seven-member selection committee conducted a document review, with the chairman of the AFFRC determining three winners from among 25 candidates. Each awardee received a testimonial and a USD 5,000 cash prize.

The 2016 awardees and their research achievements are as follows:

Musaida Mercy MANYUCHI
Nationality: Republic of Zimbabwe
Institute: Harare Institute of Technology
Research Achievement: Production of Vermicompost and Vermiwash Bio-fertilizers from Food Waste

Gezahegn Girma TESSEMA
Nationality: Federal Democratic Republic of Ethiopia
Institute: International Institute of Tropical Agriculture (IITA)
Research Achievement: Novel Approaches for the Improvement of Yam Germplasm Conservation and Breeding

Alonzo Alulod GABRIEL
Nationality: Republic of the Philippines
Institute: University of the Philippines, Diliman
Research Achievement: *Precision Food Processing*: Establishment of Mathematical Models for Microbiological and Physicochemical Food Properties for Food Safety, Food Defense, and Food Quality

The 2016 awardees, members of the selection committee, and other officials

NEW RESEARCH COLLABORATION

JIRCAS has been strengthening partnerships with international organizations, such as the Consultative Group on International Agricultural Research (CGIAR), to address global issues. In FY 2016, JIRCAS concluded a new Memorandum of Understanding (MOU) with the CGIAR System Organization to contribute to the management of the CGIAR Research Program 2017-2022 (CRP2), and a researcher was sent on a long-term assignment to the CGIAR System Management Office in France to tighten close relationships with international agricultural research institutes.

JIRCAS also concluded an MOU with the World Agroforestry Centre (ICRAF) in Kenya to conduct information analysis in Africa, and a researcher was dispatched on a long-term assignment under the cross-appointment system. Furthermore, to promote economic integration in East Asia and Southeast Asia, JIRCAS sent a researcher on a long-term assignment to the Economic Research Institute for ASEAN and East Asia (ERIA) in Indonesia.

Two new research subjects were adopted as projects under the Science and Technology Research Partnership for Sustainable Development (SATREPS), a Japanese government program that promotes international joint research. JIRCAS has concluded the research contracts and started activities on the following projects:

1. Breakthrough in Nutrient Use Efficiency for Rice by Genetic Improvement and Fertility Sensing Techniques in Africa (Research institution in Madagascar: The Ministry of Agriculture and Livestock)
2. Establishment of the model for fertilizing cultivation promotion using Burkina Faso phosphate rock (Research institution in Burkina Faso: Institute of Environment and Agricultural Research [INERA])

TROPICAL AGRICULTURE RESEARCH FRONT

The Tropical Agriculture Research Front (TARF) in Ishigaki Island (24°N, 129°E) has an important mission as the only agricultural research station under MAFF in the subtropical southern region of Japan. TARF is spread across approximately 21 ha of experimental fields and facilities, including greenhouses, phytotrons, and lysimeters. Taking advantage of the subtropical environment, TARF conducts precise and reliable experiments of tropical crops on collaborative projects that are not enforceable in research sites overseas. Results obtained at TARF are applied and their effects are verified on the actual sites. Its main activities are described below.

Research and development of agricultural production technologies

TARF develops technologies for sustainable agricultural production in other tropical/sub-tropical and island regions in the world. Among the research subjects tackled in 2016 were the following: Resource management in Asia and Pacific islands; Development of blast-resistant rice, Improvement of productivity and stress tolerance in Indica Group rice; High biomass production of sugarcane by using intergeneric crosses; Elucidation of flower bud formation and analysis of genetic diversity in mango; and Researches on other tropical field crops including yam, soybean, cowpea, and *Jatropha*.

Experiments on the effect of applying sediments collected in a sand basin (Photo 1) and the combined effect of no-tillage and organic mulching practices are being conducted at the artificial sloping fields of TARF. The results will be applied to Palau, another tropical Pacific island where climate conditions are similar to Ishigaki's, in order to verify the applicability and effectiveness of the technologies and to disseminate soil conservation measures at farmers' fields in other Pacific islands. Experiments aimed at developing technologies to increase nitrogen use efficiency by adjusting nitrogen application in sugarcane and by using the biological nitrification inhibition function in *Brachiaria* grass are also being conducted using lysimeters and the fields of TARF. The results can be broadly adopted to island environments.

TARF's location in Ishigaki is ideal for Indica Group rice research because double rice cropping is practicable. We are developing Indica Group rice breeding materials to improve blast resistance, productivity, and tolerance to adverse environments. Effective gene sources are being introduced into leading varieties in the Southeast Asian nations of Bangladesh, Indonesia, Vietnam, and the Philippines, as well as in Sub-Saharan African countries. The target resistant genes were screened by DNA marker-assisted backcross breeding. Approximately 800 rice accessions from IRRI and other collaborative research institutes were introduced and evaluated for their characteristics in order to select promising lines for future research and breeding (Photo 2).

Genome editing has shown capability to improve crops. Systems of genome editing have been developed for leading varieties of rice such as Koshihikari, IR64, and NERICA1. A transformation system for yam is also being developed.

Salinity damage has been identified as one of the most serious growth constraints on soybean production in arid and semi-arid areas. The function of the salt tolerance gene, *Ncl*, has been isolated from a salt-tolerant soybean and is being analyzed using a hydroponic system.

Photo 1. Sand basin at Ishigaki Island

Photo 2. Basmathi 217, a popular aromatic rice variety from Thailand

Sugarcane is an important crop for sugar and energy production in the world. Intergeneric crosses between sugarcane and *Erianthus* have been used to introduce high biomass production and environmental stress tolerance traits into sugarcane. Backcross populations, i.e., BC_1 in Thailand and BC_2 in Ishigaki, were produced and evaluated for their agronomic traits in the respective countries. Selection using DNA markers associated with promising traits of *Erianthus* in the backcross generations are under development. In Thailand, field experiments have been initiated to develop a stable technique of cultivating multi-purpose sugarcane and to evaluate the yield of *Erianthus* in adverse environments. In order to control sugarcane white leaf disease, the ecology of insect vectors was studied and a new healthy seed cane production system is being developed.

Although mango is one of the most important tropical fruit trees, advances on mango research and development are slower in comparison with other major tropical fruits such as banana and pineapple. In mango, flowering control and stable production are the most important issues in the target countries, namely, Lao PDR and Myanmar. In order to develop technologies to control the flowering period, experiments on chemical and drought treatments have been started at TARF. Native mango genetic resources are also being collected and would be utilized to promote domestic production. Furthermore, passionfruit had been identified among tropical fruits as a promising new crop in Japan for its ability to withstand global warming. Since stable flowering under high temperature conditions is the most critical issue, related species were used in introducing heat tolerance, and the derivatives are being evaluated to identify for tolerance (Photo 3).

Contribution to domestic agriculture

TARF contributes to domestic agriculture through the following activities:

1) Generation advancement

Early generation rice populations from breeding stations of NARO all over Japan were grown two or three times.

2) Production of sugarcane F_1 seeds by crossing

Approximately 150-200 crosses (200-300 panicles) were made for the sugarcane breeding station of NARO.

3) Conservation of genetic resources

As sub-bank for tropical and subtropical crops, 534 accessions of sugarcane and its relatives (Photo 4), 150 of tropical fruit trees, and 120 of pineapple were maintained in the field or in a greenhouse.

4) Development of varieties for Nansei Islands

JIRCAS has developed and registered varieties of winged bean, common bean, papaya, sugarcane (in Thailand), and *Erianthus* (biomass plant). Newly developed varieties of passionfruit and *Brachiaria* (forage grass) are now under variety registration.

Photo 3. Evaluation for heat tolerance of progenies derived from an interspecific cross in passionfruit

Photo 4. Genetic resources of sugarcane and its wild relatives

ACADEMIC PRIZES AND AWARDS

JIRCAS receives "trophy of appreciation" during Thailand's National Science and Technology Fair 2016

Since 2007, JIRCAS has been attending Thailand's National Science and Technology Fair, an annual event organized by the Ministry of Science and Technology, Royal Thai Government, to stimulate the public's interest in science and technology by highlighting recent advancements and innovations. For its active participation, JIRCAS, together with other supporting agencies, was awarded a trophy of appreciation by the Ministry of Science and Technology on August 28, 2016. An estimated 1 million visitors attended the 11-day event, which ran from August 18 to 28.

At the opening ceremony on August 19, Dr. Pichet Durongkaveroj, the minister of Science and Technology, visited JIRCAS's exhibition booth, which featured its research on sugarcane variety development and climate change mitigation.

Regarding sugarcane variety development, the new sugarcane variety, TPJ04-768, was showcased for its high ratoon ability and high sugar and fiber production, while *Erianthus* was highlighted as a promising genetic resource that can be used in producing high amounts of fiber and in conferring high tolerance against drought. Plant and root samples were displayed in pots to provide the visitors a better appreciation of the research activity. Regarding climate change mitigation, the following research studies were exhibited, namely, carbon sequestration in agricultural soils treated with organic matter input and in no-tillage cultivation, measurement of carbon stocks on forest trees above-ground and under-ground and the results of investigation, and measurement of greenhouse gas (methane) emissions from cattle and the development of mitigation technologies.

Dr. Pichet Durongkaveroj, Thailand's Minister of Science and Technology, visits the JIRCAS booth.

Thailand's Ministry of Science and Technology awards the trophies to supporting agencies.

The Fourth Niigata International Food Award (Main Prize)

Dr. Masa Iwanaga, president of JIRCAS, has been earning international praise for his major accomplishments in crop genetic resources conservation and utilization. For this reason, he was honored with the Fourth Niigata International Food Award (Main Prize) by the Niigata International Food Award Foundation. He received the Main Prize and delivered a commemorative lecture at the award ceremony held in Toki Messe Niigata Convention Center, Niigata City on November 9, 2016.

Dr. Iwanaga had spent almost 30 years working in various international agricultural research institutions, including the International Potato Center (CIP) in Peru, the International Center for Tropical Agriculture (CIAT) in Colombia, the International Plant Genetic Resources Institute (IPGRI, now Bioversity International) in Italy, and most especially, the International Maize and Wheat Improvement Center (CIMMYT) in Mexico, where he became director general from 2002 to 2008. CIMMYT is highly regarded for its research discoveries that helped launch the "Green Revolution," which in turn led to the 1970 Nobel Peace Prize. As director general of CIMMYT, Dr. Iwanaga led the organization, with more than 800 staff members worldwide, in overcoming financial challenges and by establishing a long-term research strategy to remain a global leader in international agricultural research.

In addition to being president of JIRCAS, he also assumes other responsibilities, holding concurrent positions in international organizations and serving as a panelist for the UN Food and Agriculture Organization (FAO) Committee on World Food Security (CFS) and other international conferences.

The Fourth Niigata International Food Award (Sano Touzaburo Special Prize)

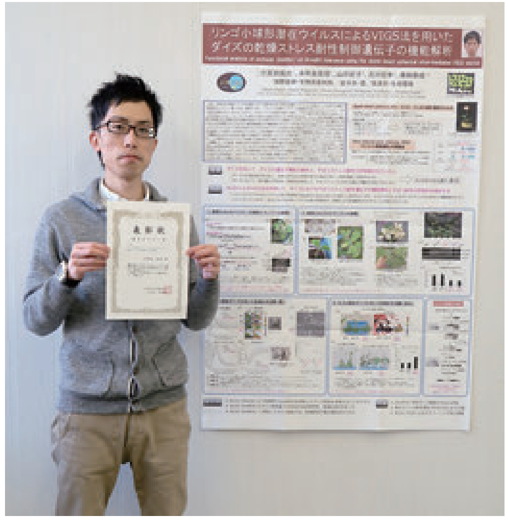
Dr. Marcy N. Wilder, a senior researcher of the Fisheries Division, received the Fourth Niigata International Food Award (Sano Touzaburo Special Prize) in a ceremony in Niigata City on November 9, 2016. The award recognizes contributions to food supply stabilization/ international development through research and policy-making. Dr. Wilder was recognized for her basic research on crustacean biochemistry and its applications to commercial aquaculture technology, and in particular, for developing together with the private sector, the world's first Indoor Shrimp Production System (ISPS), which operates on a commercial basis domestically and abroad.

Shrimp farming has become a significant industry in recent years and boasts a market value of more than 20 billion U.S. dollars annually. However, environmental issues, such as the destruction of mangrove forests especially in Southeast Asia and the pollution of marine areas from farm effluent, have become apparent with the expansion of the industry. In this regard, Dr. Wilder has focused her work on developing a more sustainable form of shrimp production, firstly collaborating with Vietnam's Can Tho University during 1995-2003 in an Official Development Assistance (ODA)-funded project to assist impoverished rice farmers raise their income levels by providing a means of culturing freshwater prawns together with rice cultivation. Thereafter, Dr. Wilder conducted research with the private sector, principally with IMT Engineering, Inc., leading to the development of the above-mentioned ISPS and its establishment in Myoko City, Niigata Prefecture in 2007. This facility enables the production of marine shrimp under closed, near-freshwater conditions, with minimal impact to the environment. The product is marketed as "Myoko Snow Shrimp®" and is known widely throughout Japan. A second ISPS plant has been built in Mongolia and has just gone into commercial operation.

The award is administered by the Niigata International Food Award Foundation and is given once every two years.

"Excellent Poster Award" at the 39th Annual Meeting of the Molecular Biology Society of Japan

Dr. Takuya Ogata, a researcher of the Biological Resources and Post-harvest Division, received the Excellent Poster Award at the 39th Annual Meeting of the Molecular Biology Society of Japan held in Yokohama, Kanagawa on Nov. 30-Dec. 2, 2016. His poster, titled "Functional analysis of soybean *GmNRA1* on drought tolerance using the *Apple latent spherical virus* (ALSV)–mediated virus-induced gene silencing (VIGS) vector," presented the result of his research on using a plant virus vector system as a novel technology for developing stress-tolerant soybean plants. In his research, he performed a functional analysis of a candidate gene, soybean *GmNRA1*, which is a homolog of an *Arabidopsis* gene involved in drought tolerance, using the ALSV–mediated VIGS method. The results of his research are expected to be applied as a novel method for molecular breeding of drought-tolerant soybean plants. Recent severe droughts have frequently caused harvest losses in many parts of the world. The establishment of research technologies that connect basic and applied researches on plant could help accelerate the development of crops that can cope with the adverse effects of climate change.



“Paper Award” from the Japanese Society of Pedology

The original paper, entitled “Effects of Tourism Activities on Grassland Degradation in Hulunbuir Grassland, Inner Mongolia, China” and written by Dr. Kenta Ikazaki, a researcher of Crop, Livestock and Environment Division, and his colleagues, was given the “Paper Award” by the Japanese Society of Pedology. In Inner Mongolia, the recent increase in the number of tourists has raised serious concerns about grassland degradation by tourism activities. The paper revealed the effects of tourism activities on soil properties and vegetation and on the basis of the results, the authors proposed a sustainable management practice for tourist sites in Inner Mongolia.

“Outstanding Paper Award” from the Japanese Society for Tropical Agriculture

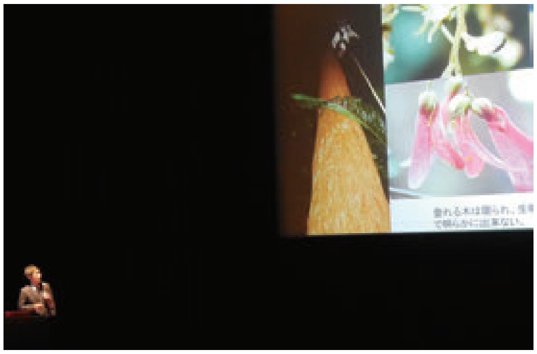
Dr. Satoshi Nakamura, a researcher of the Crop, Livestock and Environment Division, and his colleague received the Outstanding Paper Award from the Japanese Society for Tropical Agriculture (JSTA) on 11th March 2017. The commendation was given in recognition of the contribution of their academic paper, which was published by JSTA, on the development of tropical agriculture and information transmission.

The award-winning research paper has provided suggestions and substantial information on the relationship between farmers’ socio-economic/natural resource conditions and their actual soil fertility management practices. The outcomes of the study were obtained through the collaborative research, titled “The study for improvement of soil fertility with use of indigenous resources in rice systems of sub-Saharan Africa,” which was conducted for five years with Ghanaian counterparts.

“The Japanese Forest Society Award” from the Japanese Forest Society

On March 26, 2017, Senior Researcher Naoki Tani of the Forestry Division received the Japanese Forest Society Award from the Japanese Forest Society (JFS). The award, which honors scientific achievements and breakthroughs and its contribution to progress in forestry science, was founded as the Shirasawa award in 1935 and presented for the 80th time in 2017. Society President and Hokkaido University Professor Futoshi Nakamura presented the award certificate during the annual research conference held in Kagoshima City.

Dr. Tani, who also delivered an award lecture titled “Pollen dispersal and reproductive strategies of dipterocarps, a major component species in Southeast Asian tropical forest, and application to selective logging” during the event, has been receiving high praise for his research on the improvement of a selective logging protocol to maintain a healthy forest regeneration system. The research results have provided important guidance for research involving sustainable tropical forest management in the future.



“Best Paper Award” from the Crop Science Society of Japan

Dr. Yasuhiro Tsujimoto, a senior researcher of the Crop, Livestock and Environment Division, received the “Best Paper Award on Plant Production Science” at the 243rd Meeting of the Crop Science Society of Japan on March 29, 2017. Dr. Tsujimoto received the award on behalf of his co-authors, Dr. Tetsuji Oya (Senior Researcher) and Dr. Satoshi Tobita (Program Director, Environmental and Natural Resource Program), for their paper titled “Performance of maize-soybean intercropping under various N application rates and soil moisture conditions in Northern Mozambique.” The paper was praised for revealing the productivity advantages of maize-soybean intercropping system over monocropping, particularly under drought stress and low-fertility environments that prevail in Sub-Saharan Africa.

Dr. Yasuhiro Tsujimoto receiving the award certificate

RESEARCH OVERVIEW

OVERVIEW OF JIRCAS' RESEARCH STRUCTURE

1. History

The Japan International Research Center for Agricultural Sciences (JIRCAS) was first established in 1970 as the Tropical Agriculture Research Center (TARC), one of the research institutes of the Ministry of Agriculture and Forestry of Japan. TARC was reorganized into JIRCAS in 1993.

On April 1, 2001, JIRCAS became an Incorporated Administrative Agency (IAA) under the jurisdiction of the Ministry of Agriculture, Forestry and Fisheries (MAFF), in accordance with the administrative reforms of the Government of Japan to facilitate the reorganization of national government-affiliated research organizations.

2. Mission

Through research and development (R&D) and dissemination of information related to agriculture, forestry and fisheries in developing regions, JIRCAS contributes to the improvement of the international presence of Japan and towards a secure and stable supply of food worldwide including Japan.

3. The IAA System

An IAA is an organization responsible for key public services that the government is not required to provide, but which the private sector is likely to neglect for various reasons. The IAA system was introduced in 2001, as part of central government reforms based on the scheme that the planning sectors and the implementing sectors should be separated. Under the IAA system, MAFF defined JIRCAS' Fourth Medium to Long-Term Goals in FY 2016, including the maximization of R&D outcomes, the enhancement of research efficiency, and the improvement of financial performance. Based on the Fourth Medium to Long-Term Goals, JIRCAS drafted and began to implement a detailed five-year plan, the Fourth Medium to Long-Term Plan (FY 2016- FY 2020).

4. Evaluation

The performance and budgeting management of research activities conducted by JIRCAS undergo regular evaluation by the National Research and Development Agency Council established within MAFF. As for the activities of each fiscal year, the Council investigates and analyzes the progress towards achieving the Medium to Long-Term Plan, and the results of this evaluation shall be applied as deemed necessary to the modifications of the operational and financing systems for subsequent fiscal years. To meet the requirements of the general guideline concerning evaluation of the national research and development (a decision of the Prime Minister in 2016) which require efficient evaluation, JIRCAS carried out the in-house evaluation in FY 2016 as follows:

1) Research activities were evaluated, and summary reports were prepared in each Research Program.
2) These reports were then collectively evaluated at the meeting for the evaluation of research programs of the Medium to Long-Term Plan by external reviewers (government officials from the Ministry of Agriculture, Forestry and Fisheries and specialists from other research institutes) and internal reviewers (the President, the Vice-President, the Auditor, the Program Directors and the Directors of each research division) in February 2017.
3) Comprehensive evaluation of all JIRCAS activities, which also include administrative operations, was performed by external reviewers of the JIRCAS External Evaluation Committee in March 2017.

The external reviewers are listed in the Appendix. The results of the in-house evaluation and a summary of all activities were submitted to MAFF in June 2017.

5. Medium to Long-Term Plan

JIRCAS implements four programs for research activities under the Medium to Long-Term Plan. Each program consists of several projects. Major accomplishments and research highlights of the programs in FY 2016 are described in the following sections. The contents of the Medium to Long-Term Plan are also described in the Appendix.

Table 1. Number of Projects in the Fourth Medium to Long-Term Plan (FY 2016 - FY 2020)

Program	Projects
A (Environment and Natural Resource Management)	4
B (Stable Agricultural Production)	4
C (Value-adding Technologies)	5
D (Information Analysis)	1

Fourth Medium to Long-Term Plan (FY 2016 - FY 2020)

■ Program A
Development of agricultural technologies for sustainable management of the environment and natural resources in developing regions

Projects:
1. Development of agricultural technologies for reducing greenhouse gas emissions and climate-related risks in developing countries
2. Development of intensive watershed management models for soil erosion-prone areas in Sub-Saharan Africa
3. Development of sustainable resource management systems in the water-vulnerable areas of Asia and the Pacific Islands
4. Development of ecologically sustainable agricultural systems through practical use of the biological nitrification inhibition (BNI) function

■ Program B
Technology development for stable production of agricultural products in the tropics and other adverse environments

Projects:
1. Development of sustainable technologies to increase agricultural productivity and improve food security in Africa
2. Development of breeding materials and basic breeding technologies for highly productive crops adaptable to adverse environments
3. Development of technologies for the breeding and utilization of promising high-yielding biomass crops in unstable environments
4. Development of technologies for the control of migratory plant pests and transboundary diseases

■ Program C
Development of high value-adding technologies and utilization of local resources in developing regions

Projects:
1. Formation of food value chain through value addition of food resources to support sustainable rural development
2. Development of saccharification and utilization technology for lignocellulosic biomass resources in Southeast Asia
3. Multiple use and value addition of regional resources for improvement of sustainable productivity in semi-mountainous villages in Indochina
4. Development of silvicultural and forest management techniques for indigenous tree species in Southeast Asia to achieve higher value production
5. Development of technologies for sustainable aquatic production in harmony with tropical ecosystems

■ Program D
Collection, analysis and dissemination of information for grasping trends of international agriculture, forestry and fisheries

Project:
1. Evaluation of global food supply-demand and nutritional balance

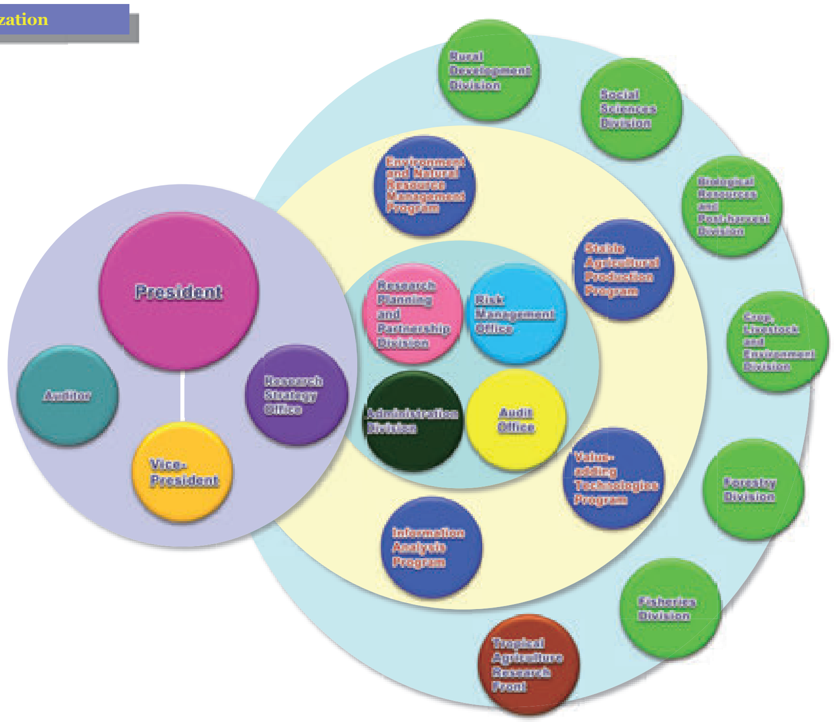
6. Collaborative Research

JIRCAS is required to cover a wide range of research fields. Human resources at JIRCAS, however, are limited. This makes collaborative research with other institutes or universities necessary towards achieving JIRCAS' project objectives. Whenever JIRCAS and its collaborators reach an agreement on the commencement of collaborative research after exchanging ideas and opinions, a Memorandum of Understanding (MOU) or a Joint Research Agreement (JRA) is usually concluded. JIRCAS developed the concept of JRAs in 2006. A JRA is a contract for collaborative research with a particular research subject and with a fixed term. A total of 111 MOUs or JRAs remained in force at the end of FY 2016.

In 2004, JIRCAS was given a Certificate of Recognition by CGIAR as a key partner and as the CGIAR focal point institution in Japan. JIRCAS has been playing an important role in promoting mutual understanding and collaboration between CGIAR and the Japanese government. It has also been intensively implementing collaborative research with several CGIAR research centers.

JIRCAS has been regularly dispatching researchers and research managers to promote research in the developing regions. Likewise, we have been dispatching researchers from other institutes and universities to promote the effective implementation of JIRCAS' projects with the cooperation of such organizations. JIRCAS has likewise implemented several invitation programs for overseas researchers and administrators at counterpart organizations. These programs facilitate not only the promotion of international collaborative research but also related exchanges of information and opinions.

Organization



7. Organization of JIRCAS

The organizational structure of JIRCAS for the Fourth Medium to Long-Term Plan period is summarized in the figure above.

Four Program Directors are responsible for the implementation of individual programs during the Fourth Medium to Long-Term Plan period.

The directors of divisions, offices, and the Tropical Agriculture Research Front (TARF) are responsible for managing staff and enhancing the capabilities of researchers.

TARF (formerly the Okinawa Subtropical Station), located in Ishigaki Island in the southernmost part of Japan, is JIRCAS's sole substation. It focuses on agricultural, forestry, and fisheries research being carried out in overseas regions with highly similar climatic and geographic conditions as Okinawa, taking full advantage of its subtropical weather and geographic location.

MAIN RESEARCH PROGRAMS

PROGRAM A
Environment and Natural Resource Management

"Development of agricultural technologies for sustainable management of the environment and natural resources in developing regions"

The Environment and Natural Resource Management Program aims at the development of technologies for sustainable management of agricultural resources to cope with global environment issues, climate change and land/soil degradation, especially in vulnerable areas of developing regions.

[Climate Change Measures]

This project, fully titled "Development of agricultural technologies for reducing greenhouse gas emissions and climate-related risks in developing countries," is the flagship project of Program A. Therefore, a considerable amount of resources has been allocated to this project, which is composed of two groups of research activities.

The first group focuses on research activities for mitigating climate change. JIRCAS has been conducting field experiments on alternate wetting and drying (AWD) in Can Tho City and An Giang Province in Mekong Delta, Vietnam, since the previous medium-term plan (FY 2011-2015). AWD is an irrigation technique originally invented for water-saving purposes in rice cropping on the initiative of International Rice Research Institute (IRRI). The effect of AWD has been verified, as compared with continuous flooding conditions in experimental plots set in farmers' paddy fields in An Giang Province. The AWD technique reduced GHG emissions considerably, both in alluvial and acid sulphate soils, and more importantly, rice yield significantly increased according to farmers, giving them a strong incentive to adopt the AWD method. In the Mekong Delta, JIRCAS has been actively conducting research on biogas digester (BD). In 2016, we introduced a system comprised of several local BDs to monitor the amount of input (animal feeds and excreta) and output (produced biogas). For the research on mitigation of GHG emissions from animal husbandry, it was revealed that cassava pulp, an effective additive to cattle feed, can be stored under anaerobic conditions to maintain feed quality for a long period. JIRCAS has committed to a long-term field experiment (LTFE), originally designed to observe soil fertility and crop yield, in Lopburi, Thailand. In accordance with the "4 per 1000 Initiative" launched at the Paris COP21 (21st Conference of the Parties) in 2015, the LTFE is expected to provide valuable data for carbon sequestration especially in tropical uplands, making it an important tool for the mitigation of GHG emissions.

The second group focuses on research activities for climate change adaptation. The countries around the Bay of Bengal, especially Bangladesh and Myanmar, are prone to floods, high tides, and storm surges caused by cyclones. We have started designing a weather index insurance program against salinity damage caused by high tides and storm surges. In Bangladesh, based on hydrological and meteorological data, we have categorized several types of floods depending on the characteristics of their damage on agriculture. In addition, based on archived global cyclone tracks, we have found that more cyclones tracked eastward toward the Myanmar coast. The weather-rice-nutrient integrated decision support system (WeRise) is a seasonal climate forecast-based decision support system that provides grain and weather advisories such as the best time of planting, suitable variety, and timing of fertilizer application. We have started disseminating the WeRise system to enhance rainfed rice production and contribute to rice self-sufficiency in the Philippines. To come up with a drought-resilient farming system in the central dry zone of Myanmar, we have started collecting hydrological and meteorological data, and have begun investigating local practices in water-saving agriculture.

[Watershed Management in Africa]

This project aims to propose small scale watershed management models to contribute to the development of land use strategies for the sustainable intensification of agriculture in the Central Plateau of Burkina Faso and the Ethiopian Highlands, both of which are experiencing the highest-risk of land degradation in Sub-Saharan Africa. In Burkina Faso, in collaboration with INERA (Institut de l'Environnement et Recherches Agricoles), several prominent soil and water conservation technologies were identified and field trials were set. Several cropping factors, such as fertilizer dose, planting densities, and varieties, were evaluated according to soils at different effective soil depths, resulting in different sorghum grain yields and suggesting the possibility of developing improved crop technologies. In Ethiopia, we have study sites in the Tigray Region. Through estimation of above- and below-ground biomass by inventory survey of *Acacia etbaica*, a dominant tree species in the highland areas, we have derived tentative allometric equations to deduce the existing natural resources. Through participant observation in a village of the study site, we clarified the severity of the current situation and utilization of natural resources in the watershed area, such as reduced cattle dung circulation in the farms and the damaging effects of illegal firewood collection in communal lands, where harvesting is restricted except for daily needs.

[Resource Management in Asia and the Pacific Islands]

In Babeldaob Island in the Republic of Palau, the Ngerikil watershed and Ngarimel dam were selected as study sites to assess the current status of water and nutrient balance and to evaluate the functional role of ecosystems using the SWAT model. A sedimentation trap was installed in a taro field to optimize cropping systems and tillage practices with minimum loss of soil and nutrients into rivers and seashores. Experiments on nitrogen fertilizer application was commenced both in Ishigaki, Japan and Negros, Philippines in order to develop a sustainable crop cultivation system while reducing N leaching into underground water. The efficiency of basal N fertilizer use was 3.8% in new plantings and 17.7% in ratoons at the clayey sugarcane fields of Negros Island, Philippines. A technical manual summarizing subsurface drainage applications to mitigate soil salinity was published in Uzbekistan. Furthermore, irrigation problems in India were clarified. Among the problems identified include declining groundwater levels along with increasing irrigation areas, and waterlogging caused by excessive irrigation. The salt-tolerance gene, *Ncl*, was introduced into a local Indian soybean strain in two combinations, and seeds of the F_2 generation were obtained. Two salt-tolerance strains were selected from 100 local soybean strains.

[BNI Utilization]

The incorporation of plant BNI (biological nitrification inhibition) function to agricultural systems is expected to contribute to sustainable natural resource management through the increase of N-fertilizer use efficiency in crops and the reduction of NO_3-N runoff/leaching into groundwater and the environment. Also, we expect the reduced emissionse of N_2O (nitrous oxide or dinitrogen monoxide), a powerful GHG chiefly emitted from croplands, to the atmosphere. JIRCAS, the leading agency in world BNI research, is currently running the BNI International Consortium. Among a wide range of wheat genotypes, an old variety (cultivated before the Green Revolution) was found to have a higher BNI ability, which makes it useful for breeding more N-efficient wheat cultivars. In the experimental field of Llanos, Colombia, we have confirmed that the previously cultivated *Brachiaria humidicola*, a well investigated pasture grass with high BNI capacity, benefited subsequent maize crops for at least 4 years (2012-2015), in terms of yield and above-ground biomass. Also in India, higher BNI activity was observed in soils where sorghum varieties had been cultivated. This higher BNI activity was attributed to the higher amount of exudate produced, of which sorgoleone, a BNI substance, was the major constituent.

TOPIC 1

Domestic biogas digesters reduce greenhouse gas emissions and provide benefits to households

The Clean Development Mechanism (CDM) is an important instrument for reducing greenhouse gas (GHG) emissions because it provides for carbon offset projects in developing countries. However, this system is not working well due to the low price of carbon credits and so on. Thus, for the mitigation technology to be disseminated widely, it should be beneficial to households. The installation of domestic biogas digesters (BDs) using mainly livestock manure (Fig. 1) is one of the mitigation actions that can be applied at the household scale. This research, therefore, aims to clarify 1) whether BD is a measurable, reportable, and verifiable mitigation technology, and 2) whether BD realizes both mitigation and household benefits.

BDs were installed in 435 households in Mekong Delta, Vietnam, and the annual monitoring results (from 1 June 2013 to 31 May 2014) of biogas usage revealed that they used biogas for cooking on 95.7% of the total number of days. During this period, a total of 446 tCO_2 of GHG were reduced by substituting conventional cooking fuel with biogas. This amount of reduction was verified and approved by the UNFCCC CDM Executive Board, and carbon credits were issued on 19 June 2015. This confirms that GHG emission is reduced by introducing BDs, and that it is a measurable, reportable, and verifiable climate change mitigation technology.

Introducing BDs reduced the amount of firewood and LP gas used (Fig. 2). GHG emission reduction and cooking fuel savings per household were estimated at 1.87 tCO_2 and USD95, respectively, based on the annual changes in the usage amount of conventional cooking fuel (Table 1). Moreover, households that adopted BD technology benefitted financially. Questionnaire results indicated that more than 99% of households were satisfied with the introduction of BDs. Participating households also evaluated the effects of BD introduction, which included cost savings on cooking fuel, time savings due to less time spent on firewood

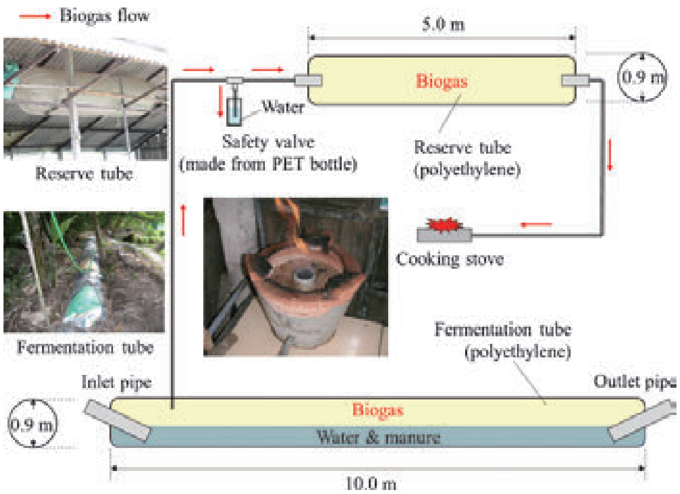


Fig. 1. Plastic biogas digester (BD) system

Table 1. Changes related to farm household cooking fuels before and after biogas digester (BD) installation (One household, Average of 66 households)

Item			Before	After	Difference
Amount of cooking fuel used	Firewood ($t\ year^{-1}$)	Cooking	1.59	0.32	-1.27
		Pig feed	1.50	0.38	-1.12
		Total	3.09	0.70	-2.39
	LP gas ($kg\ year^{-1}$)		27.3	2.4	-24.9
GHG emissions ($tCO_2\ year^{-1}$)	Firewood	Cooking	1.20	0.24	-0.96
		Pig feed	1.13	0.29	-0.84
		Total	2.33	0.53	-1.80
	LP gas		0.08	0.01	-0.07
	Total		2.41	0.54	-1.87
Expenses for cooking fuel ($USD\ year^{-1}$)	Firewood (purchase)		14	1	-13
	Firewood (collection)		53	12	-41
	LP gas		45	4	-41
	Total		112	17	-95

Note. Survey on cooking fuel expenses was conducted based on Vietnamese currency (VND) and converted to US dollar using the exchange rate as of survey period (from 2012 to 2014).

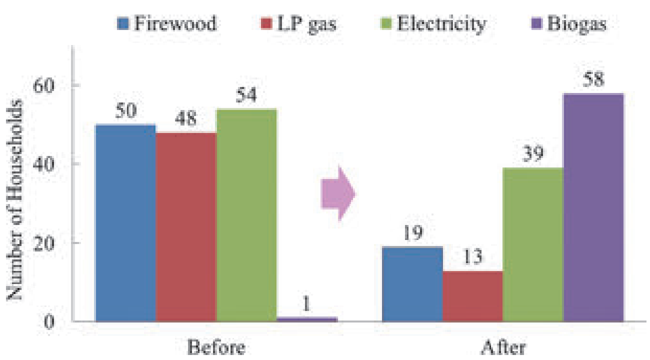


Fig. 2. Changes in cooking fuel usage before and after biogas digester (BD) installation
Note 1. Total number of surveyed households: 66
Note 2. Y-axis values refer to number of households that used each cooking fuel type during the study period
Note 3. One household used biogas digester (self-installed before project initiation)

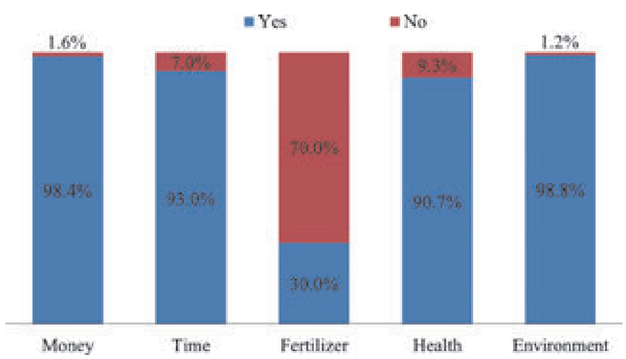


Fig. 3. Perceptions of participating households regarding the effects of biogas digester (BD) installation
Note 1. Number of surveyed households: 257
Note 2. Money = cost savings on cooking fuel; Time = time savings associated with reduced time spent on firewood collection and cooking; Fertilizer = use of BD effluent as fertilizer for gardens and ponds; Health = health benefits from avoiding smoke and soot generated from cooking by firewood; Environment = Environmental enhancement by reducing malodors and overcoming poor water quality issues.

collection, health benefits from avoiding smoke or soot generated by cooking with firewood, and environmental enhancements such as avoiding malodors and overcoming poor water quality issues (Fig. 3). The abovementioned results confirm that in addition to being a measurable, reportable, and verifiable mitigation technology for climate change, BD use also reduces greenhouse gas emissions and provides benefits to households.

The results of this research will form the basis of the suggestions that will be provided to the Vietnamese government when they try to realize their Intended Nationally Determined Contributions (INDC), which mentioned the use of biogas as among its GHG emission reduction strategies from the agricultural sector. Quantifying GHG emission reduction and household benefits derived by the installation of BDs depends on the amounts and types of cooking fuel used by the households prior to BD installation. The BD's total initial cost is estimated at around USD180 (BD unit = USD140; labor = USD20; technical support = USD20), while maintenance cost is estimated at around USD20 per year. Considering the discount rate, the BD's net present value during its useful life (about 7 years) can thus be calculated as more than USD200, which is nearly equal to two years' worth of cooking fuel expenses for one household.

(T. Izumi)

TOPIC 2

Estimation of cost and effect of food policy to mitigate rice price variation under climate change in Bangladesh

Bangladesh is located downstream of large international rivers and along the path of tropical storms, making the country prone to natural disasters and its agricultural production unstable. According to recent meteorological observations, the frequency of higher temperatures is increasing, and climate change is projected to affect the crop yields more severely in the future. To cope with the instability in agricultural production, policy tools for climate change adaptation as well as adaptation technology development are important. In this study, we estimated the cost and effect of procurement and distribution policies in mitigating rice price variation under climate change.

To estimate the policy cost and effect, we developed a rice supply-demand model in Bangladesh, based on analysis of statistical data related to paddy area, rice production, price, import and export, stock level, GDP, and population. We also estimated the yield functions of different seasonal rice, based on yield statistics and meteorological data, so we can forecast climate change impacts on rice yield. To analyze the policy, we added a policy model consisting of procurement and distribution functions. By assuming that the amount of procurement and distribution are decided by farmers' and consumers' decision-making on trade partners, with the difference between governmental and market prices as the main incentive and subject to physical constraints related to rice storage capacity and actual stock, we can apply the Tobit model to estimate procurement and distribution functions.

We made outlooks under the IPCC climate RCP6.0 and socioeconomic SSP2 scenarios, with 2010 to 2030 as the forecast period. When inputting future climate data from the global circulation model (MIROC5) into the yield model, rice yields show an increasing trend in the ranges of variation (Table 1 and Fig. 1), implying greater rice market instability and food policy importance. Figure 2 shows two rice price forecasts. The green line shows baseline and the blue line shows a new policy in which more intensive policy intervention is conducted by reducing the distribution price and increasing the procurement price when the price difference from the trend line is more than 10%. As the figure shows, the new policy reduces the range of price variation. Reduction in price variation is almost 2.34% points (Table 2). Additional policy costs per year for this variation reduction are estimated to be US$14 million for facility construction and maintenance, US$195 million for rice stock quality maintenance, and US$183 million for rice transaction. In addition, storage capacity needs to be increased from 1.7 million tons to 3 million tons.

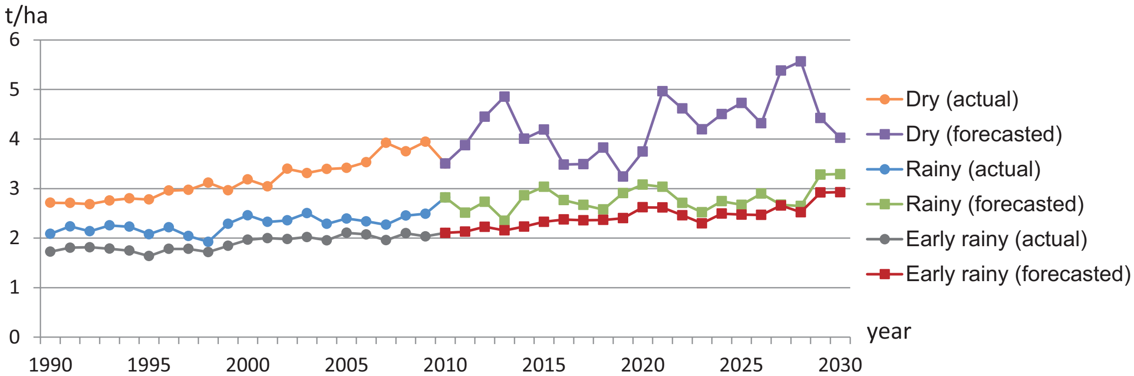


Fig. 1. Actual and forecasted rice yields of improved varieties for different rice seasons

Table 1. Rice yield variation and climate change impact

Rice season	Coefficient of variation (%)		Climate impact
	Until 2009	2010 - 2030	(% point)
Early rainy (Aus)	8.32	9.30	0.98
Rainy (Aman)	7.76	8.72	0.96
Dry (Boro)	12.28	14.6	2.32

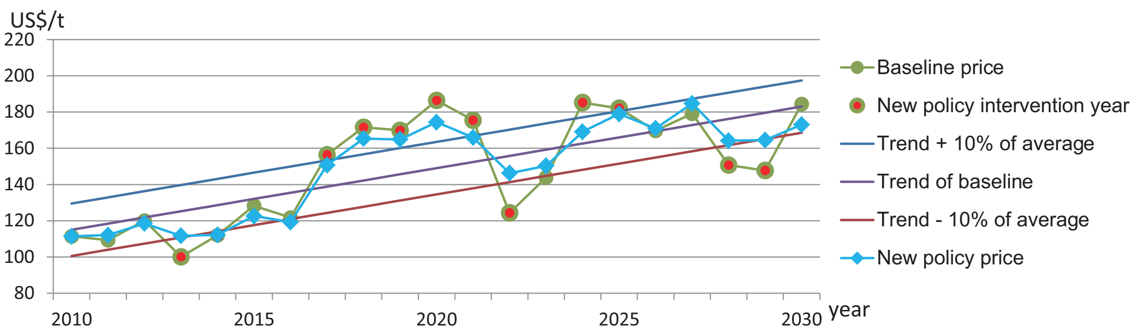


Fig. 2. Stabilization of rice price by an intensified food policy (farm gate price)

Table 2. Rice price variation and policy effect

Price type	Coefficient of variation (%)		Policy effect
	Baseline	New policy	(% point)
Farm gate	19.85	17.50	–2.35
Retail	25.75	23.42	–2.33

There are some other climate change and socioeconomic scenarios and different global circulation models. Therefore, the result of this study based on certain scenarios and a model is not the sole outlook. However, this result can provide basic information for food policy making in the era of climate change and for assessing adaptation technologies.

(S. Kobayashi, J. Furuya, Md. A. Salam [University of Tsukuba], Md. S. Alamgir [UT])

TOPIC 3

Calcination improves solubility of low-grade African phosphate rock and application of calcined products is highly effective on crop cultivation

The utilization of local African phosphate rock (PR) can be considered a key factor in solving hunger and poverty in Africa through improvement of crop productivity. It is well known that large amounts of phosphate deposits exist in Sub-Saharan Africa, with reserve estimates of around 100 million tons of P_2O_5 in Burkina Faso. However, this PR resource has not been fully utilized because of limited solubility. Numerous studies have attempted to utilize these low-grade PRs with various crops, and results have indicated that the direct application of PR exhibits substantial variation in effectiveness, reflecting the influence of various factors such as PR solubility, soil properties, and the types of crops.

For the abovementioned reason, an effective solubilization method for these PR is highly required. Sulfuric acid addition is the most popular solubilization method, and sulfuric acid is also used for partial acidulation of PR. However, in the case of low-grade African PR, the partial acidulation method is potentially problematic because of the low solubilization rate and the accumulation of residual free sulfuric acid.

We attempted to solubilize low-grade PR produced in Burkina Faso using Akiyama's calcination method, which was previously developed for high silicate PRs. Results showed that PR calcination between 900-1000 °C with composition of 25-30% Na_2O sourced by sodium carbonate (Na_2CO_3) solubilized PR effectively. Phosphorus (P) solubility in 2% citric acid solution was leached about 100%, and P solubility in water was increased to 28%.

Results also clarified that higher composition of Na_2O increases solubility in 2% citric acid and in water. On the other hand, adding larger amounts of sodium carbonate consequently decreases total P_2O_5 content in calcined PR.

Furthermore, the effects of calcined Burkina Faso PR (CBPR) application on rice and maize growth were evaluated through a pot experiment. CBPR calcined at 950 °C with 30% Na_2O was investigated for this pot experiment. Lowland rice and maize were cultivated for 56 days under four levels of P_2O_5 application, i.e., 0.0, 0.5, 1.0, and 2.0 g P_2O_5 /pot. Nitrogen and potassium were applied using 1g N and 1 g K_2O per pot.

Table 1. Total P_2O_5 content and solubility for citric acid and water of calcined PR

Treatment	Temp. of calcination	Total P_2O_5 content in calcined PR	Rate of citric acid soluble P against total P in calcined PR		Rate of water soluble P against total P in calcined PR	
	°C	g kg^{-1}	%			
Burkina PR (Untreated)		297.1	31.1		0.2	
Na20	950	227.2	73.3	a	0.5	a
	1000	231.5	73.9	a	0.5	a
Na25	850	205.8	81.8	a	17.1	b
	900	207.5	93.5	ab	17.2	b
	950*	211.8	99.8	b	16.0	b
	1000	212.7	100	b	8.3	a
Na30	850	189.5	92.6	a	27.1	a
	900	186.9	96.8	ab	28.0	a
	950	197.2	97.5	b	28.1	a
	1000	198.1	98.7	b	26.7	a

Na20, Na25, Na30 indicate Na_2O treatment compositions at 20%, 25%, and 30%, respectively. Different alphabets denote significant difference ($p < 0.05$) among calcination temperatures using Tukey's multiple comparison (n=3). *Calcined PR of Na30 at 950 °C was used for the subsequent pot experiment.

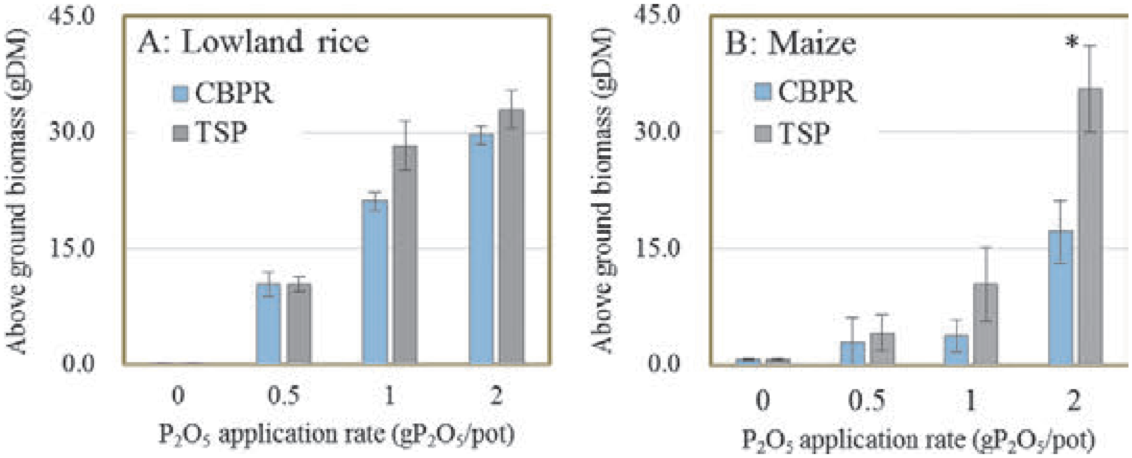


Fig. 1. Effect of applying calcined PR and TSP on aboveground biomass yield of lowland rice (A) and maize (B)
CBPR: Calcined Burkina Faso phosphate rock, TSP: Triple super phosphate. Error bars are standard errors (n=3). Asterisk in the figure denotes significant difference ($p < 0.05$) between yields of CBPR and TSP using Student's t test.

CBPR application for lowland rice indicated comparable effect with Triple Super Phosphate (TSP) application at application rates of up to 2 g P_2O_5/pot. In the case of maize, CBPR application yielded about 40% of TSP application.

Crop productivity improvement in Africa would be highly expected through provision of affordable fertilizer using low-grade African PR. Calcination technology is likely to be applicable not only for Burkina Faso PR but also for all other low-grade PRs in Africa.

(S. Nakamura, F. Nagumo, M. Fukuda, K. Toriyama, T. Imai [Taiheiyo Cement Corporation])

PROGRAM B
Stable Agricultural Production

“Technology development for stable production of agricultural products in the tropics and other adverse environments”

In developing regions including Africa, agricultural production potential has not been sufficiently realized because of adverse conditions such as low soil fertility and drought. Consequently, food and nutrition security has remained relatively low. This program, therefore, aims to enhance agricultural productivity and improve nutrition in developing countries through technology development for stable production of agricultural products in the tropics and other adverse environments (Fig. 1).

[Development of sustainable technologies to increase agricultural productivity and improve food security in Africa]

Goal 2 of the United Nations’ 17 Sustainable Development Goals (SDGs) aims to “*end hunger, achieve food security and improved nutrition, and promote sustainable agriculture.*” A critical challenge toward meeting this goal is overcoming food shortage in Sub-Saharan Africa (SSA), where 215 million people are currently undernourished.

During the third medium-term plan period, JIRCAS conducted research studies on rice in the hope of increasing yield to meet the rapidly increasing consumption rate in SSA, as well as on yam and cowpea, two regional crops that play important roles in the regional food and nutritional supply chain.

In the current fourth medium to long-term plan period, we have designated the “Development of sustainable technologies to increase agricultural productivity and improve food security in Africa” as one of the flagship projects of JIRCAS. The project was initiated in collaboration with either national or international research institutions, and aims to maximize the outputs obtained in the previous plan and contribute to food security in SSA. In this project, we conduct the planned research for development activities based on the premise of “improving sustainability with efficient utilization of resources,” “utilizing unused germplasm efficiently,” and “capturing the preferences of consumers and needs of farmers.” Program B’s flagship project focuses on the three sub-themes below:

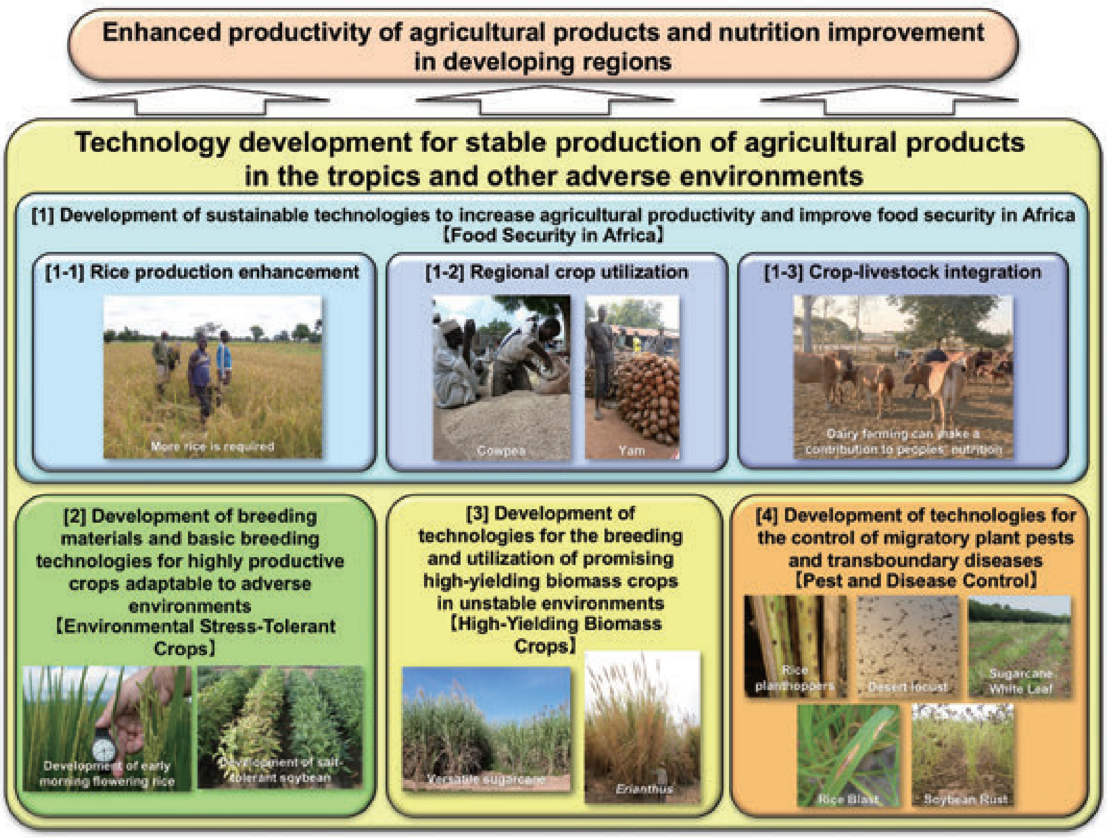


Fig. 1. Outline of the Stable Agricultural Production Program

Rice production enhancement

In this sub-theme, breeding materials with improved nutrient uptake, simple diagnosis of nutrient condition, and smart fertilizer management specific to each soil and environmental condition will be developed as essential components of efficient rice production in SSA, and their intergradation and adaptation will be examined. Other challenges under this sub-theme include the development of technologies to improve water use efficiency such as channeling excess water for rice irrigation, and impact assessment and factor analysis of farmers' acceptance of these new technologies. In FY2016, we carried out our research and obtained the following results:

1. We began generating breeding materials that have better grain quality, superior yield, and adaptability under local cultivation environments. We also introduced quantitative trait loci (QTLs) related to root elongation, nitrogen utilization, phosphoric acid utilization, etc. to varieties for SSA. Furthermore, we prepared a procedure for investigating responsiveness to sulfur deficiency, and we clarified that bronzing of leaves, root elongation, etc. under deficient conditions showed diversity among cultivars. In order to select cold-resistant varieties at the germination stage, we conducted a germination test under low-temperature conditions using 35 varieties including overseas cultivars, with one variety showing promise.
2. In order to identify dehydration-responsive genes in rice at the booting stage, we performed a microarray analysis and generated overexpressed transgenic rice for two identified novel drought-responsive transcription factor genes.
3. We have developed the world's first promoter that regulates gene expression specifically at high temperature, and that may contribute to overcome concerns about high temperature disorders of crops caused by rising temperature due to global warming. By combining with genome editing technology, we will be able to express high-temperature disorder-resistant genes specifically at high temperature in crops that have shown no decline in productivity under sudden high-temperature environments while maintaining productivity under normal circumstances. It is also expected to be used in developing technologies for the mass production of useful substances (such as vitamins, which can inhibit growth if they were always produced in plants at all times) by transient, high-temperature treatment, and the ripple effect has been large. In the future, we can expect great advances toward stabilizing world food production and improving nutrition, leading to the development of crops that can contribute to Japan's food security and healthy living (Synthetic promoter).
4. We organized basic information on soil properties and fertilizer management technologies applied on 220 rice fields in Madagascar Central Highlands. We compiled indices that are simple yet effective in estimating soil carbon quantity and indices that are effective in evaluating phosphorus deficiency in soils based on the results of nutrient absence pot tests.
5. We also started verifying the applicability of technologies and identifying the key factors in promoting the dissemination of technologies developed during the third medium-term plan of JIRCAS. Regarding channel reinforcement, we clarified that the shrinkage rate decreased by adding ash in the preparation of large blocks, reducing the number of damaged blocks produced for block reinforcement. The underground growth characteristics of plants used for reinforcement was also clarified. Furthermore, we developed a formula for calculating the estimated maintenance costs of wooden fences for each maintenance scenario and at different inspection frequencies and reinforcement periods.
6. We compiled the results of empirical investigation on supplementary irrigation using the irrigation pond and got approval from relevant organizations in Ghana to produce a manual. Along with that, we held a dissemination seminar and showed the effectiveness of supplementary irrigation and the possibility of implementation by farmers (African Rice Production Dissemination).
7. We selected target sites in Madagascar and Ghana for investigating the influence of increased rice production, brought about by the developed technologies, on nutritional intake. The survey methods and items were decided based on the baseline survey of each target area.
8. To design and demonstrate institutional strategies to promote the dissemination of development technologies, we selected the sites to be surveyed in Ghana. We also tried to get a good grasp of the dissemination activities and the actual financial conditions of farm households.

[Topic 1]: An optimal heat inducible synthetic promoter in plants

Regional crop utilization

Cowpea and yam, two important regional crops in West Africa, still hold tremendous potential to improve productivity, as well as quality, and to meet various demands deeply linked with regional culture and tradition, through utilization of unused genetic resources. We are exerting efforts towards active utilization of the extensive genetic diversity of both crops in international and national breeding programs, by aiming to generate fundamental information of their genetic diversity to explore useful parental materials and by developing tools to enable breeders to select and evaluate their materials effectively. In FY 2016, we started to evaluate yam and cowpea traits, and we prepared genetic resources for genetic analysis. We particularly addressed the following research components:

1. To evaluate the agricultural and quality characteristics of genetic resources and to develop efficient evaluation techniques, we conducted field tests in Nigeria and Burkina Faso and derived basic information using cowpea genetic resources (a total of 322 strains) and selected strains (20 strains). In addition, we proceeded with the development of a software for evaluating traits related to the quality of cowpea. In addition, we published the *EDITS-Cowpea* genetic resources database.
2. We developed a technology to quickly evaluate the grain protein content available for the breeding process by estimating the nitrogen content of the powder sample of a cowpea grain using infrared spectroscopy and converting it into protein content.
3. We conducted trait assessment of representative yam genetic resources (about 100 strains) and accumulated data (Africa Yam).
4. For the yam crossing group (2 groups), we evaluated agricultural- and tuber-quality-related traits, and accumulated data such as withering days and browning degree or tuber coloration.
5. Varietal differences in browning of yam tubers can be distinguished into four types.
6. We started preparation for genetic analysis of cowpea and yam.

[Topic 2]: Application of infrared spectroscopy for rapid prediction of crude protein content in cowpea (*Vigna unguiculata*) grain

Crop-livestock integration

To increase dairy production in topical savanna areas, which have distinct rainy and dry seasons, we will develop an effective and efficient crop-livestock integration model applicable throughout the year. With crop and livestock as main components of the model, we will develop technologies to produce animal feeds that utilize byproducts generated from crop production and food processing. We will also utilize wastes from livestock farming as a soil fertility management method to improve food crop production and sustainable forage crop production by farmers. In FY2016, we focused on the following research activities:

1. We analyzed the present condition of livestock farming in Mozambique and conducted interviews with dairy farmers in order to identify potential feed resources in the area necessary for developing a crop-livestock integration model as well as to grasp the actual condition of dairy farming management in southern Mozambique.
2. We listed some grass and legume crop species that may become components in the crop-livestock integration model.
3. Through discussions with Agricultural Research Institute of Mozambique (IIAM) researchers and the results of field surveys, we proposed a cow dung processing and utilization method that could contribute to income stability and improvement for both crop farmers and livestock farmers.
4. We also examined the grassland usage method, including dry season usage, and the farmers' crop selection method for high value-added production.
5. We began to validate the applicability of decision support systems for farming in farmers' fields toward the development of a profitable agricultural system in the tropical savanna in southern Africa (JICA Project for Improving Research and Technology Transfer Capacity for Nacala Corridor Agriculture Development, Mozambique).

[Development of breeding materials and basic breeding technologies for highly productive crops adaptable to adverse environments]

In order to establish stable and sustainable production of agricultural crops in developing countries vulnerable to climate change, drought, high salinity, and poor soil, we are now working on the development of breeding materials and basic breeding technologies to come up with highly productive crops that are adaptable to such adverse environments. For rice, breeding materials that have high temperature resistance, drought tolerance, phosphate deficiency resistance, and high nitrogen use efficiency will be developed. For soybean, development of breeding materials that are tolerant to drought and high salinity will be undertaken. In addition, we will develop a double haploid breeding technology, a non-GM crop production technology, and a growth evaluation method in a greenhouse that mimics the stress conditions of farm fields. In FY2016, we focused on the following research:

1. In order to elucidate the genetic mutation

concerning the root system distribution of rice toward the development of crops adaptable to poor environments, we developed a simple test method that can evaluate more samples in a short time compared with the conventional basket method.
2. We identified the *ltn2* gene responsible for the low number of tillers in upland field condition on rice chromosome 7.
3. We identified a novel soybean gene that imparts alkaline salt tolerance.
4. We conducted a drought tolerance test of GM rice using a confined field or greenhouse and developed promising lines showing drought tolerance in the field (GM drought tolerance project).
5. We conducted research on the development of adverse environment-resistant crops using new plant breeding technology (NBT), and demonstrated that genomic editing technology using CRISPR/Cas9 can induce mutation of a target gene in rice including IR 64 and NERICA1, which are the leading varieties in developing areas.
6. Quinoa is a cereal native to South America. It is not only tolerant against adverse conditions, including drought, it also provides excellent nutritional value and is expected to be cultivated in developing areas. However, breeding has been restricted due to strong cross-fertilization and its complicated genome structure. Nevertheless, we have succeeded in establishing standard inbred lines suitable for molecular analysis and in clarifying the genome sequence for the first time in the world. In the future, it is highly expected that our research results will be useful in the stabilization of world food production, improvement of nutrition, and development of new quinoa varieties or other crops that can contribute to Japan's food security and healthy living.

[Topic 3]: Genome editing systems in rice cultivars and strategy for producing desired mutants with homozygous mutation
[Topic 4]: Enhancement of ozone resistance by adjusting the stomatal aperture on leaf surface
[Topic 5]: Draft genome sequence of an inbred line of *Chenopodium quinoa*, an allotetraploid pseudocereal crop with high nutritional properties and tolerance to abiotic stresses

[Development of technologies for the breeding and utilization of promising high-yielding biomass crops in unstable environments]

In this project, we aim to develop sustainable cultivation methods and utilization technologies for multi-purpose use of high-yielding biomass crops such as multi-purpose sugarcane and *Erianthus*, which is a wild relative of sugarcane tolerant to unstable environmental conditions. We also aim to develop new breeding materials that produce high biomass yield in several unstable environments through intergeneric hybridization between sugarcane and *Erianthus*. For this purpose, we are establishing techniques for evaluating important characteristics related to biomass production of *Erianthus* in stress conditions and for selecting intergeneric hybrids using DNA markers. In FY2016, we focused on the following research:

1. We clarified the possibility of utilizing the root penetration evaluation method using layers of wax in order to develop tools for assessing physical stress tolerance of roots.
2. In order to develop new resource crops that excel in biomass productivity in adverse environments, we evaluated the hybridism of intergeneric backcrosses between sugarcane and *Erianthus*, and found promising lines with excellent biomass productivity under ratoon cultivation.
3. In order to design and select primers for *Erianthus* from the existing genomic information, we screened 64 combinations of amplified fragment length polymorphism (AFLP) primers and selected primers that can be used with *Erianthus* in Japan.
4. We made field test plans and started the field experiments to develop stable cultivation techniques for multi-purpose sugarcane and to evaluate the yield of *Erianthus* and the effect of *Erianthus* in improving soil fertility in adverse environments.

[Development of technologies for the control of migratory plant pests and transboundary diseases]

Some insect pests and diseases spread transboundary and damage crop production. Against rice planthoppers, we will obtain information on their occurrence, insecticide resistance, natural enemies, and the resistance of rice varieties in order to develop control techniques. Against desert locusts, we will elucidate the factors that provoke phase polyphenism -- from solitary to gregarious form -- by conducting field observations. Against sugarcane white leaf disease, we will develop an integrated pest management method for healthy seed cane production based on the ecology of the vectors. Through international research networks that have been constructed by JIRCAS, we will develop rice breeding lines resistant to blast disease for Asia by incorporating field resistance genes that are expected to be stable, and soybean cultivars resistant to rust disease for South America by pyramiding resistant genes. In FY2016, we focused on the following research:

1. To develop a control technology against migratory plant pests, we have established a research system on rice planthoppers and desert locusts, and we have started research activities.
2. To obtain fundamental knowledge leading to the development of control measures against rice planthoppers, which frequently occur in Southeast Asia and migrate to Japan thereby causing damage, we have started research on its population dynamics, resistance to insecticides, the resistance of rice against the planthoppers, and the use of its natural enemies for biological control. We have selected brown planthopper and white back planthopper as target pests and planned our work with joint research institutes. We have also started interviews with farmers at research sites in the northern part of Vietnam.
3. For the desert locusts, which form huge swarms, migrate over wide areas, and cause damage to agricultural crops in Africa, we studied the factors that cause phase polyphenism (from solitary phase to gregarious phase) through field observations to develop efficient control methods. Together with the Mauritania National Desert Locust Control Center, we observed the locusts' mating behavior in the desert. We also obtained ecological findings on their egg-laying characteristics, leading to the development of technologies to efficiently control the locusts.
4. In the study of the leafhopper-transmitted white leaf disease, which is the most important disease affecting sugarcane production in Southeast Asia, we have determined the parameters for a simulation model that would evaluate the effect of insecticide applications for vector control and the risk of occurrence of sugarcane white leaf disease, toward the development of an integrated control method for healthy seed cane production based on the ecology of vector insects. Furthermore, we have developed a technique for inoculating cultivars of sugarcane and its wild species etc. with pathogens using the vectors. We also clarified the relationship between waveforms of the electrical penetration graph and the feeding behaviors of the vector.
5. The use of fungicides is effective in controlling airborne diseases like rice blast and soybean rust propagating in a wide area. However, there is a risk of missing the optimal application timing or increasing the control cost and the risk of the appearance of resistant strains. Using the international research network that we have built up, we promoted the development of rice blast resistance lines for Asia by introducing field resistance genes that can be expected to have stable resistance, and we advanced the development of soybean varieties resistant to rust for South America by pyramiding effective resistance genes.
6. We developed near-isogenic lines in which true resistance genes and field resistance genes were introduced into varieties susceptible to rice blast, and we have started evaluating resistance.
7. It is estimated that the cost of damage caused by soybean rust worldwide will be as much as 5% of soybean production, and that a large amount of fungicides is being used for control. In South America, it has already been confirmed that fungicide efficacy has declined, hence resistant varieties are highly desired. In cooperation with a joint research institute in Paraguay, we have developed a highly resistant variety by introducing three kinds of resistance genes into local varieties leading to the reduction of soybean rust, and we have applied for cultivar registration in Paraguay. By using this variety directly or as a breeding parent in the future, it is expected to contribute to stable soybean production in Paraguay and other countries.
8. We developed four new soybean lines having multiple resistance genes to rust. We also characterized pathogenic diversities in soybean rust populations in Mexico, Bangladesh, and Uruguay.
9. In addition to soybean rust, we have decided to study Cercospora leaf blight and purple seed strain as well as charcoal rot as target diseases, and we are examining inoculation methods.

[Topic 6]: Three differential soybean varieties highly resistant to Asian soybean rust carry the resistance gene *Rpp1-b*

An optimal heat inducible synthetic promoter in plants

Climate change is predicted to adversely affect agriculture. There is a growing need for the development of crops capable of adapting to change. At the molecular level, one of the most discussed environmental conditions is high temperature or heat shock (HS). Many genes have been described that respond to HS stress at the transcriptional level, and their gene products are thought to function in stress tolerance. Heat shock factors (HSFs) bind heat shock response elements (HSEs) with the core sequence to form trimers, thereby regulating downstream gene expression. The importance of the HSF–HSE interaction has previously been suggested in the HS response. However, because plant HSFs are involved not only in HS but also in water deficit stress, development, cell differentiation, and proliferation, it has been suggested that the induction of HS requires a specific combination of HSFs and HSEs.

In this study, to determine representative HS-responsive transcriptional pathways in plants, we analyzed HS-responsible genes and promoters in *Arabidopsis*, soybean, rice, and maize. We also designed an optimized HS-inducible promoter based on detailed bioinformatics predictions of conserved sequences (*cis*-acting elements) from HS-inducible promoters of these four plant species for molecular breeding purposes.

First, to characterize plant HS-responsive genes, a transcriptome analysis of *Arabidopsis*, soybean, rice, and maize was conducted using microarrays. Second, we used our in-house gene ontology database to annotate the molecular functions of all identified HS-responsive genes. Third, to determine which sequences are conserved in the promoters of HS-inducible genes, we analyzed all hexamer sequences using our promoter research tool. Fourth, based on detailed bioinformatics predictions of conserved sequences, we attempted to design a HS-specific inducible promoter and then performed functional analyses of the designed promoter. The synthetic HSE was placed in an optimal position of promoter, followed by a β-glucuronidase reporter gene (*GUS*). In our functional analyses, transcript levels of marker genes were significantly higher in cold-, dehydration-, or ABA-treated transgenic plants than in untreated transgenic plants. GUS expression did not increase in each stress-treated transgenic plant; however, its

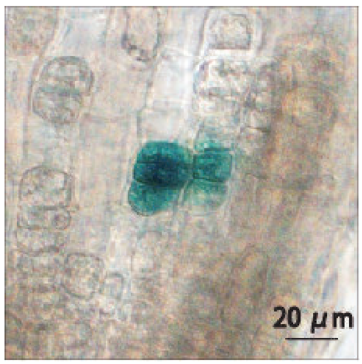


Fig. 2. GUS expression induced by infrared laser irradiation of target cells in *Arabidopsis* lateral root tips. We performed in vivo single-cell gene induction using an infrared laser-evoked gene operator (IR-LEGO) system to observe GUS activity in irradiated cells.

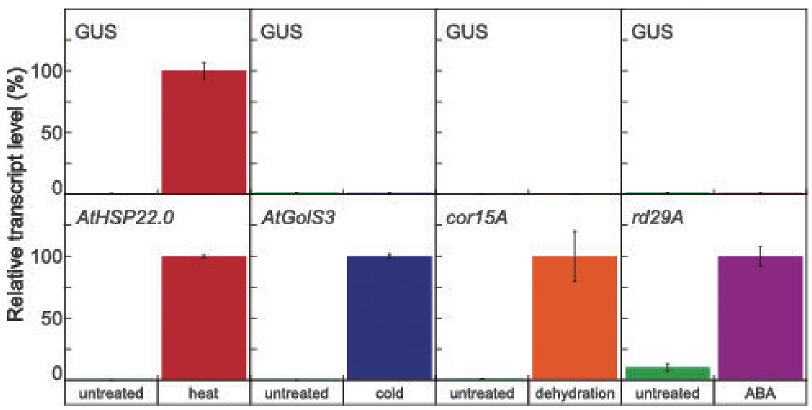


Fig. 1. Transcriptional activity of the optimal HS-inducible synthetic promoter. Levels of transcripts for genes encoding β-glucuronidase reporter gene (*GUS*) and condition-specific markers (heat, *AtHSP22.0*; cold, *AtGols3*; dehydration, *cor15A*; and ABA, *rd29A*) by quantitative reverse transcription (qRT)-PCR in transgenic plants.

expression increased significantly in HS-treated transgenic plants (Figure 1). We also performed in vivo single-cell gene induction using an infrared laser-evoked gene operator (IR-LEGO) system to observe GUS activity in irradiated cells (Figure 2). These findings demonstrate the utility of our HS-inducible promoter, which we expect to contribute to future molecular breeding of plants adapted to climate change and for the in vivo analysis of gene functions when gene expression is controlled by spatial and/or temporal conditions.

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TOPIC 2

Application of infrared spectroscopy for rapid prediction of crude protein content in cowpea *(Vigna unguiculata)* grain

Cowpea is a staple grain legume widely cultivated in Africa, playing key roles in the region as a food crop for the people and as an important cash income source for farmers. In addition to ongoing efforts toward improving crop productivity and insect-pest resistance, focus is also being placed on enhancing the grain quality and nutritional value of crops with multiple roles, especially cowpea, which serves as the primary source of protein in the region. Protein content is one of the most important grain quality traits, and significant protein content in grains can have a major impact on the livelihoods of people in the region. In this work, we focused on the crude protein content of grain as a primary nutritional property, and we developed a suitable prediction method that can be used in the breeding process and in evaluating environmental effects.

A total of 919 ground grain samples from 224 lines covering the genetic diversity in grain nitrogen content of the crop were used for the development of a calibration model to predict nitrogen content (Fig. 1). The developed infrared spectroscopy model using the actual nitrogen content obtained by the Dumas combustion method and the near-infrared (4000-4985 cm^{-1}) and mid-infrared (1400-2290 cm^{-1}) spectroscopy obtained by Fourier Transform Infrared Spectrometer had reasonable accuracy ($R^2 = 0.91$). The model also predicted the nitrogen contents of the grain samples grown in three agro-ecological zones across major cowpea-growing areas in West Africa with acceptable accuracy (R^2 = 0.90-0.92) (Fig. 2 and Table 1). Obtained nitrogen contents can be accurately converted to crude protein

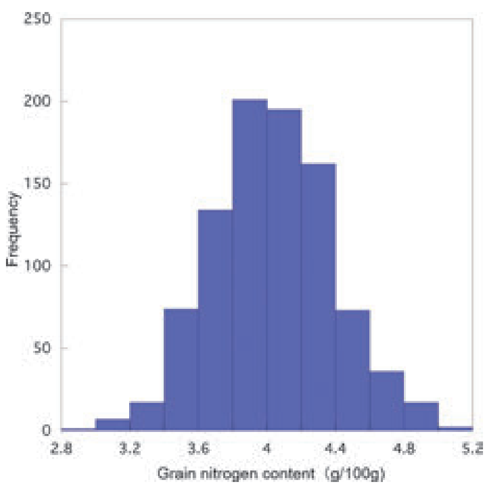

Fig. 1. Distribution of grain nitrogen content of the 224 lines used for the development of the model

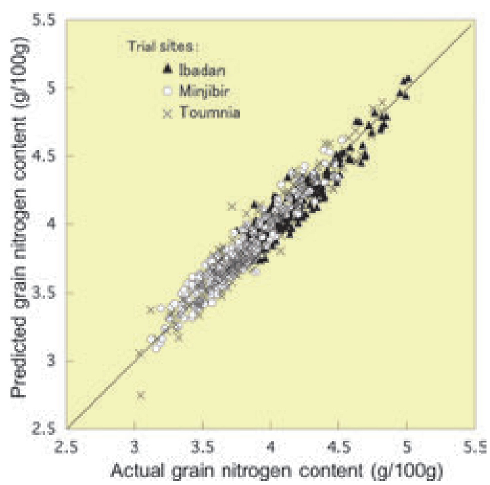

Fig. 2. Validation of the developed model for determining the nitrogen content of grain samples collected from different agro-ecological zones in Ibadan, Minjibir and Toumnia

Table 1. Variation statistics of the developed model for predicting grain nitrogen content

Validation set	R^2	RMSEP	RPD
All samples	0.93	0.10	3.68
Each agro-ecological zone			
Ibadan (Savanna-forest transition)	0.90	0.09	3.13
Minjibir (Sudan savanna)	0.92	0.09	3.40
Toumnia (Sahel)	0.92	0.10	3.46

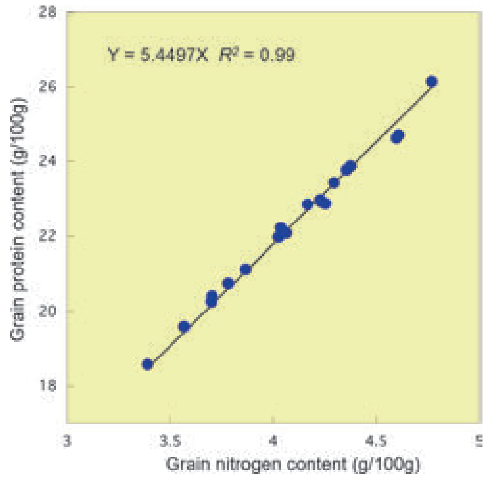

Fig. 3. Relationship between actual protein content and nitrogen content of 20 selected cowpea lines

content using a nitrogen-to-protein conversion factor of 5.45 developed for cowpea based on the relationship between amino acid composition and nitrogen content using 20 selected cowpea lines (Fig. 3). The developed method using infrared spectroscopy can predict crude protein content in cowpea grain in a time-effective manner (approx. 100 sec./sample) compared to the standard Dumas convection method (approx. 870 sec./ sample) including the time for sample loading.

The method's cost- and time-effectiveness should enable cowpea breeders in West Africa to select potential parental materials and conduct effective breeding with a focus on grain protein content. Also, the method provides useful tools for field agronomic studies, which in turn should help us understand the environmental effects on grain protein content and allow further development of suitable cultivation techniques to produce quality cowpea grains in each region.

(S. Muranaka, M. Shono, H. Ishikawa [International Institute of Tropical Agriculture])

TOPIC 3

Genome editing systems in rice cultivars and strategy for producing desired mutants with homozygous mutation

CRISPR/Cas9 is a novel tool for targeted mutagenesis and is applicable to plants, including rice. The reported studies used limited rice cultivars that have high transformation efficiencies but are now used only for research purposes. For practical application of genome editing to molecular breeding in rice, there is a need to establish CRISPR/Cas9 systems that can be used in commercial cultivars. In targeted mutagenesis, biallelic homozygous mutants in which the target mutations are inherited stably by later generations are desirable for molecular breeding. Previous reports on CRISPR/Cas9 in rice have demonstrated that target mutations are transmitted to the next generation in accordance with Mendelian law, but heritability of the target mutation and the role of inherited *Cas9* gene have not been fully elucidated. Here, we targeted the rice phytoene desaturase (*OsPDS*), whose mutants exhibit an albino phenotype, in five rice cultivars by using CRISPR/Cas9 and analyzed the segregation of target mutations. We present a strategy for generating homozygous mutants without transgenes, chimerism, or unpredicted mutations by using CRISPR/Cas9 in rice.

Agrobacterium-mediated methods using immature embryos successfully transformed a CRISPR/Cas9 system into five rice cultivars including commercially important ones and subsequently induced mutation (Table 1). Unpredicted segregations, with more mutants than theoretically predicted, were frequently found in T_1 plants from monoallelic T_0 mutants. Chimeric plants with both biallelic and monoallelic mutated cells were also observed in the T_1 (Fig. 1). Next, we followed

Table 1. Genotypes of rice cultivar mutants of *OsPDS*, produced by using the CRISPR/Cas9 system and by *Agrobacterium*-mediated transformation of immature embryos.

Cultivar	Number of transgenic plants	Number of monoallelic mutants	Number of biallelic mutants	Total number of mutants
Nipponbare	106	26	64	90
Koshihikari	17	1	10	11
NERICA1	54	16	33	49
Curinga	272	137	80	217
IR64	5	4	1	5
Total	454	184	188	372

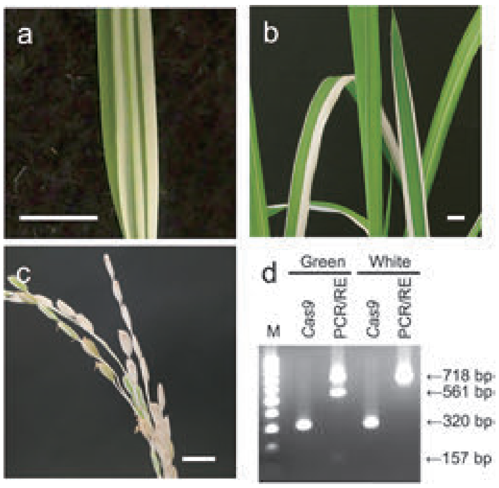

Fig. 1. Segregation of chimeric plants in the T_1. (a) Leaf of chimeric plant at seedling stage. (b) Leaves of chimeric plants grown in a greenhouse. (c) Spikelet of a chimeric plant. Bars represent 1 cm. (d) Green and white portions of chimeric plants were separately subjected to PCR-RE assay for *OsPDS* and to PCR assay for *Cas9*. In the case of monoallelic mutants, PCR-RE assay indicated three bands: 718 bp, 320 bp and 157 bp. In the case of biallelic mutants, PCR-RE assay indicated only a single band: 718 bp. Expected size of PCR products of *Cas9* was 320 bp.

the segregation of a target mutation in the T_2 from monoallelic T_1 mutants. When T_1 mutants possessed *Cas9*, unpredicted segregations of the target mutation and chimeric plants were observed again in the T_2. When T_1 mutants did not possess *Cas9*, segregation of the target mutations followed Mendelian law and no chimeric plants appeared in the T_2. T_2 mutants with *Cas9* had mutations different from the original ones found in T_0. Our results indicated that inherited *Cas9* was still active in later generations and could induce new mutations in the progeny, leading to chimerism and unpredicted segregation (Fig. 2). We conclude that *Cas9* must be eliminated by segregation in T_1 to generate homozygous mutants without chimerism or unpredicted segregation.

Genes of commercially important rice cultivars can be modified by using CRISPR/Cas9 through our transformation systems, as has been done for other "model" cultivars. Investigators also must consider the possibility of unpredicted segregation caused by somatic mutation in T_0, off-target mutagenesis, and somaclonal variation, which usually can occur in CRISPR/Cas9 technologies.

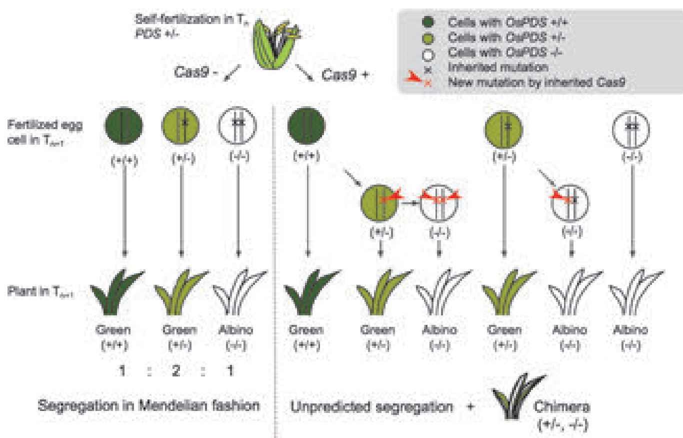

Fig. 2. Diagrammatic model of unpredicted segregation. When plants do not inherit *Cas9*, the targeted mutation segregates in a Mendelian fashion. When plants inherit *Cas9*, the *Cas9* can induce new mutations leading to unpredicted segregation and chimerism.

For the practical use of mutants produced by our systems, intellectual property rights must be handled accordingly.

(T. Ishizaki)

Enhancement of ozone resistance by adjusting the stomatal aperture on leaf surface

Tropospheric ozone (O_3) is a major photochemical oxidant and one of the most phytotoxic air pollutants. Ozone levels have been increasing in many parts of the world, with high concentrations of ozone causing serious damage to crop production. Because ozone enters the plant through the stomata, modulation of stomatal movement using transcription factors, which act as master regulators of various cellular processes, may be a useful strategy for conferring ozone resistance. However, transcription factors modulating stomatal movement have not been well characterized.

In this report, we screened a set of transgenic *Arabidopsis* lines expressing chimeric repressors for *Arabidopsis* transcription factors to identify new transcription factors related with ozone stress resistance. We found that lines expressing the chimeric repressors for GOLDEN 2-LIKE1 (GLK1) and GLK2, which have known functions in chloroplast development, exhibit remarkable ozone resistance and a closed-stomata phenotype. In addition to ozone resistance, these plants also exhibited resistance to sulfur dioxide, an oxidative stress reagent similar to ozone. On the other hand, plants that overexpress GLK1/2 exhibited higher sensitivity to ozone and sulfur dioxide, and an open-stomata phenotype. These results suggest that GLK1/2 affect ozone and sulfur dioxide resistance through the regulation of stomatal movement. We showed that lines expressing the chimeric repressors for GLK1 had reduced expression of the genes for inwardly rectifying K^+ (K^+_{in}) channels and reduced K^+_{in} channel activity, which is one of the positive regulators for stomatal opening. These results indicate that GLK1/2 act as positive regulators of genes for K^+_{in} channels and stomatal opening.

Fig. 1. Sensitivity to ozone of GLK1/2-downregulated *Arabidopsis*.
A. Two-week-old plants of wild type and GLK1/2-downregulated *Arabidopsis* (*GLK1sx* and *GLK2sx*) 1d after exposure to 0.3 ppm ozone for 7h.
B. Ion leakage of wild type and *GLK1/2sx* plants. The average of three biological replicates (three plants per replicate) is shown. Error bars represent SD.

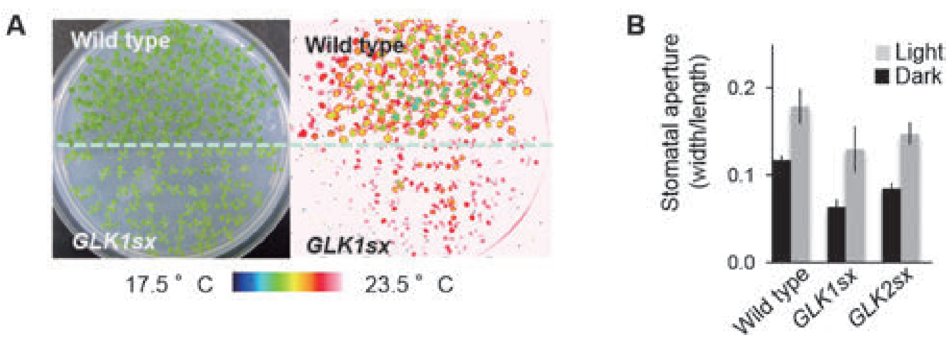

Fig. 2. Transpiration and stomatal aperture of GLK1/2-downregulated *Arabidopsis*.
A. Thermal images of wild type and *GLK1sx* plants grown on MS medium, showing the higher temperature of *GLK1sx* plants.
B. Stomatal aperture of wild type and *GLK1sx* plants grown on MS medium. The average of three independent experiments is shown (50 stomata per experiment).Error bars represent SD.

Stomata play roles in the transpiration and absorption of gases in plants. Thus, the modification of stomatal movements could prove useful for improving both the efficiency of photosynthesis and the plants' resistance to air pollutants. Regulating the expression of chimeric repressors for GLK1/2 specifically in guard cells may be a useful tool for conferring resistance to air pollutants.

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TOPIC 5

Draft genome sequence of an inbred line of *Chenopodium quinoa*, an allotetraploid pseudocereal crop with high nutritional properties and tolerance to abiotic stresses

Chenopodium quinoa (quinoa) is an annual herbaceous plant that originated from the Andes region of South America. It is a pseudocereal crop of the Amaranthaceae family, which also includes spinach (*Spinacia oleracea*) and sugar beet (*Beta vulgaris*). Quinoa is emerging as a key crop with the potential to contribute to global food security, and is considered to be an optimal food source for astronauts due to its great nutritional profile and ability to tolerate adverse environments such as high salinity. In addition, plant virologists utilize quinoa as a representative diagnostic host to identify virus species.

The major cultivation area of quinoa ranges from Columbia to central Chile, and includes altitudes from 0 m up to 4,000 m above sea level receiving an annual amount of rainfall of 80mm to 2,000mm. Quinoa exhibits great tolerance to soil salinity, frost, and drought, thus it is well suited for growing under unfavorable climatic and environmental conditions and. Moreover, quinoa is an excellent nutritional source of various minerals (e.g., Ca, Fe, P, and Zn), vitamins (e.g., A, B1, B2, C, and E), linolenate, natural antioxidants such as polyphenols, dietary fiber, and high-quality protein containing high levels of essential amino acids. Being gluten-free, quinoa is suitable for consumption by individuals who are allergic or intolerant to wheat, rye, and barley. Because of the great nutritional value of quinoa seeds and the high adaptability of quinoa plants to hostile environments, quinoa is deemed by the Food and Agriculture Organization of the United Nations (FAO) to be an important crop with the potential to contribute to food security worldwide. Moreover, the USA's National Aeronautics and Space Administration (NASA) considers quinoa as an optimal food source for astronauts on long-term space missions in isolated conditions. However, molecular analysis of quinoa is restricted by its genome complexity derived from allotetraploidy and its genetic heterogeneity due to outcrossing.

To overcome these limitations, we established the inbred and standard quinoa accession Kd that allows molecular analysis to unravel the mechanism of its high nutritional value, tolerance to

Fig. 1. Morphological characteristics of quinoa (Kd) plants. (A) Dried mature quinoa (Kd) seeds. (B, C, D) 6-, 8-, and 16-week-old quinoa (Kd) plants grown in soil. (E) Head of 17-week-old quinoa plants at harvest time.

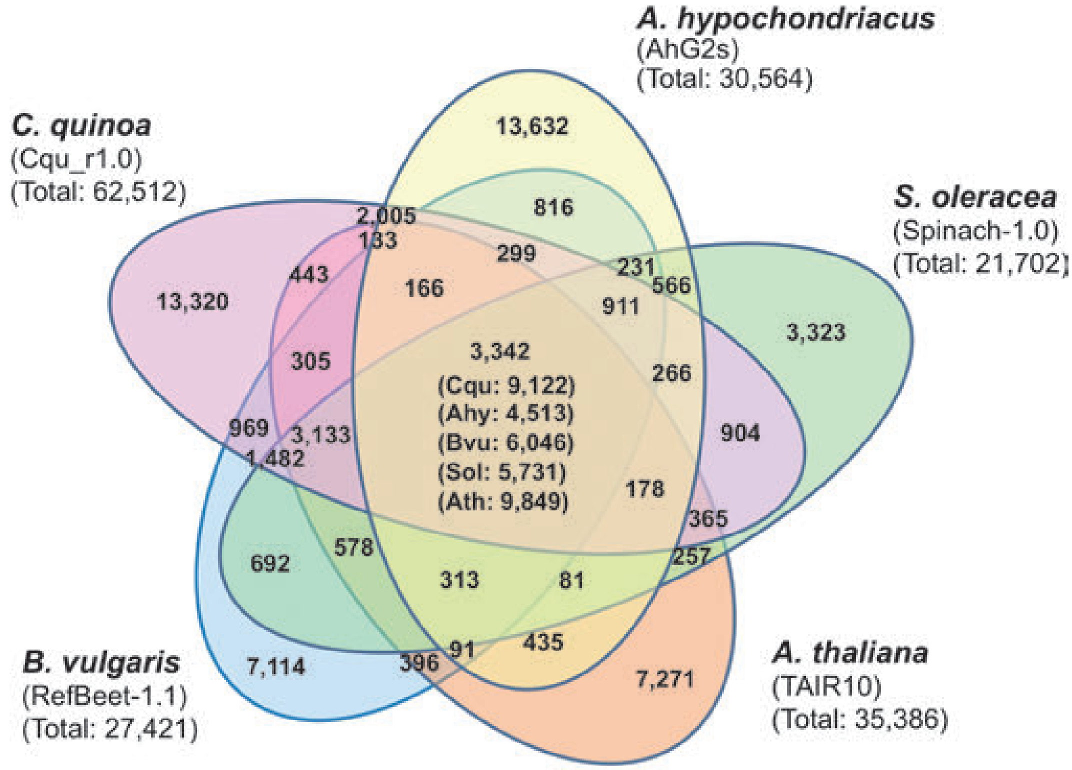


Fig. 2. Cluster analysis of the 62,512 filtered gene sequences. Predicted genes in *Chenopodeum quinoa*, *Amaranthus hypochondriacus*, *Beta vulgaris*, *Spinacia oleracea*, and *Arabidopsis thaliana* were clustered into gene families. In this analysis, we used the filtered dataset of quinoa consisting of 62,512 sequences annotated by performing BLASTP searches against the NCBI's NR database. The number in each section represents the number of clusters, and the numbers in parentheses in the center section represent the numbers of genes included in the analysis from each species. The number below the species name marks the total number of genes used as input for CD-hit (-c 0.4, -aL: 0.4).

unfavourable environments, and susceptibility to a broad range of viruses, and provided the draft genome sequence of Kd using an optimized combination of high-throughput next generation sequencing on the PacBio RS II and Illumina Hiseq 2500 sequencers. The *de novo* genome assembly contained 25 k scaffolds consisting of 1 Gbp with N50 length of 86 kbp. Based on these data, we constructed the free-access Quinoa Genome DataBase (QGDB; http://quinoa.kazusa.or.jp), which provides annotations of *in silico* predicted genes. Furthermore, we utilized comparative genomics and experimental approaches to identify genes in quinoa that are involved in abiotic and biotic stress responses. Thus, these findings yield insights into the effect of allotetraploidy on genome evolution and the mechanisms underlying agronomically important traits of quinoa.

(Y. Fujita, Y. Yasui [Kyoto University], H. Hirakawa [Kazusa DNA Research Institute], M. Mori [Ishikawa Prefectural University], T. Tanaka [Actree Co.])

TOPIC 6

Three differential soybean varieties highly resistant to Asian soybean rust carry the resistance gene *Rpp1-b*

Asian soybean rust (ASR), a soybean disease caused by *Phakopsora pachyrhizi*, is one of the biggest threats to soybean production in South America where more than half of soybean in the world market is produced. Although an environment-friendly, cost-effective, and long-term management of ASR can be achieved through use of ASR-resistant soybean cultivars, only a limited number of resistance resources are available for soybean breeding in South America because of the high virulence and diversity of ASR pathogens. For this reason, we are examining ASR-resistant soybeans whose resistance genes have not been identified yet and are therefore unused in breeding programs. We previously studied the Chinese soybean varieties PI 594767A (Zhao Ping Hei Dou), PI 587905 (Xiao Huang Dou), PI 587855 (Jia Bai Jia), and Xiao Jin Huang, and the Japanese soybean varieties Himeshirazu, Iyodaizu B, and PI 416764 (Akasaya). We identified their resistance to ASR pathogens from South America and Japan, with PI 594767A, PI 587905, PI 587855, and PI 416764 among those included in the international set of soybean differentials used in identifying the pathogenicity of ASR pathogens. The aim of this study, therefore, was to identify the ASR-resistance loci in these seven soybean varieties and tag the resistance genes to DNA markers. This information will be useful in marker-assisted breeding programs for ASR resistance.

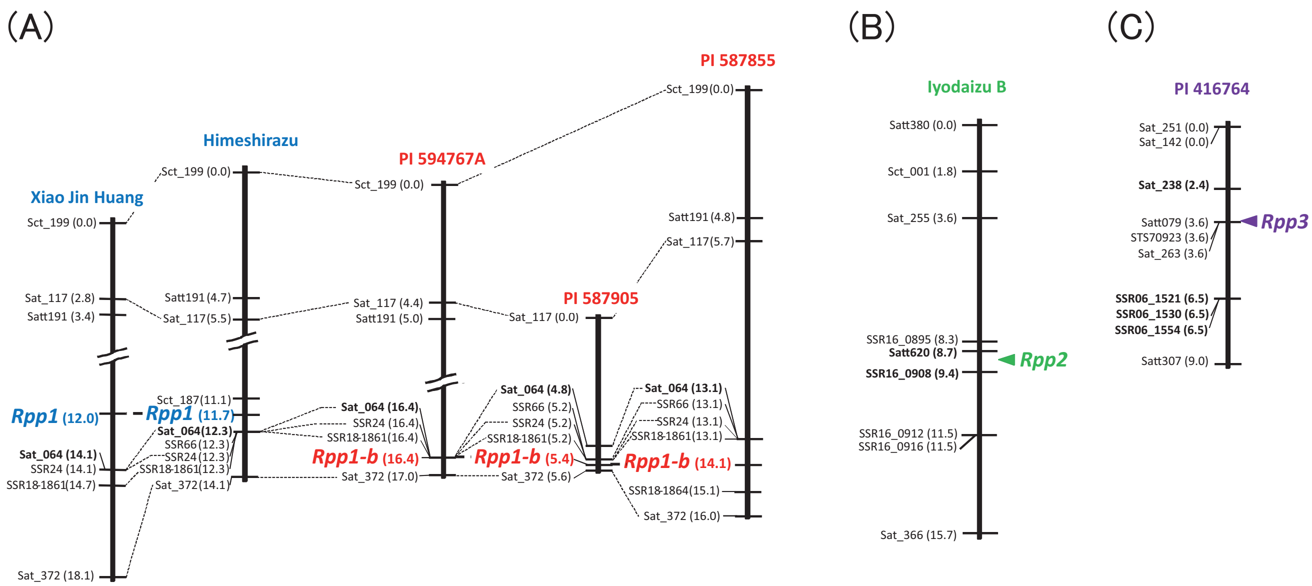


Fig. 1. Molecular linkage maps of ASR resistance loci in seven soybean varieties. It shows (A) soybean chromosome 18 where *Rpp1* and *Rpp1-b* are located; (B) chromosome 16 where *Rpp2* is located; and (C) chromosome 6 where *Rpp3* is located. The loci *Rpp2* and *Rpp3* were determined by quantitative trait locus (QTL) analysis for sporulation level (SL) in ASR disease. The names of DNA markers and genetic distance (cM) from the top of linkage groups are shown on the left side of each linkage group.

Table 1. Reactions of seven ASR-resistance soybean varieties to ASR pathogens from South America and Japan

Soybean variety	Gene	Highly virulent Brazilian ASR pathogen				Japanese ASR pathogen		Frequency of resistant phenotype to 64 pathogens from South America and Japan
		BRP-2.49	BRP-2.1	BRP-2.6	BRP-2.5	T1-2	E1-4-12	
Xiao Jin Huang	*Rpp1*	S	S	S	S	R	SR	9.7 - 16.1%*
Himeshirazu	*Rpp1*	S	S	S	S	S	HR	9.7 - 16.1%*
PI 594767A	*Rpp1-b*	HR	HR	HR	S	HR	HR	96.5%
PI 587905	*Rpp1-b*	HR	HR	R	S	R	HR	84.1%
PI 587855	*Rpp1-b*	HR	R	HR	S	-	HR	78.6%
Iyodaizu B	*Rpp2*	R	SR	S	S	S	HR	25.8 - 31.8%*
PI 416764	*Rpp3*	S	S	S	S	R	HR	34.4%

HR: Highly resistant; R: Resistant; SR: Slightly resistant; S: Susceptible; -: No data.
*The ranges of frequencies shown here are based on different varieties but carrying either *Rpp1* or *Rpp2*.

F_2 populations were developed by crossing a susceptible variety, BRS184, with each of the seven resistant varieties. Each population was inoculated with an appropriate ASR pathogen and the phenotypes were determined as either resistant (R) or susceptible (S). Then, the loci for ASR resistance were mapped together with the DNA markers. In case the boundary between R and S was unclear in the F_2 population, the resistance locus was mapped as a quantitative trait locus (QTL) for sporulation level (SL).

Figure 1 shows that Xiao Jin Huang and Himeshirazu carry *Rpp1*, whereas PI 594767A, PI 587905, and PI 587855 carry *Rpp1-b*. *Rpp1* and *Rpp1-b,* both known as ASR-resistance genes, are located close to each other on chromosome 18. Furthermore, the QTL for SL was mapped on the chromosome region of *Rpp2* and *Rpp3* for Iyodaizu B and PI 416764, respectively. Since the ASR resistance loci of these seven soybean varieties were successfully identified together with the DNA markers linked to their resistance loci, these resistant varieties can be used in marker-assisted breeding programs for ASR resistance. Among the seven varieties, PI 594767A, PI 587905, and PI 587855 have been found to carry *Rpp1-b*. They are especially useful for soybean breeding because they are resistant not only to 78.6%-96.5% of ASR pathogens from South America and Japan but also to three highly virulent Brazilian ASR races (Table 1).

(N. Yamanaka, M. M. Hossain [Bangabandhu Sheikh Mujibur Rahman Agricultural University])

PROGRAM C
Value-adding Technologies

"Development of high value-adding technologies and utilization of local resources in developing regions"

The Value-adding Technologies Program addresses the utilization of indigenous regional resources in Asia and the development of high value-adding technologies. To ensure high quality products and stable food value chains, we implement research on the identification of regional food resource characteristics, the development of effective food processing technologies, and the elucidation of customer needs. The program also supports rural development by utilizing regional resources in agriculture, forestry and fisheries. To achieve our goals, we conduct the following five research projects.

[Food Value Chain]

This project was established to study value enhancement of food products through analysis of functions in the Food Value Chain, which consist of consecutive steps from production to consumption. The first major research subject relates to food technology and is composed of two themes, namely 1) Construction of a normalized scheme to evaluate the qualities of local food resources and 2) Development of value addition technology for local food resources. The second major subject relates to socioeconomic research and is composed of two themes, namely 1) Improvement of food production and distribution systems to meet consumer needs and 2) Development of methods to evaluate the food value chain. In the initial year of the project, a research collaboration scheme was constructed with institutes in Thailand, Lao PDR, and P. R. China. We determined cereals, including processed food and traditional fermented food, of which similar products appear widely in the Asian region, to be the main target food.

One of the major results was the clarification of mechanism for generating specific textures of fermented rice noodle. Another significant result was the development of an evaluation method for food functionality such as blood pressure control using fermentation and enzymatic techniques. Also, the amino acid component of traditional fermented foods such as *pa-daek* was analyzed and found to have high variation among products. In relation to socioeconomic study, a survey of consumer preferences on rice was performed and the value chain system of *pa-daek* was investigated.

[Asia Biomass]

In order to encourage the use of biofuels and biomaterials produced from agricultural residues, we successfully developed a new saccharification technology and a biodegradable plastic production technology using old palm trunks and wastewater. Toward energy production through application of our technologies, we have successfully isolated a novel anaerobic thermophilic microbe with a strong lignocellulose-degrading ability from biocompost. In addition, we are developing a saccharification and biogas fermentation reactor using the microbes, in cooperation with Japanese companies in Thailand and Malaysia. These achievements are good examples of our technologies being utilized in many practical applications.

[Multiple Use of Regional Resources in Semi-mountainous Villages]

In the inland areas of the Indochinese Peninsula, farmers' livelihoods are threatened due to decreased agricultural productivity caused by inappropriate land use. Thus, stable food production is an important subject, particularly in Laos where high poverty ratio and insufficient nutritional supply in rural areas are national problems.

In order to improve the situation, the selection of potential upland rice varieties that have higher productivities and the technical development of paddy fish culture have been accelerated. Furthermore, an evaluation of nutritional status in remote rural villages has implied a seasonal deficiency in protein. Research activities on water resource management in paddy areas, sustainable use of forest areas relevant to NTFP utilization, and technical development of tropical fruit seedling production were also undertaken.

[Higher Value Forestry]

We have started research activities on higher value forestry production from planted trees, such as teak and dipterocarp species, with a few Southeast Asian countries.

In Thailand, we have initiated onsite and unmanned aerial vehicle (UAV) observations of teak plantations for silvicultural treatment analyses as well as experiments for improved teak seedling production through soil improvement and molecular breeding. Soil surveys have been implemented across a hilly landscape in northern Laos for selecting suitable teak plantations, and environmental resiliency tests have been initiated for domestic dipterocarp species in Malaysia. In addition, genomic selections of higher productivity domestic dipterocarp lineages have been started in Indonesia.

Outputs from previous forestry researches in Malaysia and Thailand were released in two special publications, namely, the Journal of Tropical Forest Science 28(5) and JIRCAS Working Report No. 85, respectively.

[Aquatic Production in Tropical Areas]

Development of technologies for sustainable aquatic production was conducted in coastal waters of Southeast Asia. In Malaysia, the water quality was examined to reveal the causes of the decrease in cockle culture production. In Myanmar, the habitat conditions of edible oyster were surveyed. In Thailand, the economic efficiency of the co-culture involving giant tiger shrimp with seaweed and snails was evaluated. In Laos, three kinds of indigenous freshwater shrimps were selected as suitable species for captive breeding based on their body size and fecundity. In the Philippines, an Integrated Multi-trophic Aquaculture (IMTA) system was demonstrated and improved by collaborating with fishermen, and the availability of low fishmeal feed using alternative resources was evaluated.

TOPIC 1

Selective protein digestion during fermentation provides a distinctive texture to traditional fermented rice noodles in Indochina

Traditional fermented rice noodles in Indochina are characterized by their unique flavor and pleasing texture. Locally known as Kanom-jeen (Thailand), Khao Pun (Laos), and Bun (Vietnam), they are widely consumed as a staple food throughout the region with the fermentation process considered a key step in providing its desirable attributes, especially texture.

Traditional preparation of Thai traditional fermented rice noodles, Kanom-jeen, involves the following steps: soaking of high amylose rice for 4-5 h in water, fermentation of the soaked rice grains for 3 days with aeration, wet-milling, fermentation of ground flour in saline solution for 3 days, filtration, kneading and pre-gelatinization, re-kneading to form a viscous slurry, extruding the viscous slurry into noodles, and cooking in boiling water (Fig. 1).

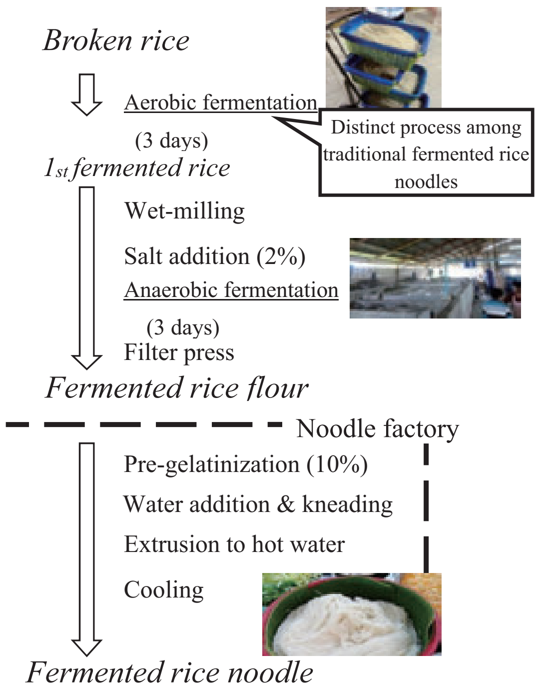


Fig. 1. Traditional processing of Thai fermented rice noodles, Kanom-jeen.

The results showed that protein content significantly decreased during the 1st aerobic fermentation process for 3 days as shown in Figure 2. Their protein composition revealed that Protein Body II, the digestible proteins in rice kernel, disappeared during rice fermentation, while Protein Body I, the indigestible proteins, remained. Microstructural analysis (Fig. 3) demonstrated that cluster-like structures consisting of digestible proteins were formed only in the non-fermented preparation, while fermented preparation contained only uniformly spherical protein bodies formed by the indigestible proteins in starch gel. The cluster-like

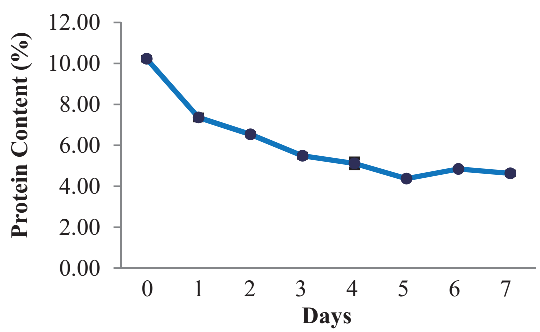
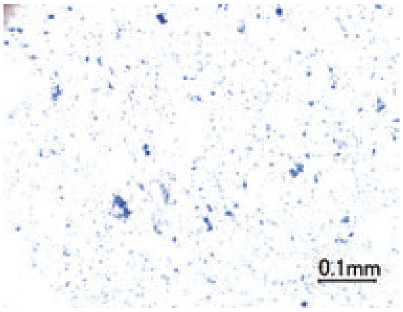
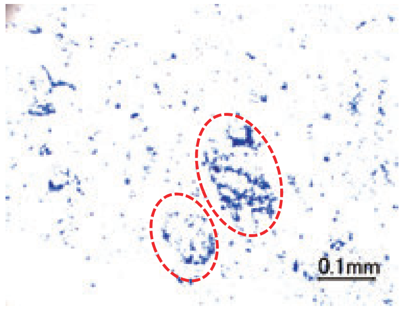


Fig. 2. Changes in protein content of rice during fermentation. Protein content significantly decreased during the 1st aerobic fermentation process for 3 days.



(a)



(b)

Fig. 3. Protein localization in fermented (a) and non-fermented (b) rice noodles.
Cluster-like structures of digestible proteins were observed only in non-fermented noodles.

protein structures are commonly found in gels of non-fermented noodles, resulting in a less uniform microstructure. These structural differences indicated that the traditional fermentation process can be considered a viable method for removing digestible proteins selectively from rice endosperm to provide a stronger gel. The fermentation process is, therefore, necessary during preparation to obtain the desired specific texture.

Eliminated proteins can be identified as part of rice allergenic proteins. Therefore, these findings may shed light on the effect of traditional processes on selective digestibility to determine its potential to reduce rice allergenicity. Moreover, remaining proteins that are indigestible have been considered as beneficial for chronic kidney disease patients who need to control their protein intake. These properties could provide benefits as a healthy food application based on traditional processing knowledge, consequently increasing the nutritional value of local traditional products.

(P. Satmalee [Institute of Food Research and Product Development, Kasetsart University (IFRPD, KU)], V. Surojanametakul [IFRPD, KU], N. Phomkaivorn [IFRPD, KU], W. Pantavee [IFRPD, KU], T. Yoshihashi)

TOPIC 2

Effect of cassava pulp supplement on 1,3-propanediol production by *Clostridium butyricum*

The three-carbon diol 1,3-propanediol (1,3-PD) is an important organic substrate for biopolymers such as polytrimethylene terephthalate. Glycerol, which is a by-product of biodiesel production, is the main substrate of 1,3-PD production by fermentation with microorganisms such as *Clostridium butyricum*. However, the yield and productivity of 1,3-PD on glycerol are low because the growth and energy production are hampered by the low assimilation rate. Supplementing the glycerol medium with glucose is expected to enhance the growth and increase of 1,3-PD production; however, it leads to catabolite repression in *C. butyricum*. Although *C. butyricum* can produce solvents from polysaccharides such as starch, the effects of polysaccharides on 1,3-PD production by this organism have not been reported. We report that supplementing the glycerol medium with small amounts of cassava pulp (CP) rather than starchy polysaccharides can improve the 1,3-PD productivity of *C. butyricum*. CP is a promising starchy-lignocellulosic biomass for biochemical production because both of its major components, namely, starch (50% dry basis) and cellulose fiber (approximately 30% dry basis), can be hydrolyzed to fermentable sugars. When the medium containing 30 g/L glycerol was supplemented with 2 g/L and 4 g/L CP (1 g/L and 2 g/L starch, respectively), the 1,3-PD concentrations were 9.5 g/L and 8.2 g/L, respectively, similar to that of glycerol alone. However, CP supplementation increased the rate of 1,3-PD production by *C. butyricum*. Specifically, in a medium containing 30 g/L of glycerol supplemented with 2 g/L of CP, the productivity of 1,3-PD (g/L/h) after 24 hours of fermentation was enhanced from 0.25 ± 0.01 (in 30 g/L of glycerol alone) to 0.43 ± 0.02. These results indicate that supplementation with

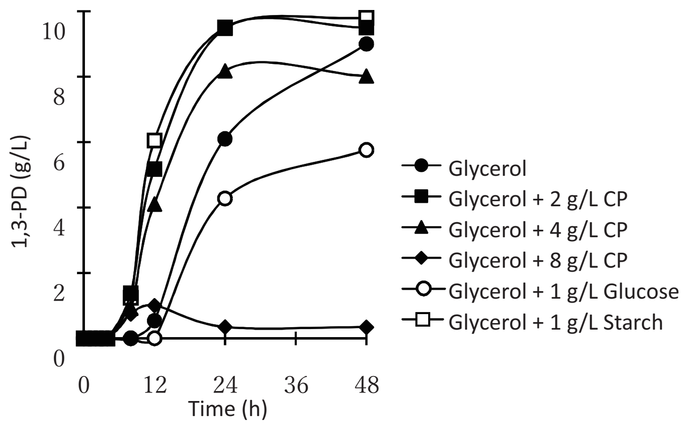


Fig. 1. Profiles of fermentative 1,3-PD production by *C. butyricum* I5-42 during batch fermentation on medium (containing 30 g/L glycerol) supplemented with CP at various concentrations.

small quantities of CP not only improves the poor growth of *C. butyricum* on glycerol medium but might also enhance 1,3-PD production by this organism.

(W. Apiwatanapiwat [Kasetsart University], P. Vaithanomsat [Kasetsart University], A. Kosugi)

TOPIC 3

Resource management and conservation of *Pa koh*, an important edible fish in Laos, based on ecological information

Laos has been experiencing a high population growth rate in recent years, resulting to the expansion of urban areas and a rapid increase in demand for edible fish. This has become a serious concern as it has led to a declining stock level of many fish species and a downsizing of the specimens. The snakehead fish, locally called *Pa koh* (*Channa striata*) (Fig. 1), is among those facing strong fishing pressure because of its daintiness and high market value. This species is strongly carnivorous, has a superior position in the regional food chain, and its population size is relatively small compared to other non-carnivorous fishes. This situation necessitates stock management of the species and requires conservation of the adult specimens (breeding population).

Against this background, an analysis of several ecological features such as age, growth, and reproduction were carried out in the present study using 530 specimens collected from the northern area of Vientiane Province, Laos, and the following findings relevant to efficient stock management were obtained.

1. In the otoliths of *Pa koh*, a translucent zone is formed once per year and a ring structure is deposited (Fig. 1). This ring is an annual ring and it is useful for estimating the ages of each specimen.
2. By counting the number of annual rings, the growth models (age–size relationships) are regressed, and the reproductive age and longevity can be estimated. The maximum age and size observed in the present study are 6-7 years old and approximately 50 cm standard length (SL), respectively, for both females and males (Fig. 2).
3. The growth patterns of females and males are not significantly different from the growth models (von Bertalanffy growth curves) (Fig. 2), and the model indicates slower growth compared to the growth of *C. striata* studied in other tropical areas (e.g., Sri Lanka).
4. On the basis of the growth model, gonad somatic index (GSI, gonad weight/body weight × 100%), and size-GSI relationship (figure omitted), this species was found to sexually mature at approximately 20 cm SL (2 years old). Ovary maturation progresses from the late phase of the dry season (March)

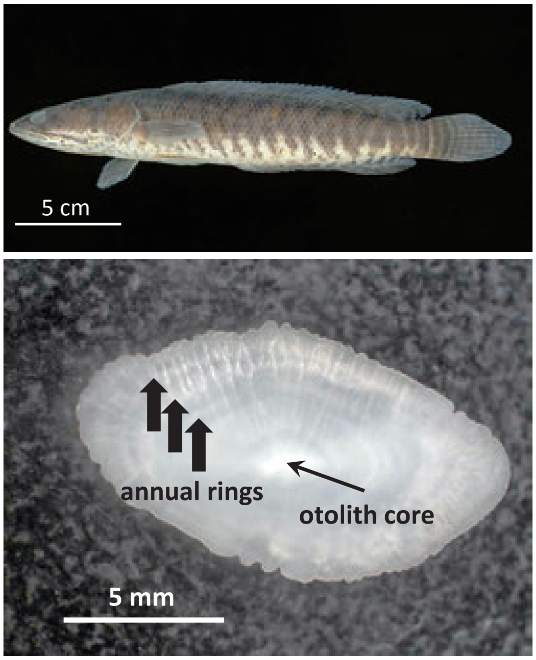


Fig. 1. Top: An adult *Pa koh* (24 cm SL); Bottom: Otolith and annual rings

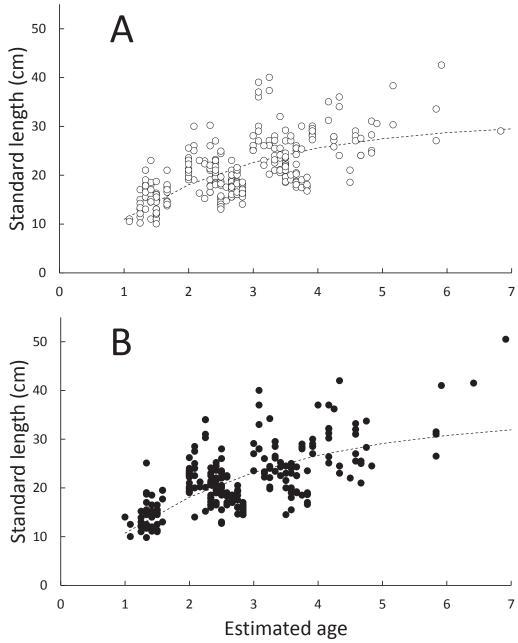


Fig. 2. Growth models of *Pa koh* (A: female; B: male)

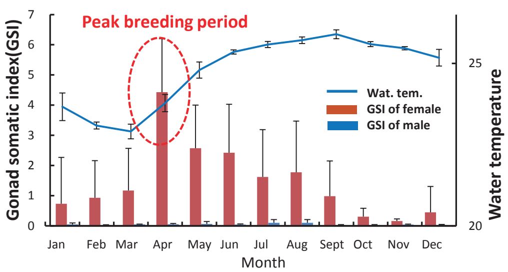


Fig. 3. Seasonal changes in the GSI of *Pa koh* and in water temperature.

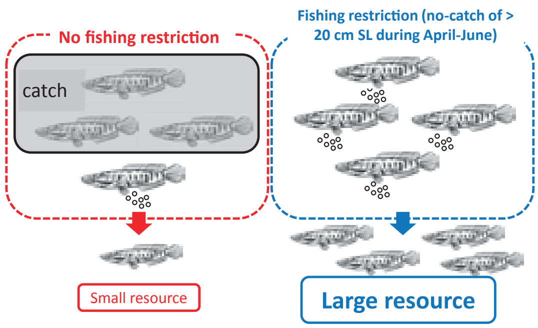


Fig. 4. Images showing the effects of unrestricted and restricted fishing

as the water temperature rises, the peak of reproduction being in April (Fig. 3).

5. In order to manage/conserve *Pa koh* stock, fishing restriction on specimens larger than 20 cm SL during breeding period (from April to June) must be imposed. Setting a non-fishing period and/or non-fishing area(s) in breeding area(s) is considered efficient.

In addition to the above findings, the following observations were noted.

1. Since several populations of *Pa koh* are widely distributed over Laos, further investigations on other populations in other areas are required for stock management in more widespread areas.
2. Juveniles of *Pa koh* (4-5 cm SL) abundantly occur in the shallow area(s) of ponds/lakes/rivers, and they are also caught as edible food. It is also necessary that such activity be controlled for better stock management of *Pa koh*.

(S. Morioka, B. Vongvichith [Living Aquatic Resources Research Center])

TOPIC 4

Improvement of selective logging criteria for dipterocarp timber species to maintain healthy seed production

Maintaining regeneration is essential for sustainable forest management when products, such as timber, are being extracted. It has been widely believed that the forests have sufficient resilience to recover from selective logging without enrichment planting, and selective logging regimes have been widely applied in sustainable management programs for tropical forests. However, selective logging may also threaten the pollination and sexual reproduction systems of tropical tree species. Consequently, outcrossing restrictions can markedly increase the proportion of unhealthy offspring through inbreeding depression. Thus, selective logging regimes must be optimized in terms of remaining tree density to ensure that healthy outcrossed seeds are produced in sufficient numbers to support the sustainable management of secondary forests.

Parameters of pollen dispersal and flowering intensity were estimated from paternity of seeds collected from mother trees of four focal dipterocarp timber species and a subsequent hierarchical Bayesian model (See JIRCAS Research Highlights 2011, Topic 15). To simulate reductions in outcrossing pollen clouds after logging, we raised the selective logging criterion (cutting limit) in 1 cm increments from 40 cm to 100 cm. At each step, we calculated the amount of outcrossing pollen in the pollen cloud of the mother trees from the remnant trees which were smaller than the arbitrarily assigned cutting limit. However, we applied unified parameter values for every simulation step.

Pollen dispersal patterns of dipterocarps are strongly affected by population density. Thus, as logging inevitably affects population density, it is not realistic to apply the same pollen dispersal kernel parameter estimates following logging at every cutting limit applied in simulations. The unrealistic feature of the simulation should be carefully considered before applying the results in practice. It is still a useful tool to gauge how the reduction in population densities and outcrossing pollen clouds may affect the proportion of healthy outcrossed seeds in selectively logged forests.

The simulation results presented here clearly indicate that outcrossing of *S. curtisii* is most susceptible, with *S. maxwelliana* being second

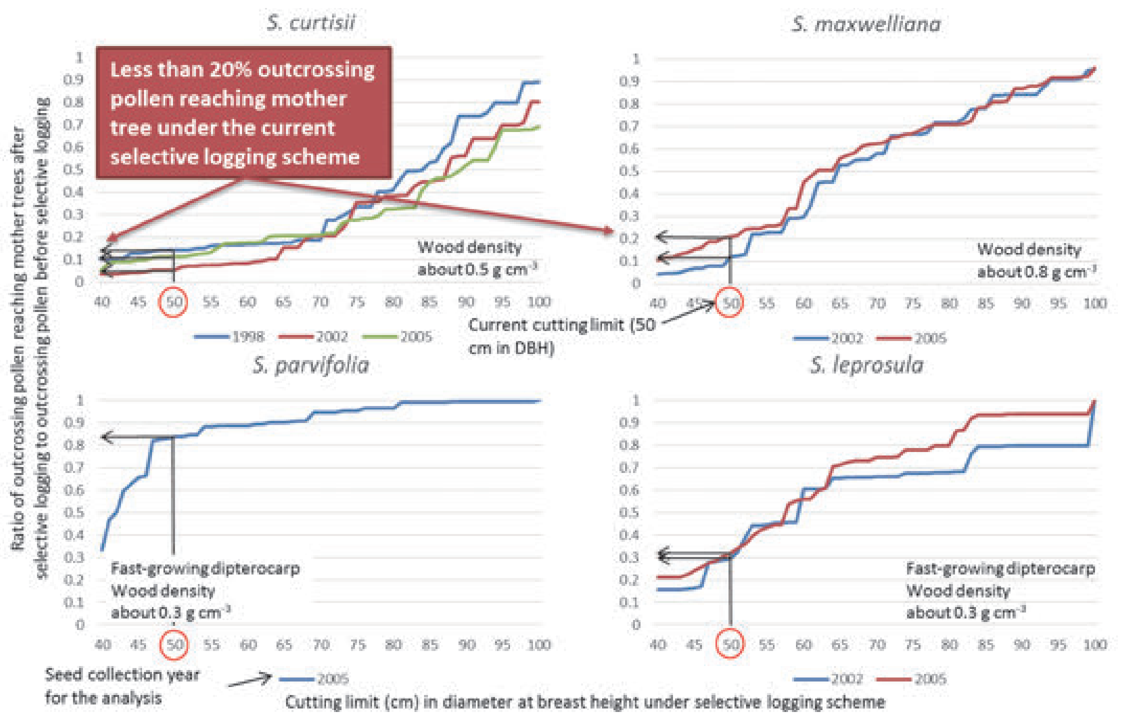


Fig. 1. Simulating the ratio of outcrossing pollen reaching mother trees after selective logging to outcrossing pollen without selective logging for four dipterocarp timber species. The simulation was conducted using the selective logging criterion (tree diameter cutting limit) of 40 cm and at every 1-cm increment thereafter.

Table 1. Ecological difference between the experimental timber species and improvement plan in response to the simulation results

Timber species		Ecological feature				Healthy seed production	
Classification	Example	Wood density	Growth	Reproductive age	Longevity	Current criteria	Improvement plan
Fast-growing sp.	*S. leprosula* *S. parvifolia*	Low	Fast	Fast	Short	Healthy mating	Current criteria
Slow-growing sp.	*S. curtisii* *S. maxwelliana*	High	Slow	Slow	Long	Reducing healthy mating	More strict criteria

most susceptible, to reductions in population density due to selective logging among the four focal dipterocarp species (Fig. 1). These species produce highly durable timber, which could relate to species' turnover rates, as species with high wood densities have low growth rates, low susceptibility to forest disturbance, and low mortality rates. In addition, the onset of reproduction at relatively large sizes for the species may increase the vulnerability of the pollen dispersal to reduction of population density due to selective logging. The post-logging decline in male fecundity in the remaining small-sized trees as implied in the simulations for *S. maxwelliana* and *S. curtisii*, which have highly dense wood, underscores the need for more species-specific cutting guidelines (Table 1). Based on our study, defining groups of timber species according to their wood density could facilitate efforts to formulate selective logging schemes that better balance the exploitation and genetic conservation of dipterocarp timber species.

(N. Tani, S.L. Lee [Forest Research Institute Malaysia], C.T. Lee [FRIM], K.K.S. Ng [FRIM], N. Muhammad [FRIM], A.R. Kassim [FRIM], S. Musa [FRIM], Y. Tsumura [University of Tsukuba])

TOPIC 5

Addition of charcoal to sandy soil in Northeast Thailand enhances growth of teak

Teak (*Tectona grandis* L. f.) is one of the most valuable timber tree species in Thailand, and it is widely planted throughout the country. However, teak growth in Northeast Thailand plantations is suppressed due to the low pH, low fertility, and low water holding capacity of the underlying sandy soil. Soil acidity can be corrected to raise the pH levels and fertilizers can be applied to improve the fertility of sandy soils, thereby accelerating the growth of teak. There have been previous researches on improving the water holding capacity of sandy soil, and some materials have been shown to be effective. However, these past studies did not examine the effect of these materials on the growth of teak.

In this study, we examined the availability of materials to improve the sandy soil's water holding capacity and increase teak growth. We selected bentonite (a clay consisting mostly of montmorillonite), charcoal, and corncob, and added these materials at the rate of 4% (by weight) to sandy soil in Northeast Thailand. The mixtures were put into 8.5-L pots, and teak seedlings were planted on these pots and raised for one year. We measured soil water content and leaf water potential at predawn. At the end of the experiment, we sampled the teak seedlings, measured the dry mass of each organ, and analyzed the concentration of nutrients in leaves. Lastly, we compared the parameters among bentonite, charcoal, corncob, and no addition (control) treatments.

Results showed that water content was high for the bentonite treatment throughout the whole period (Fig. 1). For the charcoal treatment, water content increased from September 2013. In contrast, the corncob treatment showed low water content compared with the three other treatments. The predawn leaf water potential did not decrease for bentonite and charcoal treatments (Fig. 2). Moreover, teak seedlings grown on bentonite- and charcoal-treated plots could uptake water from the soil during the whole period and did not suffer from drought stress.

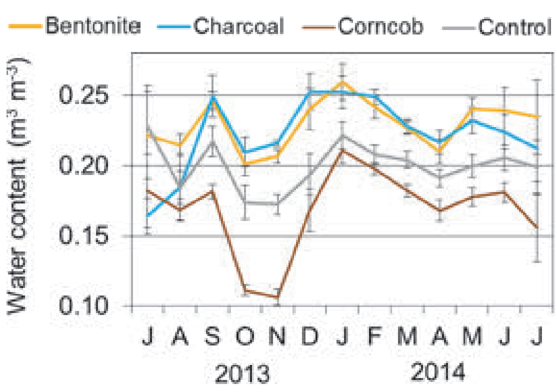


Fig. 1. Average soil water content before irrigation or rainfall (from July 2013 to July 2014)

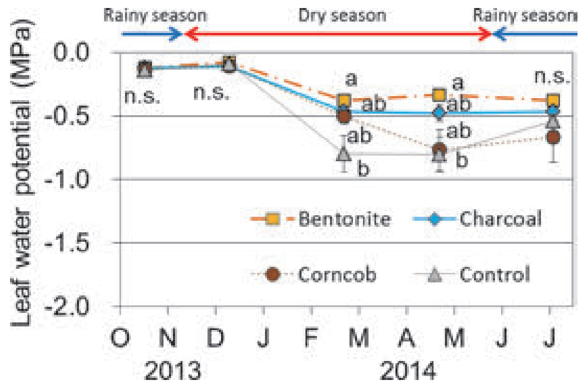


Fig. 2. Predawn leaf water potential of teak leaves (from October 2013 to July 2014)

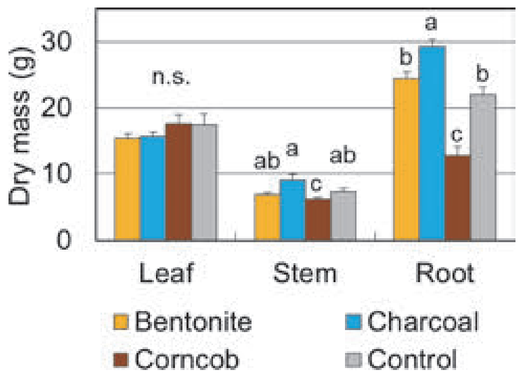


Fig. 3. Dry mass of each plant organ at the end of experiment (July 2014)

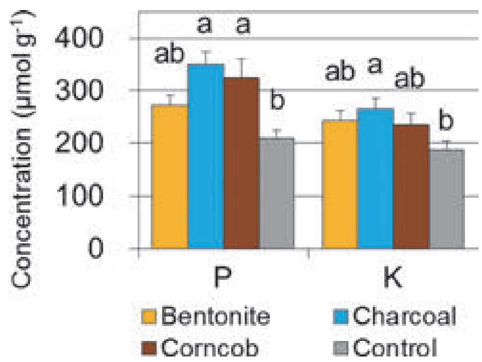


Fig. 4. Concentrations of phosphorus and potassium in teak leaves at the end of the experiment (July 2014)

Charcoal treatment showed significantly higher root dry mass compared with the other treatments despite no fertilization (Fig. 3). The concentrations of phosphorus and potassium in the leaves of teak seedlings were significantly higher for the charcoal treatment compared with the control treatment (Fig. 4). In contrast, bentonite treatment did not show high concentrations of nutrients in leaves.

Based on our experiment, we concluded that charcoal was the most suitable material among those tested and would be very useful for improving teak growth at the seedling stage in sandy soils in Northeast Thailand. Charcoal is commonly produced in various countries, and thus may be applied as soil improvement material to enhance the water holding capacity and uptake of phosphorus.

(M. Kayama, S. Nimpila [Royal Forest Department], S. Hongthong [RFD], W. Wichiennopparat [RFD], W. Himmapan [RFD], T. Vacharangkura [RFD], R. Yoneda [Forestry and Forest Products Research Institute], I. Noda [FFPRI])

Spread of infection of yellow head virus (YHV) of giant tiger prawns by cannibalism

Intensive Penaeidae cultivation is an important industry supporting the economy in tropical regions. However, due to recent disease outbreaks and their frequency (Fig. 1), the production in cultivation farms has become unstable and as such, a prompt solution is critical. In South-East Asia, yellow head virus (YHV) is a commonly occurring viral infection in shrimp. Since the first reports of YHV in Thailand, the virus continues to cause serious damage in various places. However, the transmission mechanism of the virus is still unclear. Shrimp farmers exchange the cultivation water as seldom as possible to avoid lateral infection which in turn results in water quality deterioration and reduced productivity. In this study, we carried out experiments in order to understand the mechanisms of YHV transmission and propose measures to reduce the impact of infections.

Amongst an experimental group allowed to cannibalize infected shrimp, more than 90% of all shrimp died from severe infection within 10 days (Fig. 2, Table 1). On the other hand, significantly lower rates of YHV detection and severity were identified amongst another group sharing the aquarium water with the cannibals but separated by a filter and the death rate was also significantly lower (Fig. 2, Table 1). Moreover, the YHV severity of shrimp in the second group that had survived low level infections gradually reduced after 30 days to 60 days (Table 1). These results show that YHV infection in shrimp is more severe if the infection was caused by cannibalism than by water. The gills from shrimp that had died from YHV were collected, homogenated, and filtered at 12 and 24 hours post-mortem respectively and injected into the muscle of healthy individuals. Those injected

Fig. 1. Giant tiger prawn infected with YHV at an earthen shrimp pond

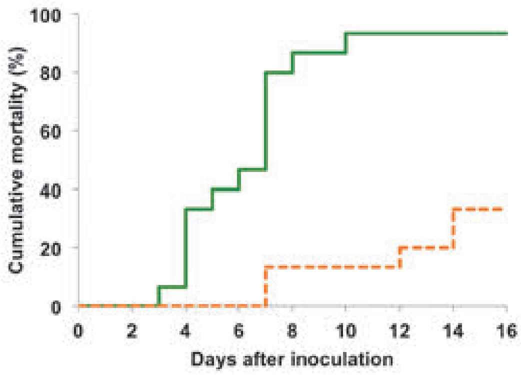


Fig. 2. Cumulative mortalities during a 16-day experiment between infected aquariums (through cannibalization and water borne routes)

Table 1. Number of deceased/surviving individuals and their infection intensity (infection through cannibalization and waterborne routes)

	Infection via cannibalism				Infection via water			
	Severely infected	Slightly infected	Undetectable	Total	Severely infected	Slightly infected	Undetectable	Total
Number of deaths	14	0	0	14	0	3	2	5
Survivors (30 days later)	0	0	1	1	0	5	5	10
(60 days later)	0	0	1	1	0	2	8	10

Deceased individuals were analyzed immediately post death. The surviving individuals were continuously raised and their infection intensity was analyzed at 30 and 60 days, respectively. Severely infectious – indicates the number of individuals that were detected positive by 1st PCR. Slightly infectious – indicates the number of individuals that were detected positive by nested-PCR. Our analyses were performed with 3 shrimps from each tank and 5 replicates for each infection route (total 15 individuals).

Table 2. Gills from individuals that had died from YHV infection were collected at 12 and 24 hours post-mortem, and the homogenate was injected into the muscle of eight healthy individuals. The number of dead/surviving individuals and their infection intensity was recorded.

	12 hours later				24 hours later			
	Severely infected	Slightly infected	Undetectable	Total	Severely infected	Slightly infected	Undetectable	Total
Number of deaths	8	0	0	8	1	0	0	1
Survivors	0	0	0	0	0	2	5	7

Dead individuals were analyzed immediately after death. The surviving individuals were analyzed at 16 days.

with gills collected 12 hours post death all died within 4 days. On the other hand, only one among those injected with gills collected 24 hours post death died after 7 days (Table 2). YHV activity is still high 12 hours post-mortem but significantly reduces after 24 hours. In shrimp cultivation, the possibility of YHV infection via pond water is low; therefore, avoiding water exchange is not necessary. Furthermore, it is more important to reduce the incidence of healthy individuals feeding (cannibalizing) on other shrimp that have died from YHV infection. For example, prompt collection of deceased individuals and low-density production would be effective measures against YHV infection.

Appropriate water exchange will enhance the water quality, which in turn will enhance the expected recovery of individuals with low level infections. Greater results could be anticipated by introducing and implementing specific pathogen-free (SPF) juvenile shrimp. The mechanism of the first occurrence of YHV infection in shrimp cultivation ponds is still unknown; hence, further studies are required for a detailed understanding of YHV infection.

(I. Tsutsui, K. Hamano [Japan Fisheries Research and Education Agency], D. Aue-umneoy [King Mongkut's Institute of Technology Ladkrabang])

Program D
Information Analysis

"Collection, analysis and dissemination of information for grasping trends of international agriculture, forestry and fisheries"

The global situation and problems surrounding agricultural production and the food market as well as food and nutrient supply are widely diverse, and they are constantly affected and changing along with global phenomena such as climate change, deteriorating natural environments, and international socio-economic trends. To address the stable and sustainable development concerns of agriculture, forestry, and fisheries, it is essential to do the following: analyze the current status, identify the problems, assess the impact of past development efforts, and integrate foresight studies. It is also important to provide regular feedback and turn the results of analyses into institutional strategies to make the research for development (R4D) activities more adequately focused, efficient, and cost-effective.

In the project "Evaluation of global food supply-demand and nutritional balance," we examined the current situation of agricultural production, food consumption, and nutrient supply. A comparative analysis between supplies of nutritional elements calculated from the food balance sheet and the nutritional requirements in Madagascar showed the deficits or low absorption rates of some micronutrients in the country. A statistical analysis of world food has made clear that nutrition intake from vegetables will increase in Europe, China, and Central Asia, and that nutrition intake from tubers is high in Sub-Saharan Africa (SSA). Furthermore, a world food model analysis has shown that nutritional deficit in SSA will improve in the next 30 years and that climate change will reduce nutrition intake in many higher latitude countries. These results were reported to international organizations, such as the Organisation for Economic Co-operation and Development (OECD) and the Food and Agriculture Organization of the United Nations (FAO), and to some national government agencies through the World Outlook Conference.

Under the Third Medium-Term Plan, JIRCAS built an econometric model, i.e., a middle-term non-equilibrium supply and demand model, to make projections related to agro-food products. An instruction manual was subsequently published, a copy of which can be downloaded from the AFSIS website (http://www.aptfsis.org/), to facilitate dissemination. [Topic 1].

The goal-oriented "Basic research with a view to developing technology seeds that will lead to future innovation" was recently launched under the Fourth Medium to Long-Term Plan. It tackles novel research ideas in the hope that the results of pure research may lead to technological innovation and creation of new businesses in the agricultural, forestry, fishery, and food industries. Five subjects were accepted as "goal-oriented basic research," among them the development of 'Sunny Shine,' a new passion fruit cultivar with lower acidity, which has already been registered with the Ministry of Agriculture, Forestry and Fisheries (MAFF) in Japan [Topic 2].

Under Program D, JIRCAS, as a representative of Japan on matters relating to information analysis, actively participated in several important meetings, including the 6th Tokyo International Conference on African Development (TICAD VI) in Kenya, the Global Conference on Agricultural Research for Development (GCARD3) in South Africa, and the 5th Meeting of G20 Agricultural Chief Scientists (G20 MACS) in China.

At TICAD VI, the launching of the Initiative for Food and Nutrition Security in Africa (IFNA) was mentioned by Prime Minister Shinzo Abe. JIRCAS joined its steering committee together with FAO and WHO, among others.

JIRCAS also participated in the activities of the Global Rice Science Partnership (GRiSP), a Consultative Group on International Agricultural Research (CGIAR) research program; the Wheat Initiative (WI); the Asia-Pacific Association of Agricultural Research Institutions (APAARI); and the Coalition for African Rice Development (CARD), playing an important role in contributing to technology development and in connecting related national and international stakeholders, as well as in building international consensus on agricultural development.

Furthermore, JIRCAS continuously gathered local information on agricultural research priorities in Southeast Asia and Africa (The World Agroforestry Centre [ICRAF]) by maintaining liaison offices in Thailand and Kenya, respectively. Regional representatives also attended various meetings and events to exchange ideas on current and future collaborations.

In addition, a staff member of JIRCAS was sent on a long-term assignment to the International

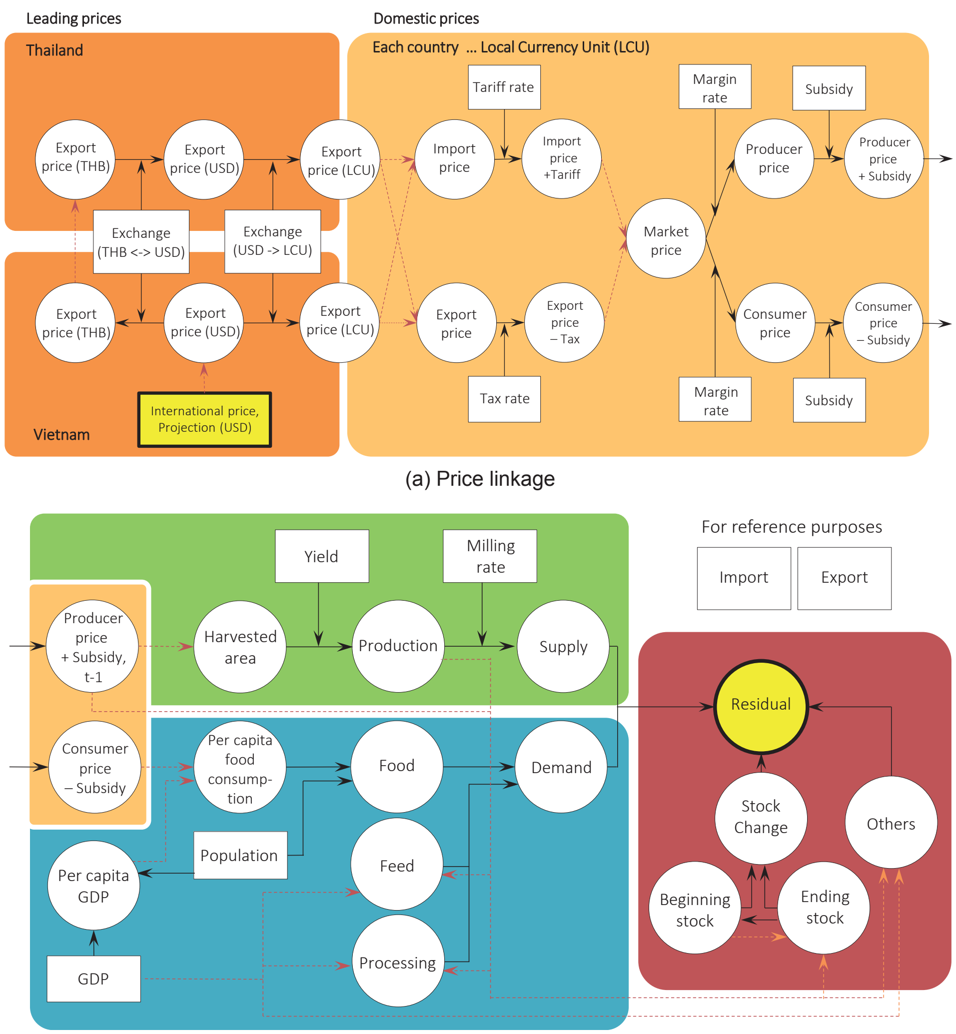
Renewable Energy Agency (IRENA) to assess the bio-energy supply potential of five Asian countries. Another staff member of JIRCAS was sent recently on a long-term assignment to the CGIAR System Management Office in France to promote partnership between international agricultural research institutes and JIRCAS.

Finally, to celebrate the auspicious occasion of the International Year of Pulses 2016, JIRCAS organized the JIRCAS International Symposium, titled "Legumes Improve Our Livelihood!" at the U Thant International Conference Hall, United Nations University, Tokyo, Japan on December 2, 2016.

TOPIC 1

Dissemination of a food commodity supply and demand model for ASEAN countries through an instruction manual

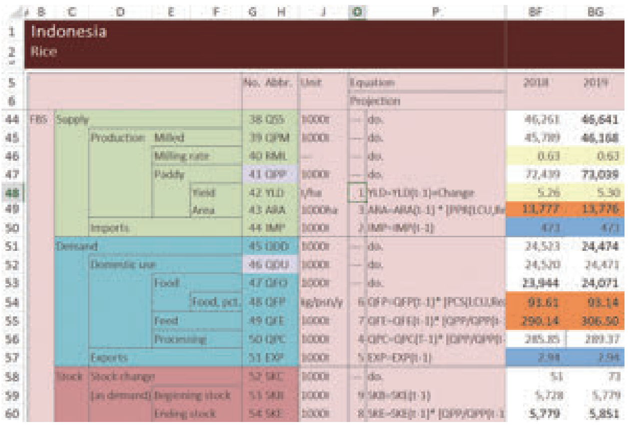
Future trends in food supply and demand have been gaining attention among ASEAN countries where agricultural trade liberalization is expected because of the establishment of the ASEAN Economic Community in 2015. In line with this, JIRCAS built an econometric model, i.e., a middle-term non-equilibrium supply and demand model, for making future projections related to agro-food products, and an instruction



(a) Price linkage

(b) Food balance sheet

Fig. 1. Conceptual diagram of the model (USD: US dollar, THB: Thai baht, LCU: Local currency unit)



					No.	Abbr.	Unit		Equation / Projection	2018	2019
1	Indonesia										
2	Rice										
44	FBS	Supply			38	QSS	1000t	—	do.	46,261	46,641
45			Production	Milled	39	QPM	1000t	—	do.	45,789	46,168
46				Milling rate	40	RML	—	—	do.	0.63	0.63
47				Paddy	41	QPP	1000t	—	do.	72,439	73,039
48				Yield	42	YLD	t/ha	1	YLD=YLD(t-1)+Change	5.26	5.30
49				Area	43	ARA	1000ha	3	ARA=ARA(t-1) * [PPR(LCU,Re	13,777	13,776
50			Imports		44	IMP	1000t	2	IMP=IMP(t-1)	473	473
51		Demand			45	QDD	1000t	—	do.	24,523	24,474
52			Domestic use		46	QDU	1000t	—	do.	24,520	24,471
53				Food	47	QFO	1000t	—	do.	23,944	24,071
54				Food, pct.	48	QFP	kg/prs/y	6	QFP=QFP(t-1)* [PCS(LCU,Re	93.61	93.14
55				Feed	49	QFE	1000t	7	QFE=QFE(t-1)* (QPP/QPP(t-	290.14	306.50
56				Processing	50	QPC	1000t	4	QPC=QPC(T-1)* (QPP/QPP(t-	285.85	289.37
57			Exports		51	EXP	1000t	5	EXP=EXP(t-1)	2.98	2.98
58		Stock	Stock change		52	SKC	1000t	—	do.	51	73
59			(as demand)	Beginning stock	53	SKB	1000t	9	SKB=SKE(t-1)	5,728	5,779
60				Ending stock	54	SKE	1000t	8	SKE=SKE(t-1)* (QPP/QPP(t-1	5,779	5,851

Fig. 2. Sample spreadsheet data and equations for the model

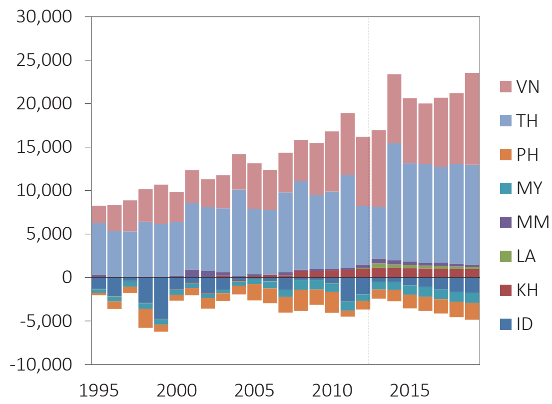


Fig. 3. Estimated surplus in rice supply (2012-2019) (1000t)

manual was subsequently published to facilitate dissemination. The know-how about the model had already been transferred to government officers in ASEAN countries through collaboration with the ASEAN Food Security Information System (AFSIS). The manual would be useful to officers, researchers, and students who are interested in understanding, building, and utilizing the model.

The manual contains the conceptual diagram (Fig. 1), the model structure expressed in an Excel worksheet (Fig. 2), and the projection results of the model (Fig. 3) as well as examples of scenario analyses. The non-equilibrium model in this manual does not presume equilibrium of food supply and demand in the domestic market, and would be the foundation for understanding more complicated models like the partial-equilibrium model often used by international organizations such as the Organization for Economic Cooperation and Development, Food and Agriculture Organization (OECD-FAO).

The manual shows how to use the model for policy evaluation and for comparative statics or welfare analysis. It also explained the basic concepts of econometrics required to develop the model including regression analysis, the adjusted coefficient of determination, and the standard error. In addition, for AFSIS project participants, the methods used to run the programs in developing and utilizing the model are further described.

The manual was published and disseminated to government staffs of ASEAN member states who participated in the project. It can also be downloaded from the AFSIS website (http://www.aptfsis.org/). It must be noted, however, that readers and users need to scrutinize the data and parameters in the manual, as these were collected and estimated by project participants. To produce better information from the analysis, provincial-level or more site-specific data should be used to build the model rather than the country-level model referenced in the manual. Furthermore, the model can be extended to partial-equilibrium models, where the effects of supply-demand balance on food prices are highlighted.

(E. Kusano, S. Shiratori, J. Furuya)

'Sunny Shine': A new passion fruit cultivar with low acidity and good appearance

In Japan, passion fruit (*Passiflora edulis*) ranks third in production among tropical fruits after pineapple and mango. It is produced mainly in the southern areas and consumed as fresh fruits, juice, and for processing. Some of the problems with fresh fruit consumption are immature fruit drop during periods of high temperature (above 30°C) and high acidity after harvest. All conventional cultivars that were examined had the same problem.

To cope with these problems, JIRCAS developed the new passion fruit cultivar 'Sunny Shine,' which produces fruits that have lower acidity and good appearance. It was selected from seedlings obtained from a cross between JTPF-009 and 'Summer Queen.' JTPF-009 is a variety with a non-abscising fruit while 'Summer Queen' is a major passion fruit cultivar in Japan. The fruit quality and cultural performance were evaluated until 2015. In 2016, the new cultivar was named 'Sunny Shine' and an application for registration was filed (application number: 30972) in accordance with The Plant Variety Protection and Seed Act of Japan.

The average fruit weight of 'Sunny Shine' is about 110g (Table 1). The fruit color is red-purple with a smooth and glossy skin (Fig. 1). The matured fruit juice brix is about 18. The acidity of matured fruit juice during high temperature season is 1.5 to 2.0%, which is much lower than that of 'Summer Queen' (>2.0%), though there is no difference in juice acidity during low temperature season. 'Sunny Shine' has less immature fruit drop than 'Summer Queen' during high temperature season resulting in good coloring of the skin (Fig. 3). Days from flowering to fruit drop is longer in 'Sunny Shine' than 'Summer Queen' (Table 1) probably because it partly inherited the non-abscising characteristic of JTPF-009, resulting in lower acidity and less immature fruit drop. However, the cultural performance of 'Sunny Shine' is quite different depending

Table 1. Characteristics of 'Sunny Shine' and 'Summer Queen' (2013-2015)

Month	Cultivar	Days from flowering to harvest	Yield (kg/tree)	Fruit weight (g)	Pulp & seed (%)	Brix	Acidity (%)	Sugar-acid ratio
5	Sunny Shine	62	0.27	131	43.1	17.3	3.4	5.2
	Summer Queen	64	1.38	117	46.6	18.0	2.9	6.7
6	Sunny Shine	65	2.00	113	48.3a	18.2	2.2a	8.7a
	Summer Queen	62	2.62	110	46.8b	18.4	2.8b	6.8b
7	Sunny Shine	76a	2.04a	109a	55.1a	16.9a	1.5a	11.8a
	Summer Queen	55b	1.11b	98b	46.8b	17.9b	2.3b	8.1b
8	Sunny Shine	98	0.38	110	54.4	15.5	1.5	10.8
	Summer Queen	-	-	-	-	-	-	-

a,b: Different letters indicate statistically significant differences ($p<0.05$)

Fig. 1. Mature fruits of 'Sunny Shine' (top) and 'Summer Queen' (bottom)

Fig. 2. Fruit cross sections of 'Sunny Shine' (left) and 'Summer Queen' (right)

Fig. 3. Mature fruit color of 'Sunny Shine' (top) and 'Summer Queen' (bottom) during high temperature period

on soil condition. The types of suitable soil and appropriate cultural management for growing 'Sunny Shine' are is under examination.

'Sunny Shine' is suitable for fresh fruit consumption because of its relatively large fruit size, good aroma, high brix, lower acidity during high temperature season, and glossy appearance. The development of this new cultivar with desirable traits will enhance production and consumption of passion fruit in Japan.

(T. Ogata, S. Yamanaka, H. Takagi, N. Kozai [National Agriculture and Food Research Organization], Y. Yonemoto [Yonetropics])

TRAINING AND INVITATION PROGRAMS

INFORMATION EVENTS

INVITATION PROGRAMS AT JIRCAS

In keeping with its role as an international research center, JIRCAS has implemented several invitation programs for foreign researchers and administrators at counterpart organizations. These programs facilitate the exchange of information and opinions on agriculture, forestry, and fisheries research. At the same time, their implementation and administration serve as an opportunity to strengthen research ties among scientists and administrators in participating countries, mostly in the developing regions. Current programs are described in detail below.

Administrative Invitation Program

Under the Administrative Invitation Program, JIRCAS invites administrators from counterpart organizations to its Tsukuba premises to engage in discussions and reviews of ongoing researches to ensure that collaborative projects run smoothly. In addition, the program exposes administrators to the current activities at JIRCAS and other MAFF-affiliated National Research and Development Agencies (NRDAs). Furthermore, the program provides opportunities for the exchange of information and opinions concerning policy-making and project design at the administrative level, thereby contributing to deeper mutual understanding and international collaboration. Sixty-four visits to JIRCAS were made during FY 2016 under the Administrative Invitation Program. Invited administrators and their home institutions are listed below.

Administrative Invitations, FY 2016		
Naruatai Warasatit	Office of Agricultural Research and Development Region 3, Department of Agriculture, Ministry of Agriculture and Cooperatives, Thailand	Aug. 30 - Sep. 3, 2016
Nilubon Taweekul	Office of Agricultural Research and Development Region 5, Department of Agriculture, Ministry of Agriculture and Cooperatives, Thailand	Aug. 30 - Sep. 3, 2016
Sumana Ngampongsai	Chainat Field Crop Research Center, Department of Agriculture, Ministry of Agriculture and Cooperatives, Thailand	Aug. 30 - Sep. 3, 2016
Aroonothat Sawwa	Biotechnology Research and Development Office, Department of Agriculture, Ministry of Agriculture and Cooperatives, Thailand	Aug. 30 - Sep. 3, 2016
Wacharee Wittayawannakul	Plant Protection Research and Development Office, Department of Agriculture, Ministry of Agriculture and Cooperatives, Thailand	Aug. 30 - Sep. 3, 2016
Jacqueline d'Arros Hughes	International Rice Research Institute (IRRI), Philippines	Sep. 6 - 10, 2016
Derake Tonpayom	Department of Agriculture, Ministry of Agriculture and Cooperatives, Thailand	Sep. 10 - 13, 2016
Werawat Nilrattanakoon	Office of Agricultural Research and Development Region 2, Department of Agriculture, Ministry of Agriculture and Cooperatives, Thailand	Sep. 10 - 13, 2016
Sukit Rattanasriwong	Office of Agricultural Research and Development Region 4, Department of Agriculture, Ministry of Agriculture and Cooperatives, Thailand	Sep. 10 - 13, 2016
Tattawin Saruno	Office of Agricultural Research and Development Region 8, Department of Agriculture, Ministry of Agriculture and Cooperatives, Thailand	Sep. 10 - 13, 2016
Phatchayaphon Meunchang	Agricultural Production Sciences Research and Development Division, Department of Agriculture, Ministry of Agriculture and Cooperatives, Thailand	Sep. 10 - 13, 2016

Administrative Invitations, FY 2016		
Manabu Ishitani	International Center for Tropical Agriculture (CIAT), Colombia	Sep. 10 - 21, 2016
Masahiro Kishii	International Maize and Wheat Improvement Center (CIMMYT), Mexico	Sep. 11 - 21, 2016
Victor Maurice Kommerell	International Maize and Wheat Improvement Center (CIMMYT), Mexico and c/o INRA (Paris), France	Sep. 12 - 17, 2016
Michael Peters	International Center for Tropical Agriculture (CIAT), Colombia	Sep. 12 -16, 2016
Joseph Tohme	International Center for Tropical Agriculture (CIAT), Colombia	Sep. 12 -17, 2016
Madhusudana Rao Idupulapati	International Center for Tropical Agriculture (CIAT), Colombia	Sep. 12 - 17, 2016
Bruno Guy E. Gerard	International Maize and Wheat Improvement Center (CIMMYT), Mexico	Sep. 12 - 17, 2016
Jose Ivan Monsterio Rosas	International Maize and Wheat Improvement Center (CIMMYT), Mexico	Sep. 12 - 17, 2016
Jean-Christophe Sebastie Frederic Lata	UPMC (Université Pierre et Marie Curie) - Paris, France	Sep. 12 - 16, 2016
Cristina Maria Nobre Sobral de Vilhena da Cruz Houghton	CE3C - Centre for Ecology, Evolution and Environmental Changes, Faculdade de Ciências da Universidade de Lisboa, Portugal	Sep. 12 - 16, 2016
Antony Mark Hooper	Rothamsted Research UK, United Kingdom	Sep. 12 - 16, 2016
Harvinder Singh Talwar	Indian Institute of Millets Research (IIMR), India	Sep. 12 - 16, 2016
Yiyong Zhu	Nanjing Agricultural University, PR China	Sep. 13 - 16, 2016
Ir. Mohammad Na'iem	Faculty of Forestry, Universitas Gadjah Mada, Indonesia	Oct. 16 - 22, 2016
Wei Qi	Department of Personnel, Chinese Academy of Agricultural Sciences (CAAS), PR China	Oct. 22 - 26, 2016
Dai Xiaofeng	Institute of Food Science and Technology (IFST), Chinese Academy of Agricultural Sciences (CAAS), PR China	Oct. 22 - 26, 2016
Wang Daolong	Institute of Agricultural Resources and Regional Planning (IARRP), Chinese Academy of Agricultural Sciences (CAAS), PR China	Oct. 22 - 26, 2016
Fang Jinbao	Zhengzhou Fruit Research Institute (ZFRI), PR China	Oct. 22 - 26, 2016
Ruan Jianyun	Tea Research Institute, Chinese Academy of Agricultural Sciences (CAAS), PR China	Oct. 22 - 26, 2016
Xu Ming	Bilateral Partnership, Department of International Cooperation, Chinese Academy of Agricultural Sciences (CAAS), PR China	Oct. 22 - 26, 2016
Kai-Yi Chen	National Taiwan University, Taiwan ROC	Nov. 23 - 26, 2016
Chih-Wei Tung	National Taiwan University, Taiwan ROC	Nov. 23 - 26, 2016
Kuo-Chen Yeh	Academia Sinica, Taiwan ROC	Nov. 23 - 26, 2016
Rong-Kuen Chen	Tainan District Agricultural Research & Extension Station, Taiwan ROC	Nov. 23 - 26, 2016
Huu-Sheng Lur	National Taiwan University, Taiwan ROC	Nov. 23 - 26, 2016
Wei-Huang Tsai	Council of Agriculture, Taiwan ROC	Nov. 23 - 26, 2016
Akio Takenaka	Food and Fertilizer Technology Center, Taiwan ROC	Nov. 23 - 26, 2016
Chungchi George Kuo	Food and Fertilizer Technology Center, Taiwan ROC	Nov. 23 - 26, 2016

Administrative Invitations, FY 2016		
Chung-Hsing Lee	Food and Fertilizer Technology Center, Taiwan ROC	Nov. 23 - 26, 2016
Roel R. Suralta	DA-Crop Biotechnology Center, Philippine Rice Research Institute, Philippines	Nov. 23 - 26, 2016
Mohd Shahril Firdaus Ab Razak	Malaysian Agricultural Research Development Institute, Malaysia	Nov. 23 - 26, 2016
Jirapong Jairin	Ubon Ratchathani Rice Research Center, Thailand	Nov. 23 - 26, 2016
Kenneth McNally	International Rice Research Institute, Philippines	Nov. 23 - 26, 2016
Dwinita Wikan Utami	Indonesian Center for Agricultural Biotechnology and Genomic Resources Research and Development, Indonesia	Nov. 23 - 26, 2016
David Jon Bergvinson	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India	Nov. 29 - Dec. 3, 2016
Robert Clement Abaidoo	College of Agriculture and Natural Resources, Kwame Nkrumah University of Science and Technology (KNUST), Ghana	Nov. 29 - Dec. 4, 2016
Girish Prasad Dixit	Indian Council of Agricultural Research (ICAR), Indian Institute of Pulses Research, India	Nov. 29 - Dec. 4, 2016
Md. Abu Bakr Siddique	Bangladesh Rice Research Institute, Bangladesh	Dec. 12 - 17, 2016
Md. Ismail Hossain	Bangladesh Rice Research Institute, Bangladesh	Dec. 12 - 17, 2016
Anna Maria Helene	Faculty of Landscape Management and Nature Conservation, University for Sustainable Development Eberswalde, Germany	Feb. 2 - 12, 2017
Zhao Minjuan	College of Economics and Management, Northwest Agriculture and Forestry University, PR China	Feb. 13 - 18, 2017
Patcharee Tungtrakul	Institute of Food Research and Product Development (IFRPD), Kasetsart University, Thailand	Feb. 12 - 18, 2017
Jean Kinsey	Department of Applied Economics University of Minnesota, United States of America	Feb. 15 - 19, 2017
Nguyen Thi Minh Nguyet	Agricultural Genetic Institute (AGI), Vietnam	Feb. 28 - Mar. 5, 2017
Jonathan Manito Niones	Philippine Rice Research Institute (PhilRice), Philippines	Feb. 28 - Mar. 5, 2017
Thelma Padolina	Philippine Rice Research Institute (PhilRice), Philippines	Feb. 28 - Mar. 5, 2017
Aris Hairmansis	Indonesian Center for Rice Research (ICRR), Indonesia	Feb. 28 - Mar. 5, 2017
Suwarno	Indonesian Center for Rice Research (ICRR), Indonesia	Feb. 28 - Mar. 5, 2017
Mohammad Ashik Iqbal Khan	Bangladesh Rice Research Institute (BRRI), Bangladesh	Feb. 28 - Mar. 5, 2017
Emmanuel N. Compaore	Institute of Environment and Agricultural Research (INERA), Burkina Faso	Mar. 24 - 31, 2017
Albert Barro	Institute of Environment and Agricultural Research (INERA), Burkina Faso	Mar. 24 - 31, 2017
Samuel Bénéwendé Neya	Institute of Environment and Agricultural Research (INERA), Burkina Faso	Mar. 24 - 31, 2017
Teyoure Benoît Joseph Batieno	Institute of Environment and Agricultural Research (INERA), Burkina Faso	Mar. 24 - 31, 2017

Counterpart Researcher Invitation Program

The Counterpart Researcher Invitation Program provides invitations for periods of up to six months to researchers engaged in collaborative work with JIRCAS research staff. Counterparts conduct in-depth research at JIRCAS, at other MAFF-affiliated NRDAs, at prefectural research institutes, or at national universities. This invitation program aims to enhance the quality of research conducted overseas and to facilitate exchanges of individual research staff between JIRCAS and the counterpart institutions. Eighteen researchers were invited under this program during FY 2016. Invited researchers, their affiliated research organizations, and their research activities are summarized below.

Counterpart Researcher Invitations, FY 2016

Sirilak Baramee	School of Bioresources and Technology, King Mongkut's University of Technology Thonburi, Thailand	Study on the molecular cloning of the genes encoding for multienzyme complex subunits from novel cellulolytic *Clostridium sp. A7*	Jul. 11 - Oct. 14, 2016
Natra Joseph Stalin	School of Industrial Technology, Universiti Sains Malaysia, Malaysia	Study on the preparation of RNA and protein from sugar accumulated oil palm trunks	Aug. 7 - Nov. 30, 2016
Motaher Hossain	Plant Pathology Department, Bangabandhu Sheikh Mujibur Rahman Agricultural University, Bangladesh	Investigation of pathogenic variation of Asian soybean rust pathogen in Bangladesh	Aug. 29 - Oct. 28, 2016
Nese Sreenivasulu	International Rice Research Institute, IRRI, Philippines	Participation and presentation at the IRRI-JIRCAS-NARO joint symposium "Towards Achieving Sustainable Rice Production in Asia" held at the International Congress Center in Tsukuba City	Sep. 6 - 10, 2016
Buyung Asmara Ratna Hadi	International Rice Research Institute, IRRI, Philippines	Participation and presentation at the IRRI-JIRCAS-NARO joint symposium "Towards Achieving Sustainable Rice Production in Asia" held at the International Congress Center in Tsukuba City	Sep. 6 - 10, 2016
Hei Leung	International Rice Research Institute, IRRI, Philippines	Participation and presentation at the IRRI-JIRCAS-NARO joint symposium "Towards Achieving Sustainable Rice Production in Asia" held at the International Congress Center in Tsukuba City	Sep. 6 - 10, 2016
George Paul Kotch	International Rice Research Institute, IRRI, Philippines	Participation and presentation at the IRRI-JIRCAS-NARO joint symposium "Towards Achieving Sustainable Rice Production in Asia" held at the International Congress Center in Tsukuba City	Sep. 6 - 10, 2016
Charles Ogugua Nwuche	Department of Microbiology University of Nigeria, Nigeria	Study on "The ethanol production from cassava wastes by fermentation using thermotolerant yeast, *Issatochenkia orientalis*"	Sep. 10 - Dec. 9, 2016

Counterpart Researcher Invitations, FY 2016			
Jacobo Arango Mejia	International Center for Tropical Agriculture (CIAT), Colombia	Participation and presentation at the "2nd International Biological Nitrification Inhibition (BNI) symposium" 14th – 15th September 2016 at the Epochal Conference Hall, International Congress Center in Tsukuba City	Sep. 12 - 16, 2016
Santosh Pandurang Deshpande	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India	Participation and presentation at the "2nd International Biological Nitrification Inhibition (BNI) symposium" 14th – 15th September 2016 at the Epochal Conference Hall, International Congress Center in Tsukuba City	Sep. 12 - 16, 2016
Kazuki Saito	Africa Rice Center, Cote d'Ivore	Development of the international collaborative research strategy about the value chain construction of rice	Jan. 5, 2017 - Jan. 4, 2020
Phonevilay Sinavong	Planning and Cooperation Division, National Agriculture and Forestry Research Institute, Lao PDR	Participation in the workshop and series of meetings for the research project "Diversity Research Environment Realization Initiative- International Collaborative Research by Female Researchers"	Feb. 12 - 18, 2017
Zhou Lin	Institute of Food and Nutrition Development, Ministry of Agriculture, PR China	Participation in the workshop and series of meetings for the research project "Diversity Research Environment Realization Initiative- International Collaborative Research by Female Researchers"	Feb. 13 - 18, 2017
Prapinwadee Sirisupluxana	Department of Agricultural and Resource Economics Faculty of Economics, Kasetsart University, Thailand	Participation in the workshop and series of meetings for the research project "Diversity Research Environment Realization Initiative-International Collaborative Research by Female Researchers"	Feb. 13 - 18, 2017
Jichun Wang	Institute of Plant Protection (IPP) Jilin Academy of Agricultural Sciences(JAAS), P. R. China	Virulence analysis of rice blast fungus isolates and screening of standard differential blast isolates for identification of resistance gene(s) in rice germplasms and clarification of genetic mechanism of resistance in rice cultivar	Mar. 1 - Aug. 31, 2017
Qingyu Wang	Department of Plant Science, Jilin University, PR China	Participation in a series of meetings and visit to relevant research organizations for the collaborative project "Development of soybean breeding materials adapted to adverse environments"	Mar. 16 - Apr. 15, 2017
Buruh Abebe Tetemke	College of Dryland Agriculture and Natural Resources Management, Mekelle University, Ethiopia	Conduct of research on fragmentation problems of exclosures and the need for ecological networking in Hagereselam, Northern Ethiopia	Mar. 18 - 31, 2017
Eveline Marie Fulbert Windinmi Compaore	Institute of Environment and Agricultural Research (INERA), Burkina Faso	Participation in a series of meetings for the collaborative project "Understanding of cowpea's role in farmers' household and nutritional supply"	Mar. 22 - 31, 2017

Project Site Invitation Program

In FY 2007, JIRCAS launched this invitation program to invite researchers from developing countries to the project sites in developing countries where JIRCAS researchers are engaged in JIRCAS-funded collaborative research activities on various research themes relevant to the projects on site, and other countries where workshops or planning meetings are held. Twenty-nine invited researchers implemented their programs during FY 2016 as listed below.

Project Site Invitations, FY 2016

Antonio Juan Gerardo Ivancovich	Estación Experimental Agropecuaria Pergamino, Instituto Nacional de Tecnología Agropecuaria (INTA-EEA Pergamino), Argentina	Kick-off meeting on "Development of resistant varieties of soybean to rust and other diseases" at IPTA-CICM, Capitan Miranda, Paraguay	Jul. 26 - 28, 2016
Adrian Dario de Lucia	Estación Experimental Agropecuaria Cerro Azul, Instituto Nacional de Tecnologia Agropecuaria (INTA-EEA)-Cerro Azul, Argentina	Kick-off meeting on "Development of resistant varieties of soybean to rust and other diseases" at IPTA-CICM, Capitan Miranda, Paraguay	Jul. 27, 2016
Monica Isabel Heck	Annual Crops Department, Estación Experimental Agropecuaria-Cerro Azul, Instituto Nacional de Tecnologia Agropecuaria (INTA-EEA Cerro Azul), Argentina	Kick-off meeting on "Development of resistant varieties of soybean to rust and other diseases" at IPTA-CICM, Capitan Miranda, Paraguay	Jul. 27, 2016
Miori Uno Shimakawa	Fundacion Nikkei-Cetapar (Cetapar), Paraguay	Kick-off meeting on "Development of resistant varieties of soybean to rust and other diseases" at IPTA-CICM, Capitan Miranda, Paraguay	Jul. 26 - 28, 2016
Silvina Stewart	Instituto Nacional de Investigacion Agropecaria (INIA) - La Estanzuela, Uruguay	Kick-off meeting on "Development of resistant varieties of soybean to rust and other diseases" at IPTA-CICM, Capitan Miranda, Paraguay	Jul. 26 - 28, 2016
Nicolas Maldonado Moreno	Las Huastecas Experimental Station, National Institute of Forestry, Agricultural, and Livestock Research (INIFAP), Mexico	Kick-off meeting on "Development of resistant varieties of soybean to rust and other diseases" at IPTA-CICM, Capitan Miranda, Paraguay	Jul. 25 - 29, 2016
Miguel Lavilla	UNNOBA (National University of Northwest Buenos Aires) - Pergamino, Argentina	Kick-off meeting on "Development of resistant varieties of soybean to rust and other diseases" at IPTA-CICM, Capitan Miranda, Paraguay	Jul. 26 - 28, 2016
Alias bin Man	Department of Fisheries, Malaysia	Kick-off meeting on "Development of technologies for sustainable aquatic production in harmony with tropical ecosystems," Thailand	Sep. 26 - 28, 2016
Masazurah binti A. Rahim	Impact Assessment Division, Fisheries Research Institute Batu Maung, Malaysia	Kick-off meeting on "Development of technologies for sustainable aquatic production in harmony with tropical ecosystems," Thailand	Sep. 26 - 28, 2016
Kaviphone Phouthavong	Living Aquatic Resource Research Center (LARReC), Lao PDR	Kick-off meeting on "Development of technologies for sustainable aquatic production in harmony with tropical ecosystems," Thailand	Sep. 26 - 28, 2016

Project Site Invitations, FY 2016			
Aloun Kounthongbang	Living Aquatic Resource Research Center (LARReC), Lao PDR	Kick-off meeting on "Development of technologies for sustainable aquatic production in harmony with tropical ecosystems," Thailand	Sep. 26 - 28, 2016
Roger Edward P. Mamauag	Southeast Asian Fisheries Development Center/Aquaculture Department, Philippines	Kick-off meeting on "Development of technologies for sustainable aquatic production in harmony with tropical ecosystems," Thailand	Sep. 26 - 28, 2016
Nyo Nyo Tun	Marine Science Department, Myeik University, Myanmar	Kick-off meeting on "Development of technologies for sustainable aquatic production in harmony with tropical ecosystems," Thailand	Sep. 25 - 29, 2016
Nguyen Thi Minh Nguyet	Agricultural Genetics Institute, Vietnam	Participation in the workshop for JIRCAS Blast Research Network and the 7th International Rice Blast Conference, Philippines	Oct. 9 - 14, 2016
Mohammed Abdul Latif	Bangladesh Rice Research Institute (BRRI), Bangladesh	Participation in the workshop for JIRCAS Blast Research Network and the 7th International Rice Blast Conference, Philippines	Oct. 9 - 14, 2016
Aris Hairmansis	Indonesian Center for Rice Research (ICRR), Indonesia	Participation in the workshop for JIRCAS Blast Research Network and the 7th International Rice Blast Conference, Philippines	Oct. 9 - 14, 2016
Jonathan M. Niones	Philippines Rice Research Institute (PhilRice), Philippines	Participation in the workshop for JIRCAS Blast Research Network and the 7th International Rice Blast Conference, Philippines	Oct. 9 - 14, 2016
Jennifer Tagubase Niones	Philippines Rice Research Institute (PhilRice), Philippines	Participation in the workshop for JIRCAS Blast Research Network and the 7th International Rice Blast Conference, Philippines	Oct. 9 - 14, 2016
Li Chengyun	Yunnan Agricultural University, PR China	Participation in the workshop for JIRCAS Blast Research Network and the 7th International Rice Blast Conference, Philippines	Oct. 9 - 14, 2016
Bounthong Bouahom	National Agriculture and Forestry Research Institute, Lao PDR	Attendance to the Inception Workshop of JIRCAS-NAFRI-NUOL collaborative projects, Lao PDR	Oct. 27, 2016
Lien Thikeo	Ministry of Agriculture and Forestry, Lao PDR	Attendance to the Inception Workshop of JIRCAS-NAFRI-NUOL collaborative projects, Lao PDR	Oct. 27, 2016
Somsy Gnorphanxay	National University of Laos, NUOL, Lao PDR	Attendance to the Inception Workshop of JIRCAS-NAFRI-NUOL collaborative projects, Lao PDR	Oct. 27, 2016
Yusuke Murakami	JICA Laos Office, Lao PDR	Attendance to the Inception Workshop of JIRCAS-NAFRI-NUOL collaborative projects, Lao PDR	Oct. 27, 2016

Project Site Invitations, FY 2016			
Ambassador Takeshi Hikihara	Embassy of Japan, Lao PDR	Attendance to the Inception Workshop of JIRCAS-NAFRI-NUOL collaborative projects, Lao PDR	Oct. 27, 2016
Erdiman	Assessment Center for Agricultural Technology, West Sumatra Office, Agency of Agricultural Research and Development, Ministry of Agriculture, Indonesia	Attendance to the meetings for the project on the "Improvement of irrigation water productivity for paddy rice production by means of SALIBU ratoon technology in CDZ, Myanmar"	Oct. 29 - Nov. 5, 2016
Resfa Fitri Amir	Directorate of Agricultural Irrigation, Directorate General of Agricultural Infrastructure and Facilitites, Ministry of Agriculture, Indonesia	Attendance to the meetings for the project on the "Improvement of irrigation water productivity for paddy rice production by means of SALIBU ratoon technology in CDZ, Myanmar"	Oct. 30 - Nov. 5, 2016
Erdiman	Assessment Center for Agricultural Technology, West Sumatra Office, Agency of Agricultural Research and Development, Ministry of Agriculture, Indonesia	Participation in a series of meetings for the project on the "Improvement of irrigation water productivity for paddy rice production by means of SALIBU ratoon technology in CDZ, Myanmar" at the Department of Agricultural Research (DAR), Nay Pyi Taw, Myanmar	Jan. 24 - Feb. 1, 2017
Resfa Fitri Amir	Faculty of Economics and Management, Bogor Agricultural University, Indonesia	Participation in a series of meetings for the project on the "Improvement of irrigation water productivity for paddy rice production by means of SALIBU ratoon technology in CDZ, Myanmar" at the Department of Agricultural Research (DAR), Nay Pyi Taw, Myanmar	Jan. 24 - Feb. 1, 2017
Alejandro Bonifacio	Fundacion PROINPA, La Paz, Bolivia	Participation in project meetings and on-site survey to collect information for future collaborative project on quinoa breeding and related interdisciplinary studies to improve health and nutrition in poor farming communities in Bolivia	Feb. 22 - 23, 2017

FELLOWSHIP PROGRAMS AT JIRCAS

JIRCAS Visiting Research Fellowship Program at Tsukuba and Okinawa

The current JIRCAS Visiting Research Fellowship Program has its beginnings in FY 1992 with the launching of the JIRCAS Visiting Research Fellowship Program at Okinawa under which researchers are invited to conduct research on topics relating to tropical agriculture for a period of one year at the Tropical Agriculture Research Front (TARF, formerly Okinawa Subtropical Station). Since October 1995, a similar program (JIRCAS Visiting Research Fellowship Program at Tsukuba) has been implemented at JIRCAS's Tsukuba premises, aiming to promote collaborative researches that address various problems confronting countries in the developing regions. In FY 2006, these fellowship programs were modified and merged into one. In FY 2016, a total of three researchers were invited to conduct research at JIRCAS HQ and one researcher was invited to conduct research at JIRCAS TARF.

JIRCAS Visiting Research Fellowship at Tsukuba (October 2016 - September 2017)			
Pradipta Ranjan Pradhan	Innovation Systems for the Drylands International Crops Research Institute for the Semi-Arid Tropics, India	Evaluation of relationship between sorgoleone release ability from root system of sorghum and the suppression of nitrous oxide (N_2O) emission in soil	Oct. 3, 2016 - Sep. 30, 2017
Phakhinee Thianheng	Department of Food Business Management University of the Thai Chamber of Commerce, Thailand	Study on lignocellulose degradation ability by novel alkali-thermophilic anaerobic bacteria *Clostridium sp. A7*	Oct. 3, 2016 - Sep. 30, 2017
Yongliang Yan	Innovation and Utilization of Crop Germplasm Resources, Institute of Crop Germplasm Resources, Xinjiang Academy of Agricultural Sciences, PR China	Identification of gene(s) controlling root development in soybean	Oct. 24, 2016 - Sep. 30, 2017

JIRCAS Visiting Research Fellowship Program at Project Sites

This fellowship program has been implemented since May 2006 at collaborating research institutions located in developing countries where collaborative researches are being carried out by JIRCAS researchers. It aims to promote the effective implementation of ongoing collaborative researches at the project sites through the participation of local research staff. Furthermore, through this fellowship program, JIRCAS intends to contribute to capacity-building of the collaborating research institutions. In FY 2016, one researcher was invited to Madagascar. The fellow and his research subject are listed below.

For inquiries on the JIRCAS Visiting Research Fellowship Program, please contact the International Relations Section (Tel. +81-29-838-6336; Fax +81-29-838-6337; e-mail: irs-jircas@ml.affrc.go.jp)

JIRCAS Visiting Research Fellowship at Okinawa (October 2016 - September 2017)			
Burhanuddin Rasyid	Department of Soil Science, Faculty of Agriculture, Hassanudin University, Indonesia	Development of sustainable cropping and manuring technologies with utilization of lysimeter in Okinawa	Oct. 2, 2016 - Sep. 30, 2017

JIRCAS Visiting Research Fellowship at Project Site (October 2016 - September 2017)			
Tovohery Rakotoson	Association Centre De Recherche (FADES), Madagascar	P dynamics in the rice-soil system as affected by the integrated application of mineral P fertilizer and organic manure under P-deficient soils in the tropics	Oct. 1, 2016 - Sep. 30, 2017

Other Fellowships for Visiting Scientists

The Government of Japan sponsors a postdoctoral fellowship program and a researcher exchange program for foreign scientists through the Japan Society for the Promotion of Science (JSPS). The program places post-doctoral and sabbatical fellows in national research institutes throughout Japan according to research theme and prior arrangement with host scientists, for terms of generally one month to three years. Fellowships can be undertaken in any of the ministries, and many fellows are currently working at various NRDAs affiliated with MAFF. The visiting scientists who resided at JIRCAS in FY2016 are listed below.

JSPS Postdoctoral Fellowship for Overseas Researchers (April 2016 to March 2017)			
Amrit Kaur Nanda	Australian National University, Australia	Characterizing candidate genes to improve rice performance on zinc-deficient soils	Sep. 8, 2014 - Sep. 7, 2016
Vincent Pujol	Australian National University, Australia	Influence of the rhizosphere and root microbiome on phosphorus uptake in rice	Sep. 8, 2014 - Sep. 7, 2016
Mohammad Ashik Iqbal Khan	Bangladesh Rice Research Institute, Bangladesh	Study for co-differentiation of blast races and resistance genes in rice	Nov. 1, 2014 - Oct. 31, 2016
Hsiang-Yin Chen	University of North Carolina Wilmington, USA	Shrimp reproduction, the roles of stimulatory hormones, and new aquaculture technology	Jul. 1, 2015 - Jun. 30, 2017
Clement N. Bardon	Claude Bernard University Lyon 1, France	Characterization of the biological nitrification inhibition (BNI) function in *Sorghum bicolor*	Aug. 1, 2016 - April 29, 2017

JSPS Invitation Fellowship for Research in Japan (April 2016 to March 2017)			
Short-Term			
Asad Jan	The University of Agriculture, Peshawar, Pakistan	Functional analysis of stress-responsive genes encoding CCCH-type zinc-finger proteins in rice	Jun. 30, 2016 - Aug. 29, 2016

WORKSHOP

Inception Workshop of JIRCAS-NAFRI-NUOL Collaborative Projects from 2016 to 2021

On October 27, 2016, an inception workshop was held at Lao Plaza Hotel, Vientiane, Lao PDR, aimed at synergizing inter-agency efforts and ensuring the success of JIRCAS's Value-adding Technologies Program (Program C) under its newly launched Fourth Medium to Long-Term Plan (FY 2016-2020). The gathering, titled "Inception Workshop of JIRCAS, NAFRI (National Agriculture and Forestry Research Institute, Laos), and NUOL (National University of Laos) Collaborative Projects from 2016 to 2021," discussed the following research projects, namely, "Food value chain," "Multiple use of regional resources in semi-mountainous villages," "Higher value forestry," and "Aquatic production in tropical areas."

The workshop was attended by Dr. Thongphat Vongmany, Ministry of Agriculture and Forestry (MAF) Vice-Minister; H. E. Mr. Takeshi Hikihara, Japanese Ambassador to Laos; Dr. Bounthong Bouahom, NAFRI Director General; Prof. Somsy Gnorphanxay, NUOL President; and Dr. Masa Iwanaga, JIRCAS President. In total, 72 researchers and officers from NAFRI, NUOL, and JIRCAS joined the workshop, and they actively exchanged views about the planned activities and future prospects of the above-mentioned collaborative projects.

The workshop was covered by the Vientiane Times, which reported the day after in a news article, entitled "Agricultural research in remote areas to be extended," that the collaborative research projects had generated high interest and anticipation from Laotian counterparts.

Participants of the inception workshop

From left to right: Dr. Bounthong Bouahom, NAFRI Director General; Prof. Somsy Gnorphanxay, NUOL President; Dr. Thongphat Vongmany, MAF Vice-Minister; H. E. Mr. Takeshi Hikihara, Japanese Ambassador to Laos; and Dr. Masa Iwanaga, JIRCAS President

JIRCAS Diversity Project
"Workshop on Initiative for Realizing Diversity for International Agricultural Research"

The implementation of the JIRCAS Diversity Project, an initiative that promotes gender equality and the activities of female researchers, has started this financial year. A workshop was organized by JIRCAS, supported by the "Funds for the Development of Human Resources in Science and Technology," a program under the "Initiative for Realizing Diversity in the Research Environment" of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan. The institutions selected to participate included the Tokyo University of Agriculture and Technology (TUAT), the Tokyo University of Foreign Studies (TUFS), the Greater Tokyo Initiative (TAMA), and JIRCAS.

The workshop, among the many activities lined up to achieve the goals of the Diversity Project, was held in Okura Frontier Hotel Tsukuba on February 16, 2017, with JIRCAS President Masa Iwanaga giving an opening speech and guests speakers from the USA's University of Minnesota, Thailand's Kasetsart University, China's Northwest A&F University and Institute of Food and Nutrition Development, and Lao PDR's National Institute of Agriculture and Forestry Research sharing their views and experiences. A total of 56 participants gathered at the venue, including staff from JIRCAS, researchers and students from TUAT, TUFS, TAMA, Tsukuba University, The University of Tokyo, Chiba University, and other institutes.

The workshop consisted of two parts: The first program focused on "work-life balance" and "career advancement" issues for women researchers, and the second one, on the JIRCAS project titled "Value chain of local food and consumers' needs." In the first program, two experts, Professors Jean Kinsey and Patcharee Tungtrakul, talked about attitudes and their experiences as female researchers. The second program, on the other hand, highlighted JIRCAS's ongoing international research project which, incidentally, is being managed by a female project leader. There were two keynote speeches on food value chain analysis and four country reports from project counterparts. In summary, the whole workshop, which was filled with lively discussions, was very helpful to female researchers and was a meaningful activity for research exchange.

International Symposiums and Workshops, FY 2016			
1	Technical Committee Meeting on the “Maintenance Survey for the Promotion and Diffusion of Rice Cultivation in Africa”	June 7, 2016	Tamale, Ghana
2	Kick-off Meeting for the research on “Development of a watershed management model in the Central Plateau, Burkina Faso”	June 17, 2016	Ouagadougou, Burkina Faso
3	Kick-off Meeting of the JIRCAS-CTU Climate Change Project 2016-2020	June 30, 2016	Can Tho, Viet Nam
4	First Steering Committee Meeting of the JIRCAS-RFD Joint Project on “Efficient silvicultural practices for promoting teak plantation”	July 1, 2016	Bangkok, Thailand
5	Kick-off Meeting for the research on “Forest and Farmland Conservation for Watershed Management in the Ethiopian Highlands”	July 5, 2016	Mekele, Ethiopia
6	Kick-off Meeting on “Development of soybean varieties resistant to Asian soybean rust and other soybean diseases”	July 27, 2016	Capitán Miranda, Paraguay
7	International Symposium on “Dairy Cattle Beef Up Beef Industry in Asia: Improving Productivity and Environmental Sustainability”	August 19, 2016	Bangkok, Thailand
8	Satellite Workshop on “Mitigation of Greenhouse Gases and Adaptation to Climate Change in Livestock Production Systems”	August 23, 2016	Fukuoka, Fukuoka, Japan
9	A Special Event in Connection with TICAD VI: “The Future of Wood-Based Energy”	August 25, 2016	Nairobi, Kenya
10	A Special Event in Connection with TICAD VI: “The Promotion of Forest and Landscape Restoration in Africa”	August 26, 2016	Nairobi, Kenya
11	IRRI-JIRCAS-NARO Joint Symposium: “Towards Achieving Sustainable Rice Production in Asia”	September 7-8, 2016	Tsukuba, Ibaraki, Japan
12	2nd International BNI Symposium 2016	September 14-15, 2016	Tsukuba, Ibaraki, Japan
13	Kick-off Meeting on “Development of Technologies for Sustainable Aquatic Production in Harmony with Tropical Ecosystems”	September 27, 2016	Bangkok, Thailand
14	Initiative for the Implementation of the Diversity Research Environment (Presentation of research seeds by female researchers)	October 7, 2016	Nakano-ku, Tokyo, Japan
15	JIRCAS Workshop on “Disease management and breeding” at the 7th International Rice Blast Conference	October 12, 2016	Manila, Philippines
16	IRRI-JIRCAS Workshop on “Development of breeding materials and basic breeding technologies for highly productive rice adaptive to environments”	October 14, 2016	Los Baños, Philippines
17	Inception Workshop for the JIRCAS-NAFRI-NUOL Collaborative Projects from 2016 to 2021	October 27, 2016	Vientiane, Laos
18	FFTC-JIRCAS-NARO Seminar on “Advanced Breeding Methods for Stress-tolerant Food Crops”	November 24-25, 2016	Tsukuba, Ibaraki, Japan

International Symposiums and Workshops, FY 2016			
19	JIRCAS International Symposium 2016: Legumes Improve Our Livelihood!	December 2, 2016	Shibuya-ku, Tokyo, Japan
20	Annual Meeting of the 2016 GM Drought Tolerance Project	December 9, 2016	Tsukuba, Ibaraki, Japan
21	Workshop on Integrated Multi-Trophic Aquaculture (IMTA): "Small-holder IMTA for Sustainable Coastal Livelihood Development : Technology, constraints & prospects"	December 13-14, 2016	Iloilo, Philippines
22	JIRCAS Diversity Project International Workshop: "Workshop on Initiative for Realizing Diversity for International Agricultural Research"	February 16, 2017	Tsukuba, Ibaraki, Japan
23	MOFA-KNUST-JIRCAS Study on Improvement of Micro Reservoir Technologies for Enhancement of Rice Production in Africa (IMRT for Rice): Technical Committee Meeting on the "Maintenance Survey for the Promotion and Diffusion of Rice Cultivation in Africa"	February 28, 2017	Tamale, Ghana
24	MOFA-KNUST-JIRCAS Study on Improvement of Micro Reservoir Technologies for Enhancement of Rice Production in Africa (IMRT for Rice): Seminar on the "Supplementary Irrigation Manual for Rice Production Using Small Reservoirs"	March 1, 2017	Tamale, Ghana
25	Workshop: JIRCAS Blast Research Network	March 2-3,2017	Ishigaki, Okinawa, Japan
26	Kickoff Symposium for the Creation and Nationwide Development of the "Kanto Platform" to Promote the Activities of Female Researchers	March 10, 2017	Chiyoda-ku, Tokyo, Japan
27	Workshop: JIRCAS Research on Measures against Salinization	March 13, 2017	Tashkent, Uzbekistan
28	Farmer Workshop: Application of a water-saving technology for mitigating GHG emissions	March 17, 2017	Can Tho, Viet Nam
29	JIRCAS-CTU Climate Change Project Workshop FY2016	March 23, 2017	Can Tho, Viet Nam
30	Seminar on INERA-JIRCAS Collaborative Research for Sustainable Agricultural Development in Burkina Faso	March 28, 2017	Tsukuba, Ibaraki, Japan

APPENDIX

PUBLISHING AT JIRCAS

English

1) JARQ (Japan Agricultural Research Quarterly)		
	Vol. 50 No. 3, No. 4	
	Vol. 51 No. 1, No. 2	
2) Annual Report 2015		
3) JIRCAS Newsletter	No.79, No.80, No.81	
4) JIRCAS Working Report Series	No. 85	Improvement of Utilization Techniques of Forest Resources to Promote Sustainable Forestry in Thailand

Japanese

1) JIRCAS News	No.79, No.80, No.81

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(J) Denotes articles written in Japanese; (C) Denotes articles written in Chinese
Underline indicates researcher at JIRCAS
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FOURTH MEDIUM TO LONG-TERM PLAN OF THE JAPAN INTERNATIONAL RESEARCH CENTER FOR AGRICULTURAL SCIENCES

The Japan International Research Center for Agricultural Sciences (JIRCAS) has been helping improve technologies for agriculture, forestry, and fisheries in tropical and subtropical areas, as well as in other overseas developing regions (hereinafter referred to as “developing regions”), by performing technical trials and research.

During the First Medium-Term Goal period (FY 2001 to 2005), JIRCAS worked on research and development (R&D) for the sustainable development of agriculture, forestry, and fisheries, as well as on the expansion of international research exchanges and networks, taking into account both domestic and overseas situations, such as the adoption of the United Nations Millennium Development Goals for the eradication of poverty and hunger in the world.

During the Second Medium-Term Goal period (FY 2006 to 2010), JIRCAS created a multilateral collaborative research system, promoted collaborative research with world-class research organizations led by the Consultative Group on International Agricultural Research (CGIAR), established a dynamic research system, and implemented major research projects. In FY 2008, JIRCAS took over international activities from the dissolved Japan Green Resources Agency and strengthened its field activities.

During the Third Medium-Term Goal period (FY 2011 to 2015), a program/project scheme was developed for three principal research areas: environment and natural resource management; stable food production; and livelihood improvement of the rural population. In addition, flagship projects to which research resources were intensively allocated were set up to promote research. Furthermore, systems were developed to strengthen the process of disseminating research results and ensuring the safe management of experimental materials.

On the basis of the outcomes of JIRCAS’s commitments and in accordance with the Basic Plan for Agriculture, Forestry and Fisheries Research (determined at the meeting of the Agriculture, Forestry and Fisheries Research Council on March 31, 2015), three principal research areas have been identified for the Medium to Long-Term Goal period, namely: (1) development of agricultural technologies for sustainable management of the environment and natural resources in developing regions; (2) technology development for stable production of agricultural products in the tropics and other adverse environments; and (3) development of high value-adding technologies and utilization of local resources in developing regions. Resources will be allocated to these research areas on a priority basis, and innovations in research management will be promoted to maximize R&D outcomes. To best understand the needs and seeds of technological development in developing regions and to promote R&D in line with Japan’s policy, JIRCAS will strengthen its capability related to the collection, analysis, and dissemination of information on international agriculture, forestry, and fisheries.

Through this series of activities, JIRCAS, as Japan’s only research institution mandated to carry out comprehensive international research in agriculture, forestry, and fisheries, is committed to strengthening the framework of collaboration with related organizations and to play a key role in R&D targeting developing regions. In this way, it will help solve global food problems and sophisticate Japan’s research in agriculture, forestry, and fisheries.

I. Improving the Quality of Operations, Including Maximizing R&D Outcomes

JIRCAS will promote and evaluate the following five operational items as individual segments:

i. Promotion of research planning and partnership [1 to 5]
ii. Development of agricultural technologies for sustainable management of the environment and natural resources in developing regions [6(1); Attachment 1]
iii. Technology development for stable production of agricultural products in the tropics and other adverse environments [6(1); Attachment 2]
iv. Development of high value-adding technologies and utilization of local resources in developing regions [6(1); Attachment 3]
v. Collection, analysis, and dissemination of information to understand trends in international agriculture, forestry and fisheries [6(2)]

(Note) Notations within the above square brackets indicate subsections relevant to each item of operation.

<Promotion of research planning and partnership >

1. Promotion of research in line with government policy and enhancement of the PDCA (Plan, Do, Check, Action) cycle

(1) Strategic promotion of research in line with government policy

a) JIRCAS will identify research subjects and research promotion measures and will promote R&D strategically in consideration of the following issues: the need for technical improvement of agriculture, forestry, and fisheries in developing regions; the international situation; the need to contribute to government policy; the need to sophisticate Japan's research on agriculture, forestry, and fisheries; and ripple effects of R&D outcomes on technological improvement.
b) If JIRCAS, through its R&D, obtains technology seeds and findings useful to companies and producers in Japan, it will actively provide information and local support toward commercialization.
c) JIRCAS will manage the progress of research topics by preparing a process sheet stipulating the specific goals of each fiscal year before the start of research.
d) JIRCAS will evaluate research subjects adequately and rigorously, with the involvement of external experts, in accordance with the progress of the Medium to Long-Term Plan.
e) JIRCAS will pursue the approach of selection and concentration of research in light of the results of these evaluations and changes in social circumstances and will review, change, enhance, or terminate research subjects as necessary.

(2) Evaluation of the agency as a whole and allocation of resources

a) JIRCAS, as a whole agency, will develop a mechanism to conduct adequate self-evaluation and checking of the state of project management and the progress of research and will strengthen its PDCA cycle by reviewing plans adequately in light of the results of this evaluation and checking. Evaluation will be conducted according to the evaluation items and indexes specified by the Ministry of Agriculture, Forestry and Fisheries.
b) On the basis of the evaluation results, JIRCAS will develop and manage a system to allocate research resources such as budget amounts and personnel adequately to promote research activity. Effective incentives will be given to research personnel at the discretion of the President, and the research environment will be improved.
c) To further promote the Medium to Long-Term Plan, JIRCAS will make vigorous efforts to obtain external research funds, such as funds for commissioned projects and competitive funds.
d) The results of evaluations by the competent minister, and other findings, will be reflected adequately in the project management on a timely basis.

2. Promotion and enhancement of collaboration and cooperation between industry, academia, and government

a) JIRCAS will enhance collaboration and coordination with international organizations, domestic and international research institutes, extension organizations, universities, and private companies and will actively promote the exchange of information and staff.
b) In accordance with government strategies such as the Global Food Value Chain Strategy (developed on June 6, 2014 by the Committee for Global Food Value Chain Strategy), JIRCAS will use research networks to strengthen domestic and international collaboration.
c) JIRCAS will strengthen its cooperation in the use of technology seeds and human resources with such organizations as the National Agriculture and Food Research Organization (NARO) (including sections in charge of international collaboration), the Forestry and Forest Products Research Institute, and the Japan Fisheries Research and Education Agency.
d) By using the locational advantage of the Tropical Agriculture Research Front, JIRCAS will cooperate in the Genebank Project, NARO and a breeding study conducted by NARO, as well as in research projects conducted by other research organizations, to help advance agriculture, forestry, and fisheries in Japan.

3. Strategic promotion of intellectual property management

(1) Development of basic policy on intellectual property management

The basic policy on intellectual property management to promote the social implementation of R&D outcomes in developing regions will be reviewed in consideration of the Ministry of Agriculture, Forestry and Fisheries' Intellectual Property Strategy 2020 (issued on May 28, 2015 by the Ministry of Agriculture, Forestry and Fisheries) and the Policy on Intellectual Property in Research in Agriculture, Forestry and Fisheries (decreed by the Agriculture, Forestry and Fisheries Research Council on February 23, 2016).

(2) Promotion of social implementation of R&D outcomes through intellectual property management

a) A system of intellectual property management applicable to a series of processes from the planning stage of R&D to the stage after the completion of R&D will be developed and managed.
b) With goals that include using R&D outcomes as global public goods in developing regions, JIRCAS will study methods of obtaining the intellectual property rights for, preserving the confidentiality of, and disclosing R&D results; it will also study the policy of licensing. It thus aims to improve the speed of social implementation of research results and will pursue the smooth management of intellectual property.
c) On the basis of the basic policy on intellectual property management, JIRCAS will take the actions necessary for strategic management of intellectual property.

4. Enhancement of social implementation of R&D outcomes

(1) Publication of R&D outcomes

The outcomes of R&D will be published through research highlights, academic journals, and academic conferences. On such occasions, due consideration will be given to the possibility of obtaining intellectual property rights to research results and the need to preserve confidentiality.

(2) Promotion of technology dissemination

a) JIRCAS will quickly disseminate research results by converting them into databases and manuals; research results will be presented in forms available to farmers, companies, and extension organizations.
b) JIRCAS will collaborate with the relevant organizations to disseminate research results in countries and regions where the results may be utilized.

(3) Enhancement of public relations activities

a) JIRCAS will develop and implement publicity strategies to make its activities known to the public and increase its name recognition in Japan and other countries.
b) JIRCAS will disseminate information by using various media and opportunities, such as press releases, interviews, publication of journals and email magazines, and participation in external exhibitions.
c) JIRCAS will effectively disseminate information adapted to research areas and will target end-users through locally held workshops and explanatory meetings.

(4) Interactive communication with the public

a) JIRCAS will promote effective, interactive communication by holding symposiums and seminars and arranging educational tours and technical consultations.
b) JIRCAS will actively conduct outreach activities such as participating in external exhibitions and science café events and offering visiting lectures, in addition to making its facilities open to the public, in order to gain public feedback and increase public understanding of its activities.
c) JIRCAS will seek the understanding of residents in the areas targeted by research through

cooperation with research partners and local governments in these target areas.

(5) Understanding and publication of medium to long-term ripple effects of R&D outcomes

a) JIRCAS will conduct follow-up surveys systematically regarding the main R&D outcomes it has achieved since becoming an incorporated administrative agency. It will publicize the survey results on its web site and by other means.
b) JIRCAS will disseminate information through its web site and by other means to make it widely known to the public that its R&D outcomes and activities have helped advance agriculture and society in Japan and developing regions.

5. Reinforcement of ties with government departments and other organizations

a) JIRCAS will closely exchange information with the relevant administrative departments to respond to their needs at various stages, from the design of research to the dissemination and commercialization of research results. JIRCAS will invite the relevant administrative departments to annual meetings to discuss the research results.
b) On request from administrative departments, JIRCAS will cooperate in conducting emergency operations, holding liaison conferences and symposiums, and dispatching experts.
c) On request from national and local governments, organizations, or universities, JIRCAS will perform analyses and appraisals that require its highly specialized knowledge and are difficult for other bodies to perform.
d) JIRCAS will welcome participants and trainees from other national research and development agencies, universities, national and public institutions, the private sector, and overseas organizations so as to develop human resources and raise technical standards.
e) As an organization that performs comprehensive research on agriculture, forestry, and fisheries, JIRCAS will dispatch its staff to committee meetings and conferences held by related international organizations and academic associations and will cooperate in other activities on request.

<Research work>

6. Promotion of research work (experiments, research, investigations)

(1) Focused areas and direction of research

a) JIRCAS will focus on the research subjects listed in the Attachment in consideration of the need for technical improvement of agriculture, forestry, and fisheries in developing regions, the international situation, the need to contribute to government policy, the need to sophisticate Japan's research on agriculture, forestry, and fisheries; and ripple effects of R&D outcomes on technological improvement.
b) JIRCAS will exchange information and develop systems of collaboration with relevant organizations in Japan and abroad and will promote effective international joint research in collaboration with developing regions, developed countries, international research organizations such as CGIAR, private organizations (including NGOs), and international research networks.
c) JIRCAS will further strengthen its alliances with other national research and development agencies in the field of agriculture, forestry, and fisheries and will effectively promote collaborative research utilizing research resources owned by the relevant organizations.

(2) Collection, analysis and dissemination of information for grasping trends of international agriculture, forestry and fisheries

a) To help solve global food and environmental problems, JIRCAS will analyze the current status of food supply and demand, nutritional improvement, and food systems in foreign countries and will forecast the future—and analyze the ripple effects—of research results.
b) To contribute to agriculture, forestry, and fisheries R&D in developing regions and to Japan's policies, such as the development of a global food value chain, JIRCAS will collaborate with the relevant organizations in Japan and abroad and will dispatch personnel to focus areas. It will

collect and organize information and materials related to the international food situation and to agricultural, forestry, and fishery industries and rural areas in a regular, institutional, and systematic manner, and it will supply this information widely to researchers, administrative agencies, and companies in Japan and abroad.

c) To strengthen the systematic exchange of information among relevant organizations in Japan, JIRCAS will manage the Japan Forum on International Agricultural Research for Sustainable Development (J-FARD).

d) JIRCAS will promote goal-oriented basic research by using Presidential incentive expenses and other means.

e) In promoting goal-oriented basic research, JIRCAS will, in principle, abide by the Basic Plan for Agriculture, Forestry, and Fisheries Research and will choose research subjects in consideration of the significance and effectiveness of its own involvement. In addition, JIRCAS will focus on the future potential of pioneering research, including the creation of technology seeds leading to innovation and the development of new research areas through the combination of different research disciplines. Furthermore, JIRCAS will evaluate the progress of research and will take the necessary management actions, such as modification of the method of research or termination of research topics.

II. Efficient Business Management

1. Cost reduction

(1) Reduction in costs such as general and administrative expenditures

Administrative operations implemented by operational grants will be reviewed and efficiency will be further promoted. Average annual reduction targets are at least 3% with respect to the previous year for general and administrative expenditures (excluding personnel expenditures), and at least 1% with respect to the previous year for research expenditures.

(2) Streamlining of procurement

a) JIRCAS will develop a Procurement Streamlining Plan, including quantitative targets and specific indexes, by the end of June each fiscal year. It will implement the plan consistently and will conduct a self-evaluation of the plan's performance at an implementation evaluation session each fiscal year.

b) JIRCAS will maintain fairness by clarifying the reasons for adopting free contracts (e.g., when only one company can provide a special item) and extending unit-price contracts. It will try to procure items for R&D rapidly.

c) JIRCAS will collaborate with NARO to improve efficiency by conducting joint procurement and sharing tender price information.

2. Review and improvement of efficiency in organization and operations

(1) Restructuring of organization and operations

a) JIRCAS will review its organization and operations flexibly toward achieving the Medium to Long-term Goal and strengthening the PDCA cycle.

b) JIRCAS will promote the computerization of operations by, for example, improving the corporation's information systems. It will improve efficiency by using a TV conference system and Information and Communication Technology (ICT).

c) Through the above efforts, JIRCAS will optimize personnel arrangement and operations.

(2) Integration of research facilities and equipment (plan of facilities and equipment)

Planned renovation and upgrading of facilities essential to research promotion will be primarily implemented for research facilities and equipment, which are classified into three categories as follows on the basis of their age-related condition and the research prioritization of JIRCAS: facilities that will not be conducive to research promotion without renovation and upgrading; facilities that will hamper the progress of research without renovation owing to their severe age-related condition; and facilities required to be renovated by law or regulations. Increased use of such facilities will be promoted.

[Attachment] Directions related to research and investigations

The following research work will be conducted by the end of FY 2020.

1. Development of agricultural technologies for sustainable management of the environment and natural resources in developing regions

To cope with increasingly serious global problems such as climate change and environmental degradation, which affect Japan substantially, JIRCAS will develop technologies in cooperation with local research organizations. It will disseminate and establish technologies through verification tests in farm fields and collaboration with local extension organizations. These works will be implemented in developing regions, mainly in Asia and Africa. More specifically, the following priority research projects will be carried out.

To reduce greenhouse gas emissions in agriculture, JIRCAS will develop a water-saving irrigation method and a system to reduce methane generation through integration of cropping and livestock farming and will evaluate its carbon budget. JIRCAS will also address the issues of flooding and other extreme phenomena and climate change, including warming, and will develop technologies to mitigate the damage associated with such issues. [Importance: high][1]

In river basins where precipitation is unstable and vegetation is being degraded, and in areas where soil degradation and other soil problems are becoming serious, JIRCAS will develop technologies to sustain stable crop yields from the perspectives of breeding, cultivation, and soil and water control and will present a model for technological dissemination.

For the effective use of nitrogen fertilizer and the reduction of nitrous oxide emissions from agricultural land, JIRCAS will develop breeding materials utilizing the biological nitrification inhibition function.

2. Technology development for stable production of agricultural products in the tropics and other adverse environments

To enhance food production and improve nutritional status in Africa and other parts of the world, JIRCAS will conduct technological development and verification trials in cooperation with local organizations and will prepare manuals and commentary articles in tropical areas and other developing regions where potential crop productivity is not fully exploited owing to adverse conditions such as droughts and low fertility. In addition, JIRCAS will promptly disseminate the technologies it develops to breeders, government departments, and farmers. More specifically, the following priority research projects will be carried out.

In Africa, JIRCAS will develop technologies to utilize the diversity of food crop genetic resources; crop breeding materials of high productivity adapted to the planting environment and those materials adapted to local preferences; and crop production and livestock raising technologies that effectively utilize organic materials, water, and other local resources. [Importance: high][2]

JIRCAS will develop basic technologies for producing high-yield crops adaptable to adverse conditions such as low fertility, drought, and salt damage. It will also develop pioneering breeding materials, as well as technologies for their evaluation and utilization in the field in developing regions.

To control migratory plant pests and transboundary diseases that can spread and invade Japan, JIRCAS will work on pest control based on the epidemiology of migratory pests and vectors, and will develop technologies to prevent their invasion and spread. In addition, JIRCAS will develop disease-resistant varieties by using the research networks it has developed.

3. Development of high value-adding technologies and utilization of local resources in developing regions

In Asian areas where development needs are increasing along with economic growth, JIRCAS will use diverse regional resources and will develop new high value-adding technologies. In this way, it will support rural development by pursuing environmentally friendly and sustainable agriculture, forestry, and fisheries; help increase the incomes of farmers in developing regions; and contribute to the Global Food Value Chain Strategy promoted by Japan. More specifically, the following priority research projects will be carried out.

To secure high-quality products and develop food value chains, JIRCAS will develop a way of evaluating potential high value-added products of agriculture, forestry, and fisheries and will develop the processing and distribution technologies needed to add high value. In addition, JIRCAS will work on enhancing value addition by clarifying consumer needs and improving distribution systems. [Importance: high][3]

To establish agriculture, forestry, and fisheries in a sustainable, resource-recycling way, JIRCAS will develop technologies for saccharification from unused biomass resources such as agricultural waste and will promote their advanced use. JIRCAS will also develop technologies for the sustainable production and use of diverse resources to produce high value-added products in semi-mountainous areas. It will develop technologies for the development and maintenance of forest resources, technologies for the production of high value-added wood products, and technologies for improving the productivity of forest plantations in harmony with ecosystems. Moreover, JIRCAS will develop efficient aquaculture technologies and will utilize aquatic resources in harmony with ecosystems with the aim of sustainable consumption of aquatic resources.

In these efforts, JIRCAS will use international research networks, collaborate with Japanese and local private sectors, and promote systematization and transfer of technologies. Furthermore, JIRCAS will prepare technical manuals and exhibit technologies for dissemination among farmers and will provide information for technology transfer to local processors and distributors.

<Descriptions of importance>

[1] [Importance: high] According to the Fifth Assessment Report of the IPCC, adaptation to climate change may exceed a limit in the future, and a combination of effective adaptation measures and mitigation measures will promote a resilient society and sustainable development. In this regard, it is very important to take action in developing regions, where agriculture contributes to a large proportion of the economy.

[2] [Importance: high] As outlined in Goal 2 of the sustainable development goals (SDGs), i.e., to “end hunger, achieve food security and improved nutrition, and promote sustainable agriculture,” it is very important to solve the food problems in Africa, where large populations are deficient in nutrients and agricultural productivity is low.

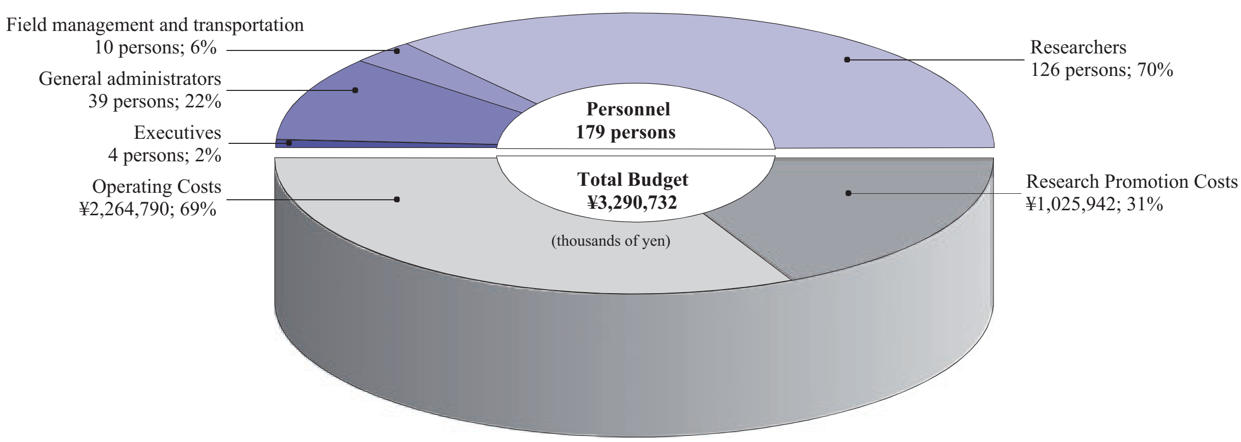
[3] [Importance: high] Because the Global Food Value Chain Strategy indicates that we need to develop a food value chain that adds high value in agriculture, forestry, and fisheries, it is very important to help increase farmers’ incomes through this effort.

FINANCIAL OVERVIEW

Fiscal Year 2016

	thousands of yen
TOTAL BUDGET	**3,290,732**
OPERATING COSTS	**2,264,790**
Personnel (179)	1,966,180
President (1), Vice-President (1), Executive Advisor & Auditor (2)	
General administrators (39)	
Field management (10)	
Researchers (126)	
* Number of persons shown in ( )	
Administrative Costs	298,610
RESEARCH PROMOTION COSTS	**1,025,942**
Research and development	477,168
Overseas dispatches	181,195
Collection of research information	86,492
International collaborative projects	261,661
Fellowship programs	19,426

Budget FY 2016 (Graph)



MEMBERS OF THE EXTERNAL EVALUATION COMMITTEE

Members of the JIRCAS External Evaluation Committee

Hiroto ARAKAWA	Former Special Advisor, JICA Research Institute
Kiyoko IKEGAMI	Professor, Graduate School of Social and Cultural Studies, Nihon University
Hiroko ISODA	Director, Alliance for Research on North Africa, University of Tsukuba
Toshihiko KOMARI	Vice President, Corporate Strategy Division, Japan Tobacco Inc.
Shin-ichi SHOGENJI	Professor, Graduate School of Bioagricultural Sciences, Nagoya University

JIRCAS STAFF in FY 2016

President

Masa Iwanaga

Vice-President

Osamu Koyama

Executive Advisor & Auditor

Hisaya Kakiuchi
Mari Inoue

Research Strategy Office

Kunihiro Doi, Director

Research Coordinator
Yasuko Inoue, Bioenergy, Forestry and Rural Development
Miyuki Iiyama, Development Economics
Satoru Muranaka, Plant Physiology

Regional Representative for Southeast Asia
Naruo Matsumoto, Representative of Southeast Asia Office (Thailand)

Researcher
Sakiko Shiratori, Agricultural Economics

Program Director

Satoshi Tobita, Program A: Environment and Natural Resource Management
Kazuo Nakashima, Program B: Stable Agricultural Production
Yukiyo Yamamoto, Program C: Value-adding Technologies

Research Planning and Partnership Division

Masayoshi Saito, Director

Research Planning and Management Office
Tomohide Sugino, Head

Research Planning Section
Takeshi Watanabe, Head

Research Management Section
Mie Kasuga, Head
Akira Hirokawa, Intellectual Property Expert

Senior Researcher
Kazuo Ise, Rice Breeding

Technical Specialist
Elvira G. Suto

Field Management Section
Takashi Komatsu, Field Operator
Hiroyuki Ishiyama, Field Operator

Research Support Office
Norio Tadokoro, Head

Research Coordination Section
Kaoru Watanabe, Head
Keiko Ikeda, International Affairs Expert
Katsunori Kanno, Coordination Subsection Head
Reiko Nagatsuka, Overseas Travel and Invitation Program Subsection Head
Ryoichi Mise, Overseas Affairs Subsection Head

Research Support Section
Akira Urushibara, Head
Toshiki Kikuchi, Budget Subsection Head
Koichi Fuse, Support Subsection 1 Head

Information and Public Relations Office
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Senior Researcher
Masaki Morishita, Rural Development

Public Relations Section
Yumiko Arai, Head

International Relations Section
Kunimasa Kawabe, Head

Publications and Documentation Section
Masahiro Maeda, Head
Hiromi Miura, Network Subsection Head
Takanori Hayashi, Information Management Subsection Head (Librarian)

Administration Division

Hidenori Aoki, Director

General Affairs Section
Takayoshi Takeda, Head
Shin-ichiro Takada, General Affairs Assistant Head
Takashi Oosato, Personnel Management Assistant Head
Sachiyo Tatebe, General Affairs Subsection Officer
Yumiko Sasaya, Welfare Subsection Head
Gaku Takeda, Personnel Subsection 1 Head
Kumi Ehara, Personnel Subsection 2 Head

Accounting Section
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Kazuo Miyajima, Accounting and Examination Assistant Head

Toru Shimura, Procurement and Asset Managing Assistant Head
Takeshi Usuku, Financial Subsection Head
Noriko Osonoe, Accounting Subsection Officer
Yuka Takatsuto, Audit Subsection Officer
Hifumi Takahashi, Procurement Subsection 1 Head
Yuki Hibiya, Procurement Subsection 2 Head
Kazuya Fujikawa, Facilities Subsection Head
Jun-ichi Irino
Gen-ichiro Hanaoka

Administration Section (Tropical Agriculture Research Front)
Toshiaki Hayashi, Head
Takashi Ichimi, General Affairs Subsection Head
Hiroe Nagatomo, Accounting Subsection Head

Risk Management Office

Takeshi Kano, Head

Compliance Management Section
Maiko Saito, Management Subsection Officer

Safety Management Section
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Inspection Section
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Audit Office

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Rural Development Division

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Naoki Horikawa, Hydrology

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Tsutomu Kobayashi, Rural Engineering
Yukio Okuda, Rural Engineering
Hideki Furihata, Agricultural Engineering
Kazuhisa Kouda, Agricultural Engineering
Shinji Hirouchi, Agricultural Engineering
Takeshi Matsumoto, Grassland Management
Koichi Takenaka, Rural Development Forestry
Mamoru Watanabe, Rural Development
Taro Izumi, Rural Development
Kenji Ishido, Agricultural Engineering
Haruyuki Dan, Rural Development
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Katsumi Hasada, Rural Development
Junya Onishi, Irrigation
Chikako Hirose, Agricultural Engineering

Researcher
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Subproject Leader
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Shunji Oniki, Agricultural Economics
Akira Hirano, Geographic Information Systems
Shintaro Kobayashi, Agricultural Economics
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Biological Resources and Post-harvest Division

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Akihiko Kosugi, Molecular Microbiology

Subproject Leader
Kazuhiko Nakahara, Food Chemistry

Senior Researchers
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Satoru Nirasawa, Food Functionality
Yasunari Fujita, Plant Molecular Biology
Tadashi Yoshihashi, Food Science
Yoshinori Murata, Applied Microbiology
Naoki Yamanaka, Plant Molecular Genetics
Kyonoshin Maruyama, Plant Molecular Biology
Mitsuhiro Obara, Plant Physiology and Genetics
Takamitsu Arai, Molecular Microbiology
Toshiyuki Takai, Crop Science and Genetics
Jun-ichiro Marui, Molecular Microbiology

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Masato Oda, Crop Management
Satoshi Nakamura, Insect Ecology
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Sada Ando, Animal Nutrition
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Keiichi Hayashi, Soil Management
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Yasuhiro Tsujimoto, Crop Science

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Kotaro Maeno, Entomology
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Akihiro Imaya, Soil Science
Masazumi Kayama, Tree Physiology

Researcher
Masaki Kobayashi, Tree Molecular Biology

Fisheries Division

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Shinsuke Morioka, Fish Biology

Senior Researchers
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Toru Shimoda, Marine Chemistry
Isao Tsutsui, Aquaculture
Hajime Saito, Marine Bivalve Ecology
Tsuyoshi Sugita, Fish Nutrition and Fish Physiology
Masashi Kodama, Marine Chemistry
Tomoyuki Okutsu, Aquatic Animal Physiology

Researcher
Bong Jung Kang, Aquatic Animal Physiology

Tropical Agriculture Research Front

Kazuhiro Suenaga, Director
Yasuaki Tamura, Research Coordinator
Koshun Ishiki, Public Relations Officer

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Hide Omae, Crop Science
Shotaro Ando, Soil Science

Subproject Leader
Mariko Shono, Plant Physiology

Senior Researchers
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Tatsushi Ogata, Pomology
Tsutomu Fushimi, Food Analysis and Oil Crops
Shinsuke Yamanaka, Molecular Biology
Shinkichi Gotoh, Soil Science
Takuma Ishizaki, Plant Molecular Biology
Yoshifumi Terajima, Sugarcane Breeding
Youichi Kobori, Entomology

Researcher
Shin-ichi Tsuruta, Molecular Genetics

Technical Support Office
Koji Yamato, Head
Hirokazu Ikema, Machine Operator
Masato Shimajiri, Machine Operator
Masakazu Hirata, Machine Operator
Yasuteru Shikina, Machine Operator
Masashi Takahashi, Machine Operator
Masahide Maetsu, Machine Operator
Yuto Hateruma, Machine Operator

THE JAPANESE FISCAL YEAR AND MISCELLANEOUS DATA

The Japanese Fiscal Year and the Annual Report 2016

The Japanese fiscal year is defined as the period of fiscal activity occurring from April 1 through March 31 of the following year. Thus, Fiscal Year (FY) 2016 covers the period from April 1, 2016 through March 31, 2017. The Annual Report 2016 summarizes the full extent of JIRCAS activities that occurred during this period. The subsequent Annual Report will detail events and programs from April 1, 2017 through March 31, 2018 (FY 2017).

Buildings and campus data

Land	(units: m^2)
Tsukuba premises	109,538
Okinawa Tropical Agriculture Research Front	294,912
Total	404,450

Buildings	(units: m^2)
Tsukuba premises	10,766
Okinawa Tropical Agriculture Research Front	9,485
Total	20,251

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About JIRCAS' symbol mark (shown on front/back cover): The mark was conceived by Takayuki Ishikawa of the Crop Production and Environment Division, and Toshifumi Murakami, former Senior Researcher in the Research Planning and Coordination Division. The Earth enveloped in a revolving swirl of clouds represents the dynamics of international research and JIRCAS' aim to target all world areas. The star was added to serve as a polestar for international agricultural research and to represent the importance of cooperation.

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