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Annual Report 2018

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JAPAN INTERNATIONAL RESEARCH CENTER FOR AGRICULTURAL SCIENCES



Japan International Research Center for Agricultural Sciences

Annual Report 2018

(April 2018-March 2019)

Japan International Research Center for Agricultural Sciences

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JAPAN

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Message from the President



President
Dr. Masa Iwanaga
(FY2011-)

Climate change and planetary boundaries: The central role of agricultural research

Global agriculture feeds over 7.7 billion people, but it is also a leading cause of environmental degradation. Agriculture is the largest user of limited resources such as fresh water and land surface. Agriculture, especially animal production, emits large quantities of greenhouse gases, accounting for about 25% of total global emissions. It is also a major cause of soil erosion, deforestation, biodiversity loss, and environmental contamination. It seems that we are eating at the expense of a sustainable future.

Climate change

Climate change is the number one risk in agriculture. Agriculture has always been at the mercy of the weather. Various extreme weather events, such as droughts, heat waves and floods, are the primary ways by which we experience climate change. They have been causing detrimental impacts not only on agriculture but also on our daily lives.

The Intergovernmental Panel on Climate Change (IPCC) produced a special report in October 2018. This report presents a scientific analysis on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. According to the report, human activities have already caused approximately 1.0°C of global warming above pre-industrial levels and that global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate. It is painfully clear that we do not have much time to spare to avoid catastrophic situations caused by the 1.5°C increase.

According to the UN, global greenhouse gas emissions in 2030 would have to be 55% lower than today to limit the increase in temperature within the 1.5°C target. On the other hand, it was reported in November 2018 that global CO₂ emissions in 2017 rose for the first time in four years as many countries disappointingly fell short of achieving their nationally determined targets based on the Paris Agreement.

One relevant activity of JIRCAS with major emphasis on the climate agenda is the “Climate Change Measures” project, which addresses both mitigation and adaptation issues. JIRCAS has been working on climate change issues for many years, and I am proud to say that through this project, we were able to deliver important achievements in 2018 as highlighted in this annual report.

Planetary boundaries

The planetary boundary (PB) approach defines a safe operating space for humanity based on the intrinsic biophysical processes that regulate the stability of the Earth System (Rockström et al. 2009). The authors explained the PB concept by identifying nine key global processes and systems that regulate the stability and resilience of the Earth System – the interactions of land, ocean, atmosphere and life that together provide conditions upon which our societies depend. They argued that if these natural processes are disrupted beyond a certain ‘boundary’ point, the consequences could be irreversible and lead to abrupt environmental change, making life on earth very hard for humans.

Specifically, the nine precautionary biophysical boundaries and system processes that humanity must not transgress in order to preserve planetary habitability are as follows: climate change; changes in biosphere integrity (biodiversity loss and species extinction); stratospheric ozone depletion; ocean acidification; biogeochemical flows (phosphorus and nitrogen cycles); land system change (e.g., deforestation); freshwater use; atmospheric aerosol loading (microscopic particles in the atmosphere that affect climate and living organisms); and introduction of novel entities (e.g., organic pollutants, radioactive materials, nanomaterials, and micro-plastics).

The authors published in 2015 an updated version of the PB concept and presented the status of the boundaries (Steffen, W et al. 2015). According to them, biochemical flows (nitrogen and phosphorus) and biosphere integrity (i.e., genetic diversity) are already in the red zone

(high risk) while land-system change and climate change are in the yellow zone of uncertainty (increasing risk). Notably, these boundaries (the yellow and red zones) are all related to agricultural activities!

Sustainable agriculture and food systems

So, with all these impediments to agriculture, what and how well will we eat in the future? The answer is “It depends.” It depends on whether we, the world community, can collectively achieve the following:

- No further expansion of crop lands so as not to encroach and destroy forests and other fragile ecological systems
- Increase in crop production by 70%, which means more crops in the same area of land
- Improved use efficiency of inputs such as water, soil nutrients, and labour
- Reduction of environmental impacts
- Lifestyle and societal changes
- Finally, we will need many innovations in technologies, policies, and institutions to ensure that sufficient quantities of nutritious foods are available and affordable to all consumers who are ever growing in number.

In conclusion, a lot of things need to be done, and we must work together to enable agricultural research to fulfill its central role, which is to help build a sustainable future for the Earth System and for human society. Are we willing to take up the huge challenge we are facing now—the challenge to achieve healthy diets and sustainable food production without harming the environment and within the limit of the Earth’s capacity? The answer is upon us.

The year 2018 was highly significant for JIRCAS because it was the third year (middle of the five-year plan) 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. Moreover, we have reformulated our project portfolio in response to changing priorities, placing more emphasis on nutrition and strategic research. In October 2018, we carried out a mid-term evaluation of all the projects under the current five-year plan and confirmed that major portions of the project activities have been going

well in accordance with the plan. This annual report describes how JIRCAS has carried out its major activities under the five-year plan.

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

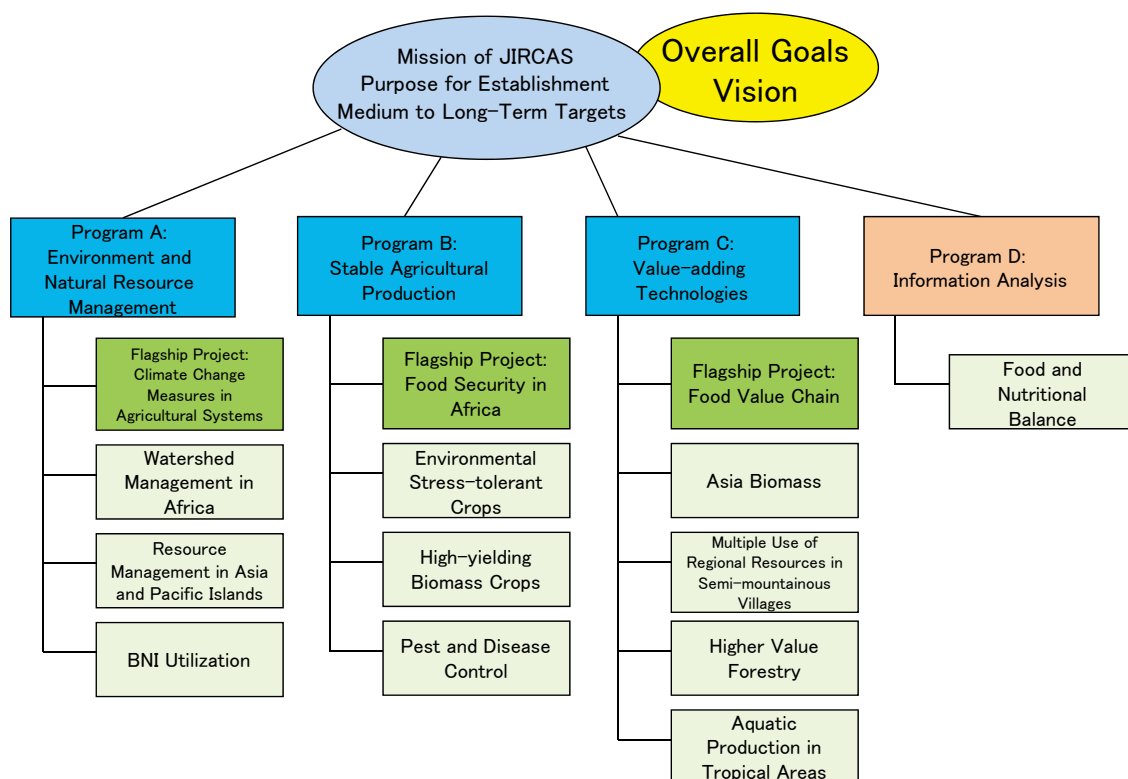


Fig. 1. Program-Project Research Framework

**66 research institutes (27 countries)
123 Memorandums of Understanding (MOUs)**



Fig. 2. Locations of our current activities based on 123 MOUs with partner institutions

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.

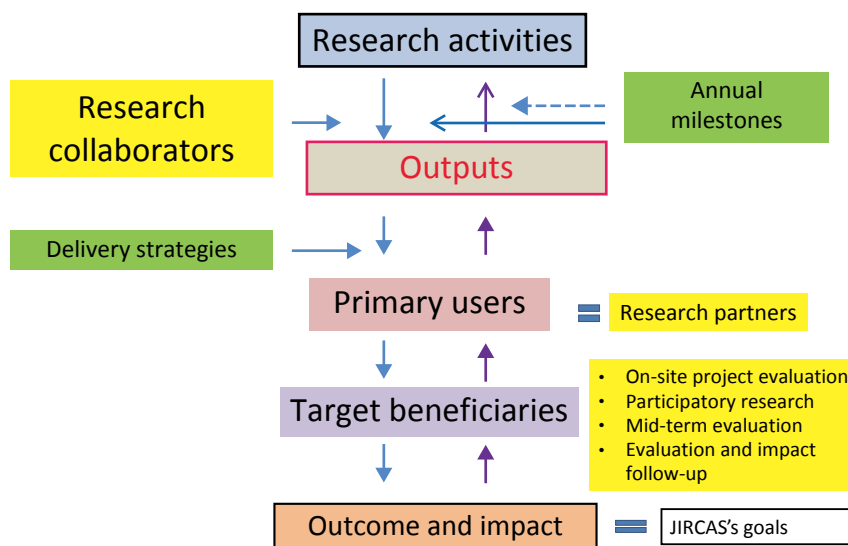


Fig. 3. Impact-oriented research for development (Operational Cycle)

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 48-year-old "research for development" tradition, hoping to produce deliverables that will be used by our target beneficiaries, resulting in significant and positive social impacts.

N. Owaga

Highlights from 2018

JIRCAS International Symposium 2018

Women in Fisheries: Sustainable Development Goals (SDGs) and Contributions to Research and Industry

JIRCAS International Symposium 2018, entitled “Women in Fisheries: Sustainable Development Goals (SDGs) and Contributions to Research and Industry,” was held on November 6, 2018 at the U Thant International Conference Hall, United Nations University (UNU) in Tokyo. The symposium was supported by Japan’s Ministry of Education, Culture, Sports, Science and Technology (MEXT) through its “Human Resources in Science and Technology Development Fund.” Under this program, JIRCAS has been jointly working with the attending organizations for the establishment of a better workplace environment so that women researchers can play more active roles. In this connection, JIRCAS has been promoting joint research activities in developing areas, as well as showing leadership in fostering human resources and achieving gender equality. JIRCAS International Symposium 2018 was accordingly held as one of the related events of the program.

There were two keynote speeches, two sessions, and a panel discussion. The first keynote speaker was Dr. Meryl Williams, chair of the Gender in Aquaculture and Fisheries Section (GAFS) of the Asian Fisheries Society (AFS) and vice chair of the Scientific Advisory Committee of the

International Seafood Sustainability Foundation, who presented “Women’s contributions to fisheries and aquaculture in the developing areas: Present achievements and future prospects for women researchers and administrators.” The second keynote speaker was Dr. Kaoru Nakata, executive director of the Japan Fisheries Research and Education Agency, who presented “Women in fisheries and aquaculture in Japan: Current achievements and future prospects in research and industry.”

The theme of Session 1 was “Women in Fisheries Research” and three speakers were invited, focusing on the active role of female researchers in the field of fisheries and aquaculture. Session 2 was entitled “Women On-site in Fisheries and Aquaculture” and two speakers shared their views about female workers’ potential contribution to the industry and SDGs. The tail end of the symposium was devoted to a panel discussion, with all speakers exchanging ideas on how to further promote women’s contributions to scientific and technological advancement in fisheries and aquaculture.

The symposium was a good opportunity to deepen cooperation among national and international organizations to support female researchers’ and employees’ career advancement and to tackle reforms to raise awareness about the role of women in fisheries and aquaculture. By doing this, a society could be built where both men and women can fully demonstrate their abilities, and people could then be expected to steadily proceed, step by step, toward the realization of a sustainable society.



Opening Remarks: Masa Iwanaga
(President, JIRCAS)



Welcome Remarks: Kazuhiko Shimada
(Deputy Director General, Agriculture, Forestry and
Fisheries Research Council Secretariat, MAFF)



JIRCAS International Symposium 2018 held at the United Nations University, Tokyo, Japan, November 6, 2018

2018 Japan International Award for Young Agricultural Researchers (Japan Award)

JIRCAS, in cooperation with the Agriculture, Forestry and Fisheries Research Council (AFFRC) Secretariat, presented the Japan International Award for Young Agricultural Researchers for the 12th consecutive year. The award recognizes and honors young foreign researchers (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 2018 commendation ceremony was held on November 6, 2018 at the U Thant International Conference Hall, United Nations University (UNU) in Tokyo.

The awardees and guests were welcomed by Mr. Yoshio Kobayashi, chairman of the

AFFRC. Congratulatory remarks were delivered by Dr. Takahiro Ueyama, executive member of the Council for Science, Technology and Innovation, Cabinet Office; Dr. Osamu Saito, academic director/academic programme officer of the UNU Institute for the Advanced Study of Sustainability; and Mr. Hideya Yamada, vice president of the Japan International Cooperation Agency (JICA). The selection process was explained by Dr. Mutsuo Iwamoto, chairperson of the Selection Committee. Mr. Kobayashi and Dr. Masa Iwanaga, president of JIRCAS, presented the prizes.

The seven-member selection committee conducted a document review, with the chairman of the AFFRC determining three winners from among 31 candidates. Each awardee received a testimonial and a monetary prize of 5,000 US dollars.

The 2018 awardees and their research achievements are as follows:



Awardee: Dr. Andry ANDRIAMANANJARA
University of Antananarivo, Madagascar
Research Achievement: Organic matter dynamics in agroecosystems of Madagascar and its effective use for crop production



Awardee: Dr. Farah Fazwa Md Ariff
Forest Research Institute Malaysia (FRIM), Malaysia
Research Achievement: Production of high-quality planting materials of popular herbal species in Malaysia, *Labisia pumila*



Awardee: Dr. Jinyong ZHANG
Institute of Hydrobiology, Chinese Academy of Sciences, China
Research Achievement: Study on diverse micro-organisms responsible for fatal parasitic disease outbreaks in farmed freshwater fish, and development of biology-based preventative measures against the diseases



The 2018 awardees, members of the selection committee, and other officials

NEW RESEARCH COLLABORATION

JIRCAS promotes its research network with international as well as national agricultural research institutions, extension systems, and universities, and the private sector, through information and personnel exchange programs. MOUs have been signed between JIRCAS and its research partners abroad to implement long-term research collaborations. In fiscal year 2018, JIRCAS signed a new MOU with the Institute of Ecology and Environmental Sciences-Paris, France (iEES-Paris), and it had 123 active MOUs as of March 2019. Based on the work plans elaborated in the respective MOUs, JIRCAS carried out joint research projects with 66 research institutions in 27 developing countries and implemented commissioned research activities with 10 research institutions in 7 countries.

TROPICAL AGRICULTURE RESEARCH FRONT

The Tropical Agriculture Research Front (TARF) in Ishigaki City, Okinawa Prefecture, is JIRCAS's sole substation. Ishigaki Island is the main island in the Yaeyama island chain at the southern edge of Ryukyu archipelago. Annual mean temperature is 24.3°C and mean annual rainfall is 2,107 mm. TARF's location has geographical advantages because its humid subtropical climate and island environment is similar to JIRCAS research sites abroad. TARF comprises 21 hectares of experimental fields, several types of greenhouses, and open research facilities including lysimeters. These geographical advantages and facilities enable us to implement basic and fundamental researches and create improved agricultural technologies that can be adopted by developing countries in the tropics/subtropics and island environments where such researches are difficult to conduct.

Research and development of agricultural production technologies

The following research activities, summarized below, are currently implemented at TARF: (1) reduction of nitrogen loads to underground systems, (2) reduction of soil erosion, (3) breeding of biomass crops, (4) improvement of Indica group rice, and (5) introduction of useful traits into rice by biotechnology.

JIRCAS also organized workshops to kick-start and strengthen collaboration with counterparts who had signed MOUs during fiscal year 2017, including the Indian Council of Agricultural Research (ICAR) and Institut de Recherche Agronomique de Guinée (IRAG).

JIRCAS also promotes collaboration with international organizations, including the CGIAR, in order to contribute to solving global challenges. JIRCAS continued the secondment of its scientists to CGIAR; one researcher was hosted at the CGIAR System Council, while another was assigned at World Agroforestry (ICRAF). Conversely, JIRCAS continued hosting one visiting scientist from AfricaRice, starting from the previous fiscal year. JIRCAS also created a new capacity development scheme that would allow JIRCAS to send junior scientists such as graduate students and post-doc scientists to CGIAR research centers under the existing JIRCAS Fellowship Program.

To reduce fertilizer input in sugarcane cultivation leading to the reduction of nitrogen loads to underground systems, we conducted experiments both at Negros Island in the Philippines and at Ishigaki Island. Our studies using the lysimeter in Ishigaki have shown that nitrogen load to the underground can be reduced by splitting nitrogen fertilization into basal fertilizer and second fertilizer. We have found that decreasing the amount of basal fertilizer application did not significantly decrease sugarcane yield. We are trying to validate the leaching of basal nitrogen fertilizer into underground and the effects of reduced basal nitrogen rate on sugarcane yield under field environments, through our ongoing experiments in Negros.

To develop countermeasures against soil erosion in the island-nation of Palau in western Pacific Ocean, we constructed an artificial sloping field in Ishigaki to examine whether applying “conservation agriculture,” defined by FAO as composed of three basic principles namely “minimal or partial tillage, mulching with organic materials, and multiple cropping systems (rotation of leguminous crop, intercrop, relayed crop and so on),” on tropical fruit or taro production systems can contribute to reducing soil erosion and nutrient leaching into the watershed. A satellite workshop was organized by JIRCAS and held in conjunction with the annual meeting of the Japanese Society of Physical Hydrology (JSPH) in Ishigaki on November 16, 2018 to present the results of our research and exchange information about the current status of natural resource management

and on-going activities in the island-nations (Photo 1). Two guest speakers and three counterpart researchers were invited to attend the workshop and present the issues concerning sustainable water management and agriculture production in Pacific islands such as Palau, Guam, and Fiji.

To improve sugarcane productivity and adaptability to adverse environments, we focused on the utilization of sugarcane-related wild germplasm such as *Erianthus* because of its high biomass productivity and superior root system. In collaboration with Thai researchers, we are trying to develop breeding technologies (crossing, phenotyping, genotyping) that will enable us to introduce desirable characteristics of *Erianthus* to sugarcane. We have established an effective crossing technique that can synchronize the heading periods of sugarcane and *Erianthus*, and developed intergeneric F_1 hybrids and their backcrossing populations (BC_1 , BC_2). We are evaluating their agronomic traits such as dry matter and sugar content, root characteristics, and cytogenetic characteristics to develop new breeding materials. Our techniques, findings, and materials could contribute to the effective exploitation of *Erianthus* in sugarcane breeding.

To achieve genetic improvement of the Indica group rice variety and its applications, we introduced, evaluated, and shared rice germplasm, breeding materials, and genetic information between collaborative countries. We are conducting genetic improvement experiments on leading rice cultivars of developing countries facing agricultural problems such as blast disease, salinity, phosphorus deficiency, low-fertility soil, and so on. We are also focusing on the plant architecture, shoot types, and traits such as culm length, number of tillers, and size of panicle, and the root types as characterized by their distributions (from shallow to deep) to

study the genetic advantage of those phenotypic characteristics against abiotic stresses.

The transgenic and genome editing approaches are relatively new plant breeding technologies. We use these technologies to introduce useful traits into rice. We have recently demonstrated that transgenic upland rice varieties expressing a gene encoding galactinol synthase isolated from *Arabidopsis* had higher grain yields than original non-transgenic varieties under drought conditions in field environments. Regarding genome editing, JIRCAS succeeded in establishing a system for genome editing that is applicable to major rice cultivars in Asia, Africa, and South America. We are currently working on generating genome-edited rice that can maintain grain yield under nutrient-deficient conditions.

Contribution to domestic agriculture

TARF contributes to domestic agriculture through the following activities:

1) Generation advancement

An early generation rice population consisting of over 150 accessions from NARO breeding stations all over Japan were grown two times.

2) Production of sugarcane F_1 seeds by crossing

Approximately 172 crosses (359 panicles) were made for the sugarcane breeding station of NARO.

3) Conservation of genetic resources

As a sub-bank for tropical and subtropical crops, 534 accessions of sugarcane and its relatives, 150 of tropical fruit trees, and 125 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 (Japan and Thailand), *Erianthus* (biomass crop),



Photo 1. Workshop on "Sustainable Resource Management and Environmental Conservation in the Pacific Islands"

and passion fruit.

Passion fruit breeding at TARF started in 2008, culminating in the variety registration of ‘SUNNY SHINE’ on Feb. 12, 2019 (Photo 2). ‘SUNNY SHINE’ has lower acidity and less immature fruit drop, resulting in good coloring of the skin and suitability for fresh consumption. Suitable soil types and appropriate cultural methods for managing growth are being examined. In addition, heat-tolerant passion fruit cultivars are

being eyed for future development.

An application for registration of the *Brachiaria* (forage grass) candidate variety ‘Isan’ (Photo 3) has been filed and is now under investigation.

There is an on-going collaboration with a brewer of local distilled spirits (called “Awamori”) in Ishigaki Island to test its performance and other possibilities for domestic use in Okinawa of the Indica group breeding materials developed under the international collaborative research.

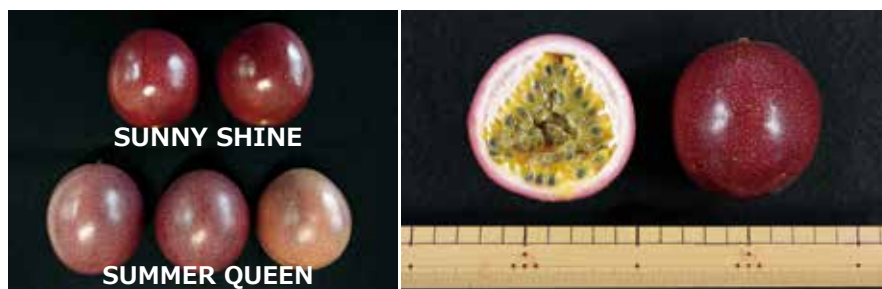


Photo 2. The new passion fruit cultivar ‘SUNNY SHINE’, bred and registered by TARF



Photo 3. The new candidate variety ‘Isan’, a *Brachiaria* grass grown at TARF. Variety registration is in progress.

ACADEMIC PRIZES AND AWARDS

21st Century Hope Prize at the Fifth Niigata International Food Award

Dr. Kotaro Maeno, a researcher in the Crop, Livestock and Environment Division, was among those chosen to receive the Fifth Niigata International Food Award, winning in the 21st Century Hope Prize category. He accepted his prizes and gave a commemorative lecture following the award ceremony at Nishi Messe Niigata Convention Center in Niigata City on November 8, 2018.

The Niigata International Food Award, Japan’s only international award in the field of food security, was established jointly by various contributors from Niigata’s industrial, agricultural, academic, and administrative sectors. It honors the achievements of individuals or groups to help solve the world’s food

problems. The 21st Century Hope Prize, which is one of the three award categories, recognizes young scientists involved in joint research or development activities that are novel and creative and has potential for future success through commercialization and implementation.

Dr. Maeno’s research on the widely distributed desert locust in Africa was highly evaluated for elucidating the physiology and ecology of the insect pests in the Sahara Desert and for being the only field survey done on the topic. The information obtained through his research is expected to contribute toward solving global-scale agricultural problems.

Dr. Masa Iwanaga, president of JIRCAS and winner of the Main Prize at the Fourth Niigata International Food Award in 2016, was also at the ceremony to give congratulatory words on behalf of the past winners.



Dr. Kotaro Maeno at the award ceremony



JIRCAS President Masa Iwanaga delivering the congratulatory message on behalf of the past winners

JIRCAS scientists among Clarivate Analytics' "Highly Cited Researchers" for 5th straight year

On November 27, 2018, Dr. Yasunari Fujita and Dr. Kyonoshin Maruyama, senior researchers in the Biological Resources and Post-harvest Division, were again named to the global "Highly Cited Researchers" list in the Plant and Animal Science category. This marked their fifth straight year of inclusion in the prestigious list provided by Clarivate Analytics, which owns and operates a collection of subscription-based services focused largely on analytics including scientific and academic research, patent analytics and regulatory standards, pharmaceutical and biotech intelligence, trademark protection, domain brand protection and intellectual property management. According to the company's website, the list recognizes world-class researchers for their "exceptional research performance, demonstrated by production of multiple highly cited papers that

rank in the top 1% by citations for field and year in *Web of Science*" (<https://hcr.clarivate.com/>).

Dr. Fujita and Dr. Maruyama have been conducting molecular biology research with the aim of developing crops that are resistant to environmental stresses, thereby contributing to the stable production of globally important agricultural crops.



JIRCAS President Masa Iwanaga with Dr. Kyonoshin Maruyama (left) and Dr. Yasunari Fujita (right)

Japanese Society of Soil Science and Plant Nutrition (JSSSPN) Journal Award

Dr. Naruo Matsumoto, a senior researcher in the Research Strategy Office and JIRCAS's regional representative for Southeast Asia, accepted the 2018 Japanese Society of Soil Science and Plant Nutrition (JSSSPN) Journal

Award. The award honors authors who have published outstanding articles in the Japanese Journal of Soil Science and Plant Nutrition, thus contributing to expanding the knowledge base relating to soil science, plant nutrition, and the environment.

The awarding ceremony took place on August 30 during JSSSPN's Annual Conference

held at the Faculty of Materials Science, Nihon University in Fujisawa City, Kanagawa Prefecture. Dr. Matsumoto's award-winning article, titled "Changes in nitrogen flow in food and feed supply during 1992-2007 in Japan" was co-authored by Dr. Kenjiro Oda (formerly with the National Institute for Agro-Environmental Sciences) and Dr. Eitaro Miwa (formerly with the Tokyo University of Agriculture). The paper appeared in the February 2017 issue (vol. 88, no. 1, pp. 1-11).

The research article gave an estimate of the changes in nitrogen flow in food and feed supply in Japan, i.e., the changes in the supply of domestically produced and imported food and feed (on the supply side), and the domestic ratio of diet food supply, feed supply for livestock farming, and food and feed supply for food processing (on the demand side). In particular, it elucidated the decrease in the domestic ratio of the food and feed supply in Japan from 1982 to 2002, which in turn were attributed to the impact of technological innovations on nitrogen flow, food and feed supply systems, and consumer preferences. The ratio of input to farmland per wasted nitrogen increased, but nitrogen load to environment decreased only slightly because nitrogen in domestic food and feed production (which absorbed the wasted nitrogen) decreased.



Dr. Naruo Matsumoto receiving the award certificate from Prof. Kazuyuki Inubushi, president of JSSSPN



JSSSPN Journal Award certificate

Best Presentation Award for Young Researchers at the 2018 ISSCT Workshops in Okinawa

Senior Researcher Yoshifumi Terajima of the Tropical Agriculture Research Front was given the Best Presentation Award for Young Researchers at the conclusion of the 2018 International Society of Sugar Cane Technologists (ISSCT) Joint 12th Germplasm & Breeding and 9th Molecular Biology Workshops in Okinawa. The ISSCT is an international sugarcane research association composed of scientists, technologists, managers, institutions and companies/corporations concerned with the technical advancement of the sugarcane industry. Mr. Terajima's oral presentation was titled "Characteristics of intergeneric hybrids between *Saccharum* spp. hybrid and *Erianthus arundinaceus*."

The workshops, held on October 22-26, 2018 at the Okinawa Institute of Science and Technology Graduate University, were attended by 113 researchers from 20 countries. There were two main sections, Germplasm & Breeding

section and Molecular Biology section, in the main program comprising 41 oral presentations, two poster sessions, discussion sessions, and a business meeting. JIRCAS played a major role and co-organized the workshops with the Okinawa Prefectural Agricultural Research Center and the Kyushu Okinawa Agricultural Research Center of the National Agriculture and Food Research Organization (<https://issct2018.okinawa/>).



Young Scientist Award (Best Presentation) certificate

Public LOD Award at the Linked Open Data Challenge Japan 2018

On December 8, 2018, the Information Management Subsection of the Information and Public Relations Office, on behalf of JIRCAS, received the “Public LOD Award” at the awarding ceremony of the “Linked Open Data Challenge Japan 2018” held at Yahoo! Japan’s LODGE in Chiyoda, Tokyo. The LOD Challenge, which is now on its 8th year, is administered by the LOD Challenge Japan Executive Committee and honors “works” that create new value by “connecting” open data. Subsection head Takanori Hayashi accepted the award and gave a short presentation and demonstration.

The award was given in recognition of its contribution to the Open Data Initiative being implemented by the government. JIRCAS’s Open Data webpage was launched in August 2018, delivering information (e.g., official publications and public notices, etc.) in a machine-readable format that is easy to access and use. JIRCAS’s effort was highly evaluated, with its award

citation stating that it may serve as a guideline in promoting open data in public organizations (excluding local governments).



Public LOD Award certificate

Certificate of Appreciation from the Philippine Sugar Regulatory Administration

On February 11, 2019, Program Director Satoshi Tobita, on behalf of JIRCAS, received from the Philippine Sugar Regulatory Administration (SRA) a certificate of appreciation “in recognition of its outstanding contribution to the Philippine Sugarcane Industry in the Development of Sustainable Sugarcane Farming in the Philippines particularly in the Study on Nitrogen Leaching and Crop Modelling.”

The certificate was signed by SRA Administrator Hermenegildo R. Serafica and presented to Dr. Tobita following the signing of a new Joint Research Agreement (JRA) extending the two agencies’ collaboration for another two years (until March 2021). The new JRA expands the coverage of the developed fertilizer application methods to sugarcane regions in the Philippines and sets up a system to monitor the effects of the technology on the regional environment.

The events took place on the first day of the two-day “Sugarcane Stakeholders’ Summit”

held in Quezon City, Philippines. Dr. Tobita also delivered a short speech in the opening session of the summit, which was attended by more than 200 stakeholders in the sugarcane industry from all over the Philippines. By strengthening its collaboration with SRA and other organizations in the Philippines, JIRCAS also hopes to further advance its research activities and maximize the project outcomes.



Certificate of Appreciation from the Philippine Sugar Regulatory Administration



Research Overview

Overview of JIRCAS's 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's 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 the evaluation of national research and development (a decision of the Prime Minister in 2016) which requires efficient evaluation, JIRCAS carried out the in-house evaluation in FY 2018 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 2019.
- 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 2019.

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 2019.

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 2018 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's 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 123 MOUs or JRAs remained in force at the end of FY 2018.

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's projects with the cooperation of such organizations. JIRCAS has also 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.

7. Organization of JIRCAS

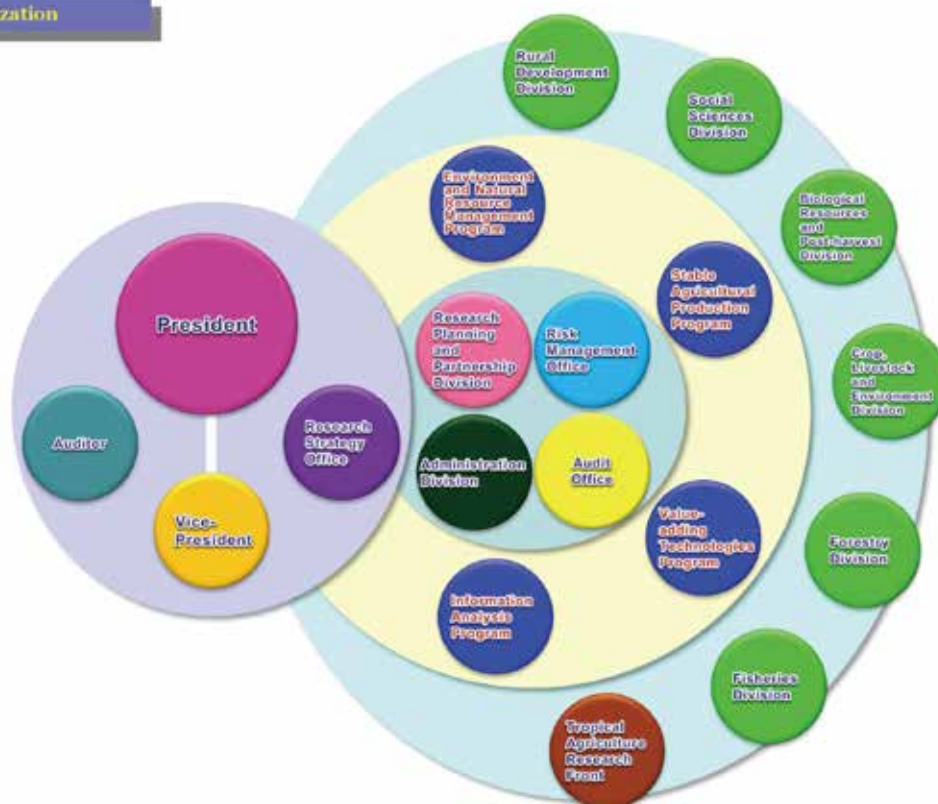
The organizational structure of JIRCAS for the Fourth Medium to Long-Term Plan period is summarized in the figure below.

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.

Organization



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

[Climate Change Measures]

Greenhouse gas (GHG) emissions from agricultural ecosystems account for 14% of anthropogenic GHGs. The development of climate change mitigation technologies for the agricultural sector is therefore of great importance, with the percentage of agriculture-related GHG outputs consequently high in developing regions due to high agricultural activity, in addition to being vulnerable to extreme events caused by climate change.

Generally speaking, mitigation techniques are not always attractive to farmers who prioritize tangible benefits. Therefore, we will integrate various mitigation techniques into one package. Farmers can apply biogas effluent to paddies in place of chemical fertilizers, and enjoy increased paddy yield through AWD (alternating wetting and drying) and electricity generated from biogas. These tangible benefits will work as strong incentives for farmers.

We are conducting experimental studies in Vietnam and Thailand on new technologies to mitigate GHG emissions from agricultural activities. On-farm trials using AWD in triple cropping paddy farming in six districts at An Giang Province in Vietnam have been completed, and results from seven consecutive crop seasons (from 2015 to 2017) have shown that AWD reduces methane gas emissions by 40% and the frequency of irrigation pump usage by one third, compared to continuous flooding. On top of these positive effects, yield is increased by 24%. AWD's economic advantages over continuous flooding can be a strong incentive for farmers to choose AWD despite the technique being an

increasing burden on water management. The research findings were compiled into a policy suggestion paper, which included some proposals toward further dissemination of AWD, and was handed over to government officers of An Giang Province.

In the field of livestock science, feeding of CNSL (cashew nuts shell liquid) to Vietnamese local cattle (Lai Sind) showed that it can reduce the relative abundance of methanogens in the rumen. We also measured the GHG emission of beef cattle manure during sun-drying, a very common practice in southern Vietnam, where the methane emission was quantitatively estimated to be 0.36 g/kg-VS. In collaboration with counterpart organizations in Thailand, soil organic carbon (SOC) data from long-term field experiments were compiled and analyzed. We showed that SOC decreased under conventional management without organic matter input; however, SOC decline was mitigated or SOC increased with organic matter input. These results contribute to the “4 per 1000” initiative as tropical areas have limited data availability.

We also continued our research activities on adapting agriculture to climate change in countries that are vulnerable to extreme weather events. In the Ayeyarwady Delta of Myanmar, we designed and tested the adaptability of weather index insurance to offset the loss of agricultural products to extreme events. Electrical conductivity (EC) in river water in the delta was monitored and correlated spatially and temporally with the Sentinel-2 satellite data during salt water intrusion in the dry season. We also analyzed the satellite-based normalized difference vegetation index (NDVI) images of the delta over ten years and discovered that it would take up to three years to recover from damages caused by great cyclone landings, e.g., the Nargis in 2008. Through these studies, we have prepared a preliminary weather index insurance design, which includes weather index, target area, and guaranteed period, and we investigated the optimum insurance money for rice farmers in case of flood disasters. In Bangladesh, we estimated the impacts of climate change on rice yield and converted it into GIS data in order to evaluate the adaptation technology for extreme events. A Computable General Equilibrium (CGE) model was formulated and prototyped for multiscale simulations.

In the study on water use practices in the Central Dry Zone (CDZ) of Myanmar, we evaluated field water consumption, irrigation water allocation, and channel function. We also carried out a

preliminary appraisal of the irrigation system and made a list of possible countermeasures. Furthermore, we examined the applicability of SALIBU technology (high yield rice ratooning) in the CDZ. On-station field trials demonstrated higher water productivity and annual paddy yield in SALIBU as compared to conventional transplanting method. Lastly, the seasonal climate prediction-based decision support tool, WeRise, was formally developed through an IRRI-Japan collaborative research project. In the Philippines, improving rainfed rice productivity is a matter of great importance. Thus, for this purpose, we conducted on-farm experiments using local varieties to calibrate the parameters for ORYZA (a crop growth simulation model for rice) for WeRise validation in the Philippines.

[Watershed Management in Africa]

This project aims to propose small scale watershed management models to contribute to sustainable and intensified land use in the Central Plateau of Burkina Faso and the Ethiopian Highlands, both of which are at greatest risk of experiencing land degradation in Sub-Saharan Africa. In collaboration with INERA (Institut de l'Environnement et Recherches Agricoles), we studied several prominent soil and water conservation technologies in Burkina Faso. Comparative advantages for tree planting using soil block nursery and soil mound combined with planting of *Andropogon gayanus* were quantified against conventional methods in the higher slopes and middle slopes of the watershed. We have found that a fallow-band technology prevented water and soil loss effectively. A determinant of productivity for three dominant soil types in the watershed was identified by performing a regression analysis between yield components and external factors (rainfall, hill density, fertilizer dosage, variety). To develop a land cover classification map based on satellite images, ground truth data were collected through field surveys. Livestock production potential was estimated for three representative types of grassland in the watershed and chemical characteristics for feeds and feedstock were determined. A simple method for soil map development was established at the commune scale, and the map was used to evaluate natural resource use in the watershed through the ArcSWAT model. Also, a prototype model was completed to evaluate the impacts of new technologies for conserving soil and water as well as increasing farmers' income.

In the Ethiopian Highlands, we hypothesized that land use would be one of the key determinants

for the growth of *Acacia etbaica*. To quantify the biomass of *A. etbaica* in the watershed, we tested the SfM method. To enhance the growth of *A. etbaica*, the effect of biochar was observed through growth, chlorophyll content, and arbuscular mycorrhiza infection. A simulation of water balance in the watershed showed inefficient water use and sedimentation as deterioration factors. Our study showed the crucial role of social norms and practices in forest conservation. It also showed that the rate of firewood consumption was much faster than tree growth, which could have accelerated deforestation in the watershed. We estimated the effect of land use on vegetation through the land use map.

[Resource Management in Asia and the Pacific Islands]

In the watershed of Ngerikil River, Babeldaob Island in the Republic of Palau, we continued to monitor water quality, quantity, and meteorological data to make up the data set for the Soil and Water Assessment Tool (SWAT) model. Low soil fertility could be attributed to the very slow recovery of forest vegetation (basically hopeless as 9% of the land is still bare) after the abandonment of agricultural fields more than 70 years ago. Tropical fruit trees were planted for the sake of soil remediation in such a low fertility area. An experiment using the artificial slopes at JIRCAS-Tropical Agricultural Research Front (TARF) in Ishigaki, Okinawa, revealed that combining minimum tillage and organic mulch reduced soil erosion almost completely. In Negros Island, the Philippines, an experiment showed that almost the same sugarcane yields are achieved by using conventional fertilizer and applying only a half dose of nitrogen fertilizer during first application. It was also found that sugarcane yield tended to be higher if the first dose of nitrogen is applied 1 to 2 months after planting than if applied immediately after planting. A lysimeter experiment at JIRCAS-TARF proved that 20% of $\text{NO}_3\text{-N}$ leaching is mitigated without decreased sugarcane yield by halving the dosage and delaying the first nitrogen fertilizer application by one month, compared with the conventional method. In collaboration with the Central Soil Salinity Research Institute (CSSRI) of ICAR, India, experiments have commenced in its salinized field in the arid area to evaluate the effect of subsurface drainage on the dynamics of water and salts in the soil. "Cut soiler," a machinery introduced from Japan, successfully created subsurface drainages at a depth of 50 cm from the soil surface. Salt concentration around the drain was shown to have

decreased in a field-simulated lysimeter test. The salt-tolerant soybean lines, conferring *Ncl* gene, were crossed and backcrossed with local soybean varieties from India and Vietnam, and the seeds of the progenies were obtained.

[BNI utilization]

Incorporating the biological nitrification inhibition (BNI) function of plants into agricultural systems contribute to sustainable natural resource management through increased N-fertilizer use efficiency and reduced environmental load through $\text{NO}_3\text{-N}$ leaching and N_2O emissions. To this end, we hosted the 3rd International BNI Meeting on October 26 and 27, 2018 in Tsukuba, Japan. BNI research achievements were shared through presentations, and participants discussed the implementation of BNI-function into agricultural systems and on *ex-ante* impact assessment analysis for potential economic and environmental benefits from adoption of the BNI-technology. Wheat lines carrying translocations containing BNI-trait from wild-wheat (*Leymus racemosus*) into elite-wheat varieties were

developed at CIMMYT (Mexico) and evaluated for BNI-trait expression at JIRCAS. A total of 444 SSR markers of *Brachiaria humidicola* were developed and located on two linkage maps. Hydrophobic BNI compounds from maize root using CIMMYT Maize Lines (CMLs) were partially characterized for BNI-component. Field experiments at CIAT in Colombia involving the establishment of *Brachiaria* sp. pasture grasses that have high- and low-BNI activities are ongoing. Field experiments at JIRCAS involving various *Brachiaria* sp. cultivars clarified their influences on nitrification activity and N_2O emission. Field experiments were also conducted at ICRISAT, India, where sorghum genetic stocks that differed in sorgoleone produced by root systems were evaluated for their influence on nitrification in the soil. A greenhouse pipe-pot experiment carried out in JIRCAS showed lower potential nitrification rates in the rhizosphere of higher-sorgoleone-producing genetic stocks. The decrease in nitrification was mainly justified by the inhibition of the ammonia-oxidizing archaeal (AOA) *amoA* genes rather than the ammonia-oxidizing bacterial (AOB) *amoA* genes.

TOPIC 1

Prediction of enteric methane emission from beef cattle in Southeast Asia

Improving national greenhouse gas (GHG) inventories is important in projecting GHG emission trends and constructing mitigation strategies. The significant contributions of enteric methane (CH_4) emissions to global GHG emissions indicate the necessity for improving CH_4 emission estimates. Enteric CH_4 from ruminants is produced during fermentation of dietary carbohydrates in the rumen, and consequently, enteric CH_4 emission is principally affected by feed intake and the type and digestibility of feed. Therefore, various equations based on dietary intake and its components for estimating enteric CH_4 emission have been provided for animal species, production systems, and regions. However, little information is available in Southeast Asia, a region characterized by producing large numbers of beef cattle in monsoonal agricultural systems focused on rice production. To develop equations for estimating enteric CH_4 emissions from beef cattle in Southeast Asia using commonly available indices, we carried out meta-data analysis using

data obtained in Thailand and Vietnam.

During the period 2005-2015, individual data ($n = 332$) were collected from 25 studies carried out in Thailand and Vietnam using a ventilated respiration apparatus equipped with a head hood. The dataset included observations on feed chemical composition, nutrient intakes, digestibilities, and CH_4 emissions. The animals from which data were obtained were Brahman male cattle ($n = 171$), Thai native male cattle ($n = 121$), and Lai Sind male cattle ($n = 40$; Photo 1).

The best equation to predict daily CH_4 emissions included dry matter intake and ether extract contents (Equation 1 in Table 1). The equation including only dry matter intake as a variable was also good for prediction (Equation 2). The best equation to predict methane conversion factor, expressed as CH_4 energy as a portion of gross energy intake, was obtained using DMI per body weight, content of ether extract and crude protein, and DM digestibility (Equation 3). Mean methane conversion factor (MCF) of cattle in High roughage group (≥ 0.68 kg/kg in their feed as DM) was higher than that of cattle in Medium (0.34-0.67 kg/kg) and Low (≤ 0.33 kg/kg) roughage groups (8.1%, 7.3%, and 7.3%,



Photo 1. Cattle breeds used in measuring methane emissions

Table 1. Regression equations for predicting daily methane emission and methane energy as a proportion of gross energy intake in cattle

	RMSE	R ²
(1) $\text{CH}_4 = 22.67 \times \text{DMI} - 3.73 \times \text{EE} + 23.32$	18.64	0.783
(2) $\text{CH}_4 = 22.71 \times \text{DMI} + 8.91$	19.36	0.766
(3) $\text{MCF} = -0.782 \times \text{DMIBW} - 0.436 \times \text{EE} - 0.073 \times \text{CP} + 0.049 \times \text{DMD} + 8.654$	1.348	0.391

CH_4 , daily methane emission (g/day); MCF, methane conversion factor expressed as methane energy as a portion of gross energy intake (J/100 J); DMI, dry matter (DM) intake (kg/day); EE, ether extract content (% DM); CP, crude protein content (% DM); NDF, content of neutral detergent fiber (% DM); DMD, DM digestibility (%); DMIBW, DMI per BW (kg/100 kg); RMSE, root mean square error.

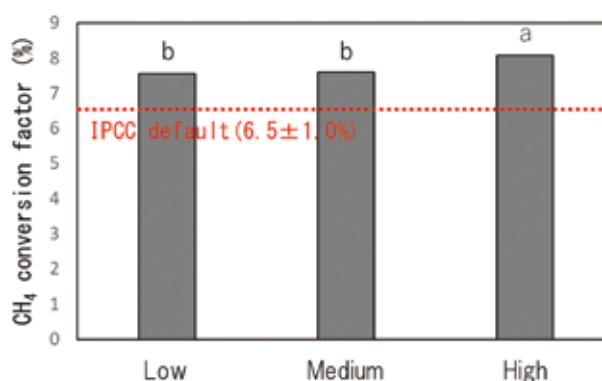


Fig. 1. Methane conversion factors in cattle by roughage proportion groups

Cattle were separated by roughage proportion (DM basis) into Low roughage (≤ 0.33 kg/kg), Medium roughage (0.34–0.67 kg/kg), and High roughage (≥ 0.68 kg/kg) groups. Dashed line shows default methane conversion factor for cattle excluding feedlot fed cattle.

^{ab} $P < 0.05$

respectively; Fig. 1). Those MCFs were higher than default MCF by the Intergovernmental Panel on Climate Change (IPCC; $6.5 \pm 1.0\%$) for cattle, excluding fattening cattle fed diets containing 90% or more concentrates. These higher MCFs were considered to reflect the characteristics of cattle feed containing relatively higher fiber contents in Southeast Asia. These present equations are applicable to improving CH_4 emission estimation in Southeast Asia.

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Cassava pulp is suitable as beef cattle feed and shows less variation in chemical contents among seasons and factories

Cassava (*Manihot esculenta*) is one of Thailand's major crops, with about half of domestic production coming from the northeastern region. Cassava pulp, the major waste produced from starch factories, is considered a nutritious feed for cattle because of its high starch and fiber contents. To promote cassava pulp utilization as cattle feed, variations in chemical composition among seasons and starch factories, energy value, and performance of beef cattle fed with cassava pulp were investigated.

Cassava pulp samples were collected in

each season -- the rainy season (mid-May to mid-October), summer (mid-October to mid-February), and winter (mid-February to mid-May) -- from four starch factories in northeastern Thailand. Significant variations in phosphorus and potassium contents were found among factories (Table 1). Constant variation in any of the chemical components was not found among the three seasons. Crude protein content of cassava pulp was close to that of cassava chip. Energy values, obtained from feeding trial using four Thai native cattle fed basal diet or basal diet with cassava pulp at maintenance level, were close to that of dried brewers' grain.

Eighteen yearling Thai native cattle were allocated to one of three dietary treatments and fed ad libitum (i.e., as much as desired) for 5 months in a randomized complete block design. Three

Table 1. Chemical composition and energy values of cassava pulp, cassava chip and dried brewers' grain

	Cassava pulp		Cassava chip ^s	Dried brewers' grain ^s
	Mean	SD		
DM (%)	18.4	3.9	89.8	91.3
Crude Protein (%DM)	2.2	0.5	2.3	25.0
Ether extract (%DM)	0.4	0.3	0.5	5.7
Neutral detergent fiber (%DM)	36.0 [†]	5.1	10.1	50.7
Non fibrous carbohydrate (%DM)	59.3 [†]	5.4	10.8	83.3
Hydrocyanic acid (ppm DM)	117.0	55.0	–	–
Calcium (%DM)	0.22	0.07	0.1	0.36
Phosphorus (%DM)	0.03 [†]	0.01	0.1	0.47
Potassium (%DM)	0.36 [†]	0.14	0.92	0.04
Magnesium (%DM)	0.09	0.02	0.09	0.23
Total digestible nutrient (%DM)	74.4	0.4	79.0	70.0
Metabolized energy (MJ/kgDM)	11.3	0.1	15.3	11.3

DM: dry matter, [†]significant difference among factories ($P < 0.05$), *interaction between factory and season ($P < 0.05$), ^sData obtained from Nutrient Requirements of Beef Cattle in Indochinese Peninsula (2010)

Table 2. Feed formula, chemical composition and energy value of fermented total mixed ration containing 10, 30 and 50% of cassava pulp (dry matter basis)

	Cassava pulp ratio		
	Low	Medium	High
Feed formula (DM basis)			
Cassava pulp	10.0	30.0	50.0
Rice straw	50.0	30.0	10.0
Palm kernel meal	23.5	23.5	23.5
Soybean meal	5.0	5.0	5.0
Rice bran	10.0	10.0	10.0
Urea	0.5	0.5	0.5
Vitamin & mineral premix	1.0	1.0	1.0
Chemical composition (%DM)			
Crude protein	9.9	9.7	9.7
Ether extract	5.9	5.9	5.9
Neutral detergent fiber	63.2	53.6	45.2
Non-fibrous carbohydrate	10.5	22.9	33.7
Metabolized energy (MJ/kgDM)	9.6	11.4	12.4

DM: dry matter

dietary treatments using different proportions of cassava pulp (10, 30 and 50% as dry matter) instead of rice straw as a base in a fermented total mixed ration were applied (Table 2). The diets were formulated to contain 10% crude protein and exceed their energy requirement. Metabolized

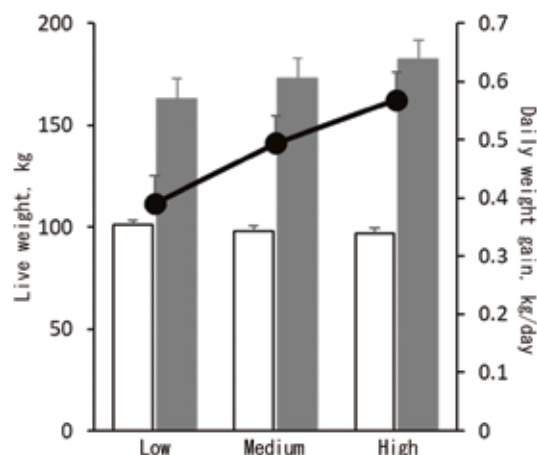


Fig. 1. Initial (□) and final (■) live weight, and daily weight gain (●) of Thai native cattle fed fermented total mixed ration containing 10, 30 and 50% of cassava pulp (dry matter basis; Low, Medium, and High, respectively) Daily weight gain linearly increased with increasing cassava pulp inclusion ($P<0.05$).

energy content and daily weight gain increased with increasing cassava pulp content (Fig. 1).

These results provide useful information on beef cattle rearing using cassava pulp and contribute in promoting the utilization of waste (cassava pulp) from cassava factories. Cassava pulp should be used as soon as possible or kept under anaerobic condition because of its low aerobic stability. The physical effective fiber content and nutrient requirements must be noted when diets are formulated with a high cassava pulp ratio.

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TOPIC 3

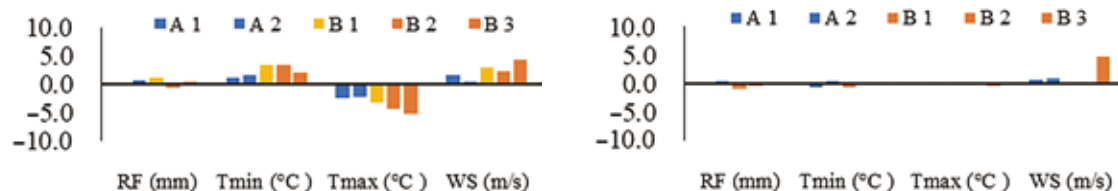
Improvement of rice grain yield by predicting the optimum sowing period for rainfed rice areas in the Asian monsoon region

Unlike irrigated rice fields, rainfed rice areas in the Asian monsoon region depend mainly on rainfall for water supply, bringing down rice productivity to nearly half of those in irrigated areas. Despite this fact, rainfed rice areas play a crucial role in meeting future demand for the staple food; thus, it is imperative that high and stable productivity is achieved through appropriate technology development. Rainfall pattern changes year to year and rainfed rice farmers can hardly anticipate the optimum sowing period for better grain yield. Seasonal climate prediction is relevant for the current problems in rainfed areas, and the expected technology for predicting rice grain yield will be applied and developed through ORYZA, a crop growth modelling tool. SINTEX-F, the coupled ocean-atmosphere general circulation model developed

by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), has a few months to one-year lead time predictability and is used for grain yield prediction through ORYZA, which in turn requires daily weather data to obtain grain yield as a function of sowing timings.

SINTEX-F is designed for predicting the El Niño-Southern Oscillation (ENSO), which has a high correlation to the Asian monsoon. However, SINTEX-F has a bias, hence it cannot be directly used for ORYZA. Thus, the outputs need to be corrected through statistical downscaling within 100 km². The results through statistical downscaling of SINTEX-F outputs show a high correlation with locally observed weather data (Fig. 1). On the other hand, model fit of ORYZA for grain yield simulation is excellent even for different sowing timings (Fig. 2). With these obtained results, grain yields can be predicted through hindcast analysis of ORYZA with downscaled predictions as it demonstrates a high correlation with grain yields obtained with observed weather data (Fig. 3).

When Ciherang, one of the most popular



(a) Mean errors between observed weather and SINTEX-F predictions before statistical downscaling (b) Mean errors between observed weather and SINTEX-F predictions after statistical downscaling

Fig. 1. Statistical downscaling for bias correction of SINTEX-F predictions

A1, A2: Sites in the Philippines, B1, B2, B3: Sites in Indonesia

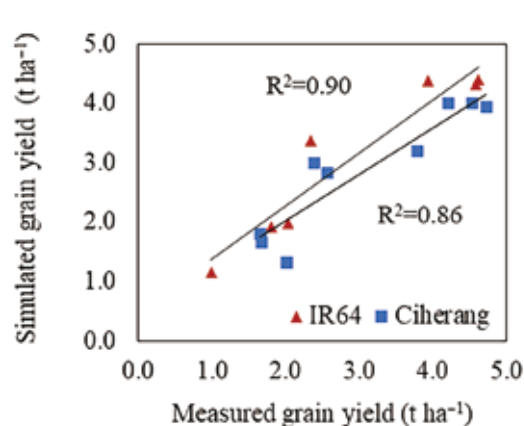


Fig. 2. Accuracy of ORYZA for predicting grain yields at different sowing dates

Red triangle: IR64, Blue square: Ciherang, Each point represents its sowing date.

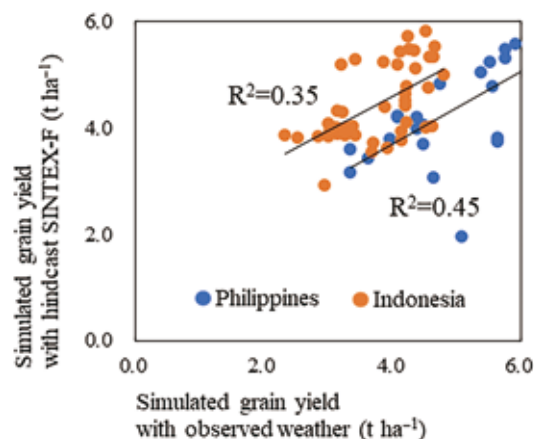


Fig. 3. Grain yield predictability through statistically downscaled SINTEX-F in ORYZA

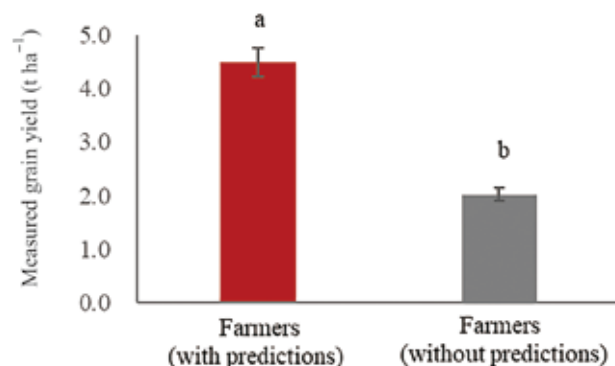


Fig. 4. Improvement in farmers' grain yield with predictions for optimum sowing timing

Bars in the graph show measured grain yield for the group of farmers with predictions for optimum sowing period and others without predictions. Five farmers were selected randomly for each group. Farmers with predictions were instructed for sowing period (from November 6 to December 10) and variety, while farmers without predictions were instructed only for variety. Sowing period for farmers without predictions was from October 10 to October 25. Different alphabets in the graph mean significant differences at 5% level by Tukey's test.

rice varieties in Indonesia, was grown with the recommended fertilizer application in Central Java, the grain yield by farmers who based their sowing timing on predictions was higher than those who missed the optimum timing because they did not rely on predictions (Fig. 4). The improvement in grain yield for the first group of farmers was significant when compared to the area's average grain yield, which was 3.42 t ha⁻¹ (Boling et al. 2008).

The obtained results can be applied to improve the predictability of WeRise, a decision support system for rainfed rice areas and another decision support system for rice that is operated in Indonesia. However, the improvement in grain yield should be combined with appropriate

fertilizer management in addition to optimum sowing timings. SINTEX-F predictions should be updated once a year and this entails a cost of 60,000 JPY/100 km². Other sources for seasonal climate predictions should be scouted in target countries in Southeast Asia for sustainable operation of the developed technology. In addition, a crop, soil, and local weather database must be developed as it is a prerequisite for ORYZA operation.

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Ground-penetrating radar can predict the soil depth at which the petroplinthic horizon starts in the Sudan Savanna, West Africa

In the Sudan Savanna (annual rainfall: 600–900 mm), Plinthosols having a petroplinthic (PP) horizon are widely distributed. Because the PP horizon reduces soil volume and storage of water and nutrients, crop production in areas occupied by Plinthosols becomes limited. However, the distribution of Plinthosols has not been precisely known and conventional soil surveys require too much cost and effort. Therefore, at the Institute of the Environment and Agricultural Research (INERA) Saria Station, Burkina Faso, we examined if ground-penetrating radar (GPR) can predict the soil depth at which the PP horizon

starts or the top boundary of the PP horizon (d in Fig. 1). GPR is an equipment that can be used to detect soil interfaces that have abrupt boundaries and contrasting soil materials. In this study, effective soil depth is defined as the soil depth at which the PP horizon starts (d in Fig. 1) since only the soils overlying the PP horizon would contribute to crop production.

Our findings are as follows:

- Because relative permittivity of the PP horizon (ϵ_2 in Fig. 1) is much higher than that of the overlying horizon (ϵ_1 in Fig. 1), GPR can predict the top boundary of the PP horizon (Figs. 1 and 2).
- Dominant soils in the Sudan Savanna (i.e., Ferric Lixisols, Petric Plinthosols and Pisoplinthic Petric Plinthosols) can be distinguished from the top boundary of the PP horizon (Ikazaki et al., 2018), and sorghum

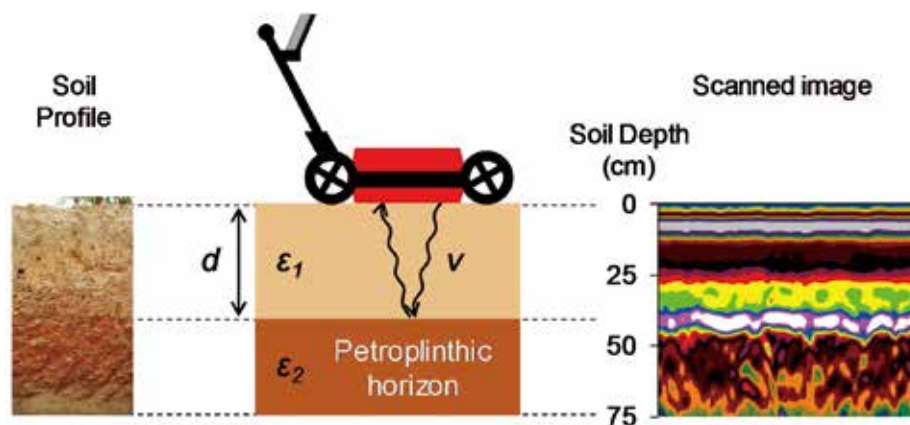


Fig. 1. Schematic diagram of the detection of the petroplinthic horizon

The soil depth at which the petroplinthic horizon starts (d) can be estimated by converting the time it took the radar to travel from the surface to the boundary, assuming that the electromagnetic wave velocity in a vacuum is 3.0×10^8 m sec⁻¹ and ϵ_1 was 3.0.

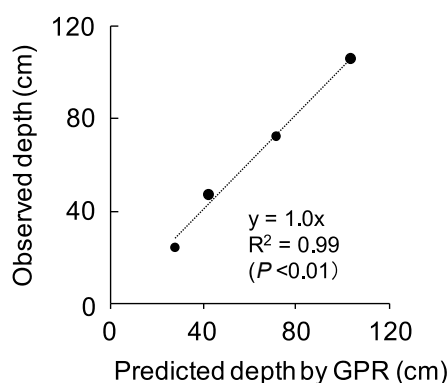


Fig. 2. Relationship between predicted depth and observed soil depth at which the petroplinthic horizon starts (d in Fig. 1)

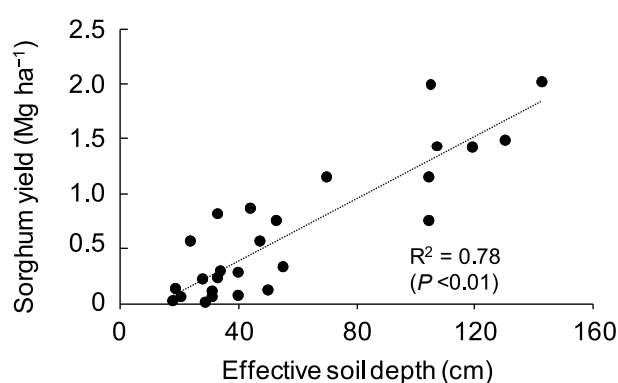


Fig. 3. Relationship between sorghum yield and effective soil depth (d in Fig. 1)

Figs. 2 and 3 are cited from Ikazaki et al. 2018. Soil Science and Plant Nutrition, 64(5), 623–631. doi:10.1080/00380768.2018.1502604

yield positively correlated with effective soil depth (Fig. 3). Therefore, maps of soil types and soil productivity can be easily created by using GPR (without conventional surveys).

- The top boundary of the PP horizon can be determined from a scanned image through a simple correction, enabling the procedure for making maps of soil types and soil productivity to become user friendly.
- Note that the above procedure can be applied only where the soil becomes very dry. This is because soil water having higher permittivity than PP horizons prevents GPR from detecting the top boundary of the PP horizon. This procedure may be applied to dry areas of

Brazil and East Africa where PP horizons are widely observed.

With these findings, researchers studying soil and water conservation, fertilization methods, crop breeding, and so forth would be able to take greater account of the inherent soil conditions, which in turn would accelerate their studies for achieving sustainable agriculture in the Sudan Savanna.

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TOPIC 5

Conservation agriculture without intercropping component can adequately control water erosion in the Sudan Savanna, West Africa

In the Sudan Savanna (annual rainfall: 600–900 mm), soil erosion caused by water is severe and a major threat to sustainable agriculture because it depletes soil nutrient and productivity. Conservation agriculture (CA) recommended by the FAO consists of three components: minimum soil disturbance, soil cover, and crop rotation/association. CA was expected to become an effective countermeasure against water erosion in the Sudan Savanna but it has not been adopted by local smallholder farmers because the three-component CA package is considered a heavy burden by farmers who have meager cash and labor resources. Therefore, we examined whether legume intercropping as a crop rotation/

association component is vitally necessary for preventing water erosion in the Sudan Savanna.

Three-year field experiments were conducted in runoff plots at the Institute of the Environment and Agricultural Research (INERA) Saria Station, Burkina Faso, and the following findings were obtained:

- Reduced soil loss in both three-component CA package and CA without intercropping was mainly attributed to the reduction in the runoff coefficient (not in the sediment concentration) (Fig. 1).
- CA without intercropping, i.e., with minimum tillage (MT) and sorghum residue mulching (SRM), effectively reduced the annual soil loss by 54% mainly due to the improvement of soil permeability by the boring of termites and wolf spiders found under the sorghum stover mulch (Figs. 2 and 3).
- When combined with MT and SRM, intercropping had no effect on soil erosion control

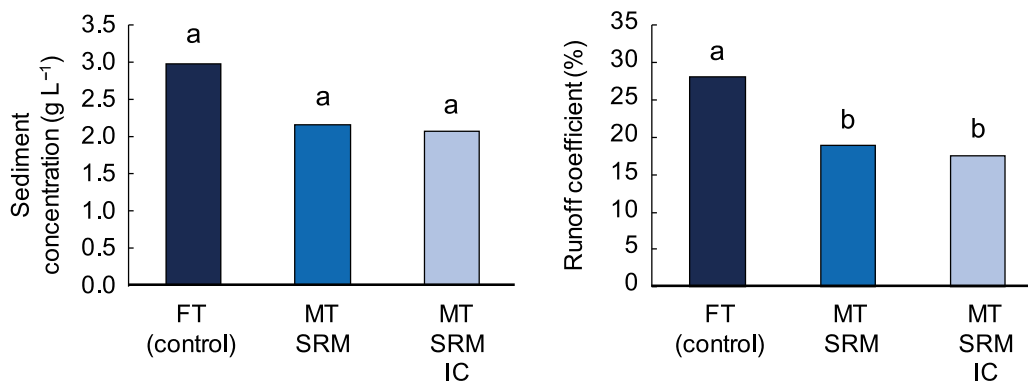


Fig. 1. Sediment concentration (left) and runoff coefficient (right) for each treatment
FT: full tillage, MT: minimum tillage, SRM: sorghum residue mulching, IC: intercropping
Mean values with different letters are significantly different between treatments ($P < 0.05$).

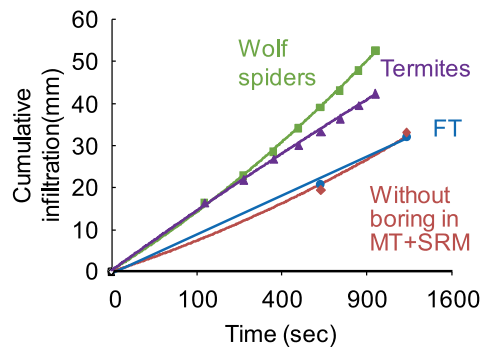


Fig. 2. Permeability of soils in full tillage plot (without animal holes) and soils with/without holes made by termites and wolf spiders in minimum tillage + sorghum residue mulching plot

Figs. 1-3 are cited from Ikazaki et al. 2018. *Soil Science and Plant Nutrition*, 64(2), 230-237. doi: 10.1080/00380768.2017.1422393

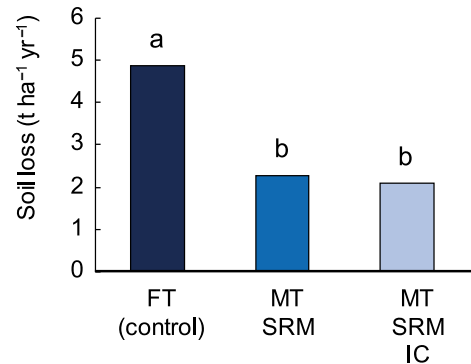


Fig. 3. Soil loss for each treatment

Mean values with different letters are significantly different between treatments ($P < 0.05$).

(Fig. 3), indicating that the third component of CA, namely legume intercropping, is not always necessary; rather, the two remaining components—minimum soil disturbance and soil cover—are sufficient for controlling water erosion in the Sudan Savanna.

These findings lighten the burden of adopting

CA, and thus facilitates its future promotion to the smallholder farmers in the Sudan Savanna.

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TOPIC 6

Simplified surge flow with improved furrow irrigation reduces infiltration loss and saves water

In arid lands, the groundwater table on irrigated farmlands has been rising due to the large amount of infiltration caused by excessive irrigation. As a result, salts become accumulated in the root zone, reducing agricultural production. In the Republic of Uzbekistan where large-scale irrigation development was carried out during the Soviet era, about 51% of irrigated farmlands are salt-affected, and it has become a serious problem. Water-saving methods such as the drip and sprinkler system are generally effective in controlling the groundwater table, but these were not adopted widely due to lack of facilities and funds. Hence, furrow irrigation with large infiltration loss was conducted in Uzbekistan's vast farmlands. Surge flow irrigation (SF) was applied in furrows to save water and reduce infiltration loss by supplying water intermittently. However, it required some investments such as water supply pipes and switching valves, thus leading to the development

of the simplified SF irrigation method.

Whereas conventional furrow irrigation is done once and SF around 4 times, simplified SF is done two times at 1-day intervals. When irrigating a 100-m furrow by Simplified SF, irrigation is carried out by supplying water from 0 m to 50 m (stopped upon reaching 50 m) (1st irrigation, SF-1). One day later, water is supplied from 0 m to 100 m (2nd irrigation, SF-2) (Fig. 1). By wetting one day before, water infiltration at the wet furrow (SF-2 condition) became slower than at the dry furrow (SF-1 condition), and the cumulative infiltration after 60 minutes decreased by 67% compared with the dry furrow (Fig. 2). Moreover, at an inflow rate to furrow of 1.7 L s⁻¹, water advanced faster during 2nd irrigation due to the decrease in infiltration following the 1st irrigation. As a result, the arrival time to the furrow end and total irrigation time became shorter (Fig. 3) compared with conventional irrigation. In the case of irrigating the 100-m furrow at a 1.7 L s⁻¹ inflow rate, simplified SF saved water by 19% compared with conventional irrigation. Further, when furrow length was shortened to 50 m, the water-saving effect increased to 22%. In the case

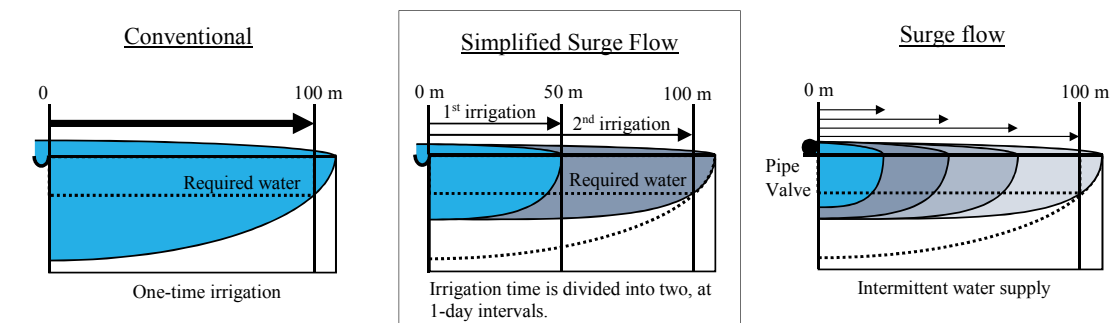


Fig. 1. Comparison between simplified SF and conventional furrow irrigation

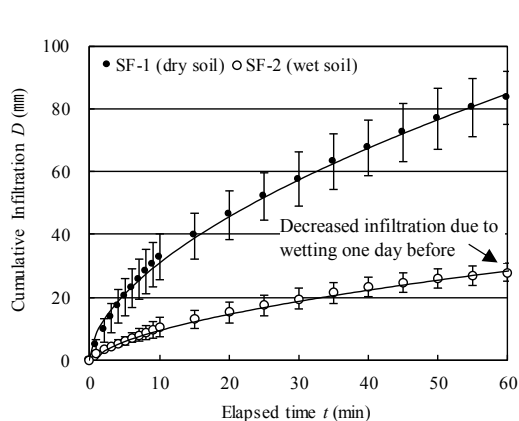


Fig. 2. Infiltration of water into the dry/wet furrow

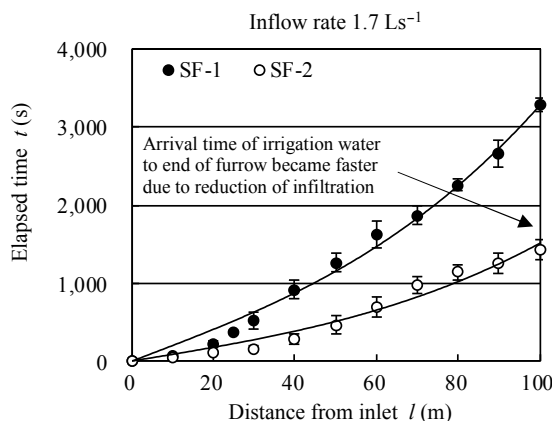


Fig. 3. Arrival times of irrigation water to each point along the furrow

Table 1. Water-saving effect and application efficiency of the Simplified Surge Flow method

Inflow (Ls^{-1})	Length (m)	Required water [RW] (m^3)	Treatment	Time (sec)		Supplied water [SW] (m^3)		Water-saving ratio*) (%)	Application efficiency [RW/SW] (%)
				Ave	Std	Ave	Std		
1.70	100	2.45	Conventional	3,289	88.2	5.59	0.15	-	43.8
	100	2.45	Simplified SF	2,667	229.3	4.53	0.39	19.0	54.1
	50	1.22	Conventional	1,299	152.6	2.21	0.26	-	55.2
	50	1.22	Simplified SF	1,014	57.5	1.72	0.10	22.2	70.9
5.00	100	2.45	Conventional	1,148	95.7	5.74	0.48	-	42.7
	100	2.45	Simplified SF	1,392	99.0	6.96	0.50	-21.3	35.2

*) Ratio of water-saving amount by Simplified SF to amount of supplied water by conventional over the same length of the furrow

of irrigating the 100-m furrow at a 5 Ls^{-1} inflow rate, even conventional irrigation could reach the furrow end in a short time as there is no reduction in the water-advance speed; apparently, under this scenario, simplified SF (i.e., irrigation done two times) does not conserve water.

Simplified SF would be most applicable as a surface irrigation method in farmlands with highly permeable soils. When applying simplified SF, farmers should consider the furrow length, the inflow rate, and the water-advance speed in the furrow. Inflow rates and water-advance speeds are affected by the slope and unevenness of the farmland; thus, to generate enough water-saving by simplified SF, land leveling at 1/500 to 1/1,000 slopes and making precise furrows are necessary. In Uzbekistan, water-saving efforts

by farmers are lacking because water fees are collected based on farmland area. Nevertheless, simplified SF can help control water table rise, thereby reducing salt accumulation, saving water, and extending the cultivation area.

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Countermeasures against freshwater lens pollution on atolls should consider the groundwater residence time

In Small Island Developing States (SIDS) where the land is formed by low-level atolls of up to several meters in height above sea level, vulnerable fresh groundwater lenses are often used as the main water resources. However, soil permeability in atoll islands is fairly rapid, and there is a high risk of groundwater pollution due to infiltration of domestic sewage from villages directly above and by drainage water from cropland and piggeries. Therefore, understanding the actual situation and taking measures for the effective management of water resources are necessary. A survey was carried out to assess the actual situation of nitrate-nitrogen ($\text{NO}_3\text{-N}$) pollution in a freshwater lens in Laura Island, Majuro Atoll, Republic of the Marshall Islands (Fig. 1), and the pollution risk was estimated based on the nitrogen load from houses, piggeries, and cropland, which was calculated by multiplying household survey data by the reported nitrogen basic unit. Here we propose an effective way of managing the freshwater lens while applying countermeasures against groundwater pollution, taking into account the groundwater residence time.

$\text{NO}_3\text{-N}$ concentration exceeded the WHO standard for drinking water (11 mg L^{-1}) at one household well out of the 73 surveyed wells in the study area, with relatively high $\text{NO}_3\text{-N}$ concentrations noted in the southeast and northwest sides of the island (Fig. 2). Nitrogen load was estimated for each main source by multiplying the respective number of people and pigs and cropland area by basic unit (amount of N per unit). Sum of nitrogen emissions on the

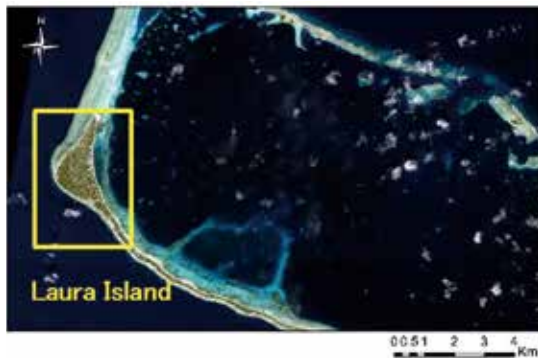


Fig. 1. Laura Island in Majuro Atoll, Republic of the Marshall Islands

island was estimated in the following order (from largest): piggeries>houses>cropland, while the nitrogen emission per source was estimated to be in this order (from largest): piggeries>cropland>houses (Table 1). If the influence of human or volcanic activity is not large, it is noted that the concentration of non-sea-salt calcium ion dissolved in groundwater reflects on the length

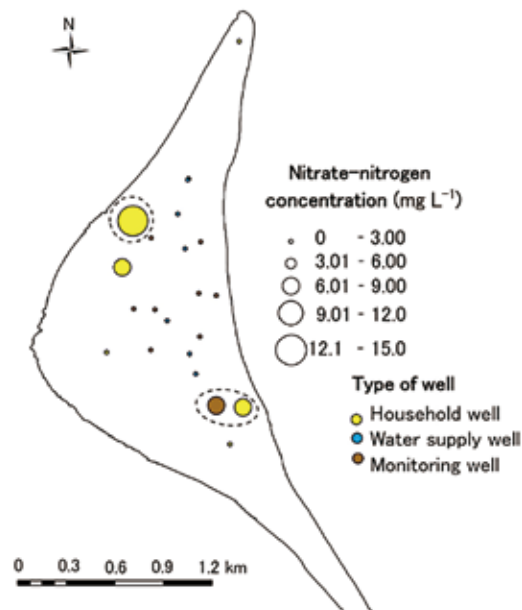


Fig. 2. Nitrate-nitrogen concentrations of groundwater in Laura Island (Feb. - Mar. 2011)

Table 1. Nitrogen loads from houses, piggeries and cropland in Laura Island

	Houses*	Piggeries*	Cropland*
Sum of nitrogen emissions (N g/day)	16,000	18,000	9,200
Average nitrogen emissions (N g/day)	70	210	120
Maximum nitrogen emissions (N g/day)	310	5,100	2,200
Ratio of each nitrogen source to total nitrogen emissions from anthropogenic sources (%)	37	42	21

*[Unit of nitrogen emission sources] Houses: one house, Piggeries: one piggery, Cropland: parcel of cropland

of groundwater residence time in the limestone area. Thus, we propose an original simplified index of groundwater residence time called $Inssal-Ca^{2+}$ (Fig. 3). When all the groundwater is recharged from seawater, the value of $Inssal-Ca^{2+}$ is 1. A higher $Inssal-Ca^{2+}$ value indicates longer residence time of groundwater because it indicates the ratio of dissolved total calcium ion to expected sea-salt calcium ion. According to our results, $Inssal-Ca^{2+}$ values of household wells in the open sea side and southern side of the island were relatively high. There is a high possibility that residence time of groundwater in these areas was relatively high. Countermeasures are required in consideration of the protracted pollution of groundwater.

The maximum NO_3-N concentration of groundwater at the study area was 13.0 mg L^{-1} , which exceeded the drinking water criterion by WHO. Due to this fact, the amount of nitrogen emission load to underground should be reduced. The results of this study will be used as basic data to reduce of nitrogen load seeping underground and contribute to the efficient implementation of the countermeasures. $Inssal-Ca^{2+}$ is a simple method; it is recommended that groundwater residence time is evaluated by multiple analyses of tritium, chlorofluorocarbons, and sulfur hexafluoride, etc. at multiple points.

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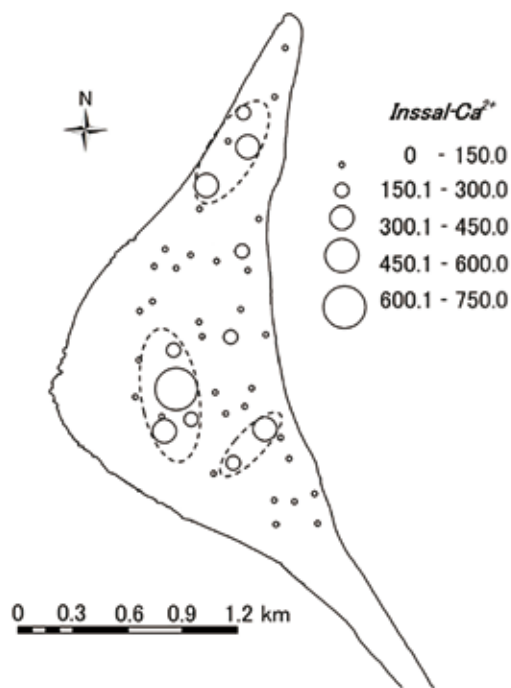


Fig. 3. $Inssal-Ca^{2+}$ values of groundwater in household wells (Jul. - Aug. 2011)

$Inssal-Ca^{2+}$ is an index of residence time of groundwater. It is calculated from the following formula:

$$Inssal-Ca^{2+} = \frac{[Diss-Ca^{2+}]}{[Diss-Cl^-] \times \frac{[Ssal-Ca^{2+}]}{[Ssal-Cl^-]}}$$

Diss: Dissolved in groundwater

Ssal: Seawater origin in groundwater

Cl^- : Chloride ion

Ca^{2+} : Calcium ion

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 a major challenge. 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.

[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. Program B's flagship project, titled “Development of sustainable technologies to increase agricultural productivity and improve food security in Africa,” was launched and is currently being implemented under the Fourth Medium to Long-term Plan period to tackle this huge challenge in front of us. The project aims to contribute to improving food security in SSA using the various outputs of our research activities in collaboration with national and international research institutions. The planned research for this flagship project was based on three major objectives, namely, to improve sustainability with efficient utilization of resources, to utilize unused germplasm efficiently, and to capture the preferences of consumers and needs of farmers. Moreover, the research activities were conducted and differentiated into three sub-themes as follows:

1. Rice production enhancement

For this sub-theme, we focused on generating essential components for efficient rice production in SSA. We have been breeding materials with improved nutrient uptake, developing a simple method for diagnosing soil nutrient conditions,

and adopting smart fertilizer management strategies specific to each soil and environmental condition while examining their integration and adaptation. 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 FY 2018, we carried out our research and obtained the following results.

In rice breeding, we conducted various activities for developing rice breeding materials with improved adaptation ability, grain quality, and yield performance in the African environment. For instance, we confirmed significant yield improvement in the field at AfricaRice in Senegal, where some near isogenic lines possessing a gene related to root elongation ability with the genetic background of major African varieties were cultivated. Promising lines with high yield performance were also selected from the field in Madagascar. On the other hand, in agronomy, we proved the effect of low-dose phosphorus fertilizer application in a farmer's field in Madagascar by dipping seedling roots into a mixture of fertilizer and mud before transplanting. Similar rice yields were achieved with smaller amounts of phosphorus fertilizer rather than normal top-dress application.

In agricultural engineering, the effect of laying mud to prevent water leakage from the bottom of a small reservoir was confirmed through monitoring of the small reservoir constructed for the Pair Pond System (PPS), as well as the repeatability of simulation results for calculating water volume changes and inflow using the curve number method.

Regarding local applicability and dissemination of PPS as one of the developed technologies for rice production enhancement, we clarified the comparative advantage (in terms of yields, income rates, etc.) of cultivating rice using supplemental irrigation over conventional rainfed rice cultivation. Quantification of the increase in income from women-led vegetable cultivation in the dry season using residual water and evaluation of the stability of domestic water supply from the small reservoir in the PPS were also performed.

2. Regional crop utilization

Cowpea and white Guinea yam are two important regional crops in West Africa, and they still hold tremendous potential for improving productivity and quality through utilization of unused genetic resources. As for improving the quality of the product, these diverse genetic resources must be compatible with various

demands that are deeply linked with regional culture and tradition. 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 FY2018, we developed a non-destructive method of evaluating shoot biomass for field-grown staking guinea yam that may be applied as a tool for effective phenotyping of agronomic traits in yam. We also completed the evaluation of various agronomic and quality traits of a selected germplasm set and a mapping population of guinea yam for further genome wide association study (GWAS). The obtained trait data was registered in YamBase, an open database.

On cowpea, F_2 generation seeds were generated from the F_1 progenies crossed among nominated materials from a mini-core collection and from elite breeding lines for the development of new breeding materials and also for genetic analysis. The relationship between soil type and productivity was identified based on the yield and growth patterns of cowpea lines cultivated in three distinct soil environments that prevail in the Sudan Savanna.

3. Crop-livestock integration

In tropical savanna areas with distinct rainy and dry seasons, we aim to develop an effective and efficient crop-livestock integration model by enhancing the utilization of natural resources leading to an increased and stable (year-round) dairy production and a sustainable agricultural system. To link crop and livestock, which are the two main components of the model, we are developing technologies toward stable production of animal feeds utilizing byproducts of crop production and food processing. On the other hand, to improve food crop production and achieve sustainable forage crop production by farmers, we are also developing a soil fertility management method that will enable the utilization of wastes from livestock farming.

In FY2018, we identified the number of cattle raised by all the dairy farmers and their locations in Manhica district, Maputo Province, Mozambique, which enabled us to understand the current milk production situation and to estimate its possible enhancement in the target area of the project.

We also conducted a census survey involving 402 farmer households in the second hamlet of Machiane village, Manhica district, where we are also conducting on-farm trials with the farming

survey.

In addition, we made progress on our study on silage and total mixed ration (TMR) as essential technologies in the crop-livestock integration model.

Moreover, in view of the fact that smallholders are dominant in SSA, we developed a farm management model to facilitate technology extension to smallholder farmers in Africa, who cultivate only a few hectares of farmlands, and thus improve their diets and livelihoods.

[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, we aim to develop breeding materials that have high temperature resistance, drought tolerance, phosphate deficiency resistance, and high nitrogen use efficiency. For soybean, development of breeding materials that are tolerant to drought and high salinity will be undertaken. In addition, we are aiming to 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 FY2018, we focused on the following research.

Seven lines with different QTLs associated with the surface root in rice were developed. A recombinant line of a novel QTL, which controls elongation of root growth under both ammonia nitrogen and nitrate nitrogen conditions, was selected. Along with the continuous field evaluation of the near-isogenic lines of a nitrogen utilization efficiency gene in the Philippine Rice Research Institute, backcrossing for the introduction of this gene into Philippine local rice varieties was continuously carried out. By genome-wide association analysis, a *qTIPS-11* gene controlling rice lateral root number was identified. In cooperation with Program D, which supervises the implementation of the goal-oriented basic research projects at JIRCAS, useful rice genetic resources and breeding materials that had been jointly developed with the International Rice Research Institute (IRRI) were introduced into Japan for future domestic rice breeding. For soybean, a wild soybean chromosome segment substitution line population, which may be used

for genetic analysis of important agronomic traits, was developed. To confirm the drought tolerance effect of a soybean root length QTL, backcross lines of this QTL were evaluated under natural drought conditions in Xinjiang, China. Meanwhile, backcrossing was continuously performed to introduce the salt tolerance gene *Ncl* into Chinese soybean commercial varieties. In addition, a space-saving, low-cost, and high-speed soybean hybridization technique was developed under growth chamber conditions. Moreover, rice lines produced using genome editing technology were evaluated, and an experimental system for evaluating salt tolerance in quinoa was established.

[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 FY2018, we focused on the following research:

1. To develop new sugarcane breeding materials, an intergeneric hybrid population between sugarcane and *Erianthus* was generated and the backcross progenies of intergeneric hybrids were evaluated in Thailand and at the Tropical Agriculture Research Front, JIRCAS.
2. To construct a linkage map of *Erianthus*, 4036 polymorphic DNA markers were obtained using the F₁ hybrid population of Thai *Erianthus*.
3. The feed value of fodder cane candidate varieties in Thailand was evaluated, with some candidates showing more than 40 t/ha of dry matter yield in ratoon cane cultivation.
4. The effect of introducing multi-purpose sugarcane (MPS) and a new inversion process for sugar and ethanol production in a sugar mill was evaluated using the life cycle assessment (LCA) method.

[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 are obtaining information on their occurrence, insecticide resistance, natural enemies, and the resistance of rice varieties in order to develop control techniques. Against desert locusts, we are elucidating the factors that provoke phase polyphenism -- from solitary to gregarious form -- by conducting field observations. Against sugarcane white leaf disease, we are developing 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 are developing 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 FY2018, we focused on the following research:

1. For rice planthoppers, we examined the susceptibility to neonicotinoid insecticides in brown planthoppers collected in Vietnam by topical application.
2. For the desert locust, we determined the spatiotemporal distribution pattern of the locust in Africa, and we revealed the relationship between crowding condition and egg size of locusts reared under semi-field conditions in Mauritania.
3. For sugarcane white leaf disease, we developed an insecticide application technique against a vector insect of the disease based on its population dynamics and the effective duration of the residual effects of insecticides.
4. To develop accumulated lines containing rice blast resistance genes with a susceptible line US-2 genetic background, we developed hybrid populations combining and harboring true and partial resistance genes.
5. To assess the performance of cultivars resistant to soybean rust, we compared disease severity and yield of newly developed cultivars (JFNC1 and JFNC2) in Paraguay.

Non-destructive shoot biomass evaluation for field-grown staking yam (*Dioscorea rotundata* Poir)

Yam is a minor but important tuber crop grown widely in temperate to tropical regions. The total yam-cultivated area is 7.5 million hectares, with an annual harvest of 65.9 million tons of tubers. West Africa is the largest yam-cultivating area, accounting for more than 94% of the world's yam production, with *Dioscorea rotundata* being the major species used for local consumption. However, the development of varieties in this

region has not benefitted from modern breeding. One reason for this slow breeding progress is the lack of phenotypic information on genetic resources due to the long growth period, low planting density, and method of reproduction (i.e., by vegetative propagation) that requires space, time, and effort for cultivation, thereby restricting the number of genetic resources in previous growth studies.

In this study, we developed a non-destructive method to predict shoot biomass by measuring spectral reflectance in staking yam. The normalized difference vegetation index (NDVI) was evaluated using a handheld sensor (GreenSeeker, Nikon Trimble, Tokyo, Japan) to vertically scan the plant from top to bottom along the length of the stake (Fig. 1). The scanning was carefully performed for 30 s per measurement, keeping the scan speed constant from top to bottom. To eliminate the background noise of the reflectance, a 1 m × 2 m board was placed behind the plant. A linear regression model was constructed to predict shoot biomass using NDVI as a parameter ($\text{NDVI} \times 297.6 + 4.7$). The observed values of shoot biomass, irrespective of the genotypes, were predicted well by the model (Fig. 2). Conversely, the model tended to underestimate the shoot biomass when the actual shoot biomass exceeded 150 g plant⁻¹; this was compensated for when the parameters of green area, calculated from plant image and plant height, were included in the model ($\text{NDVI} \times 120.9 + 205.9 \times \text{Green area} - 38.4 \times \text{Plant height} + 40.0$) (Fig. 3).

This method reduced the time, cost, effort, and field space needed for shoot biomass evaluation

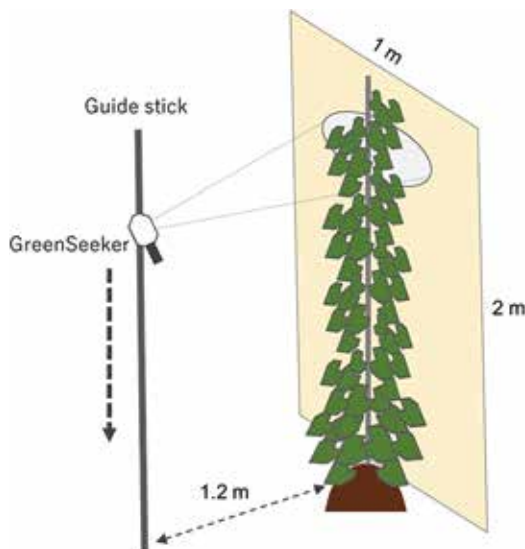


Fig. 1. NDVI measurement procedure for staking yam
The plant height was measured visually using the scale printed on the board behind the plant.

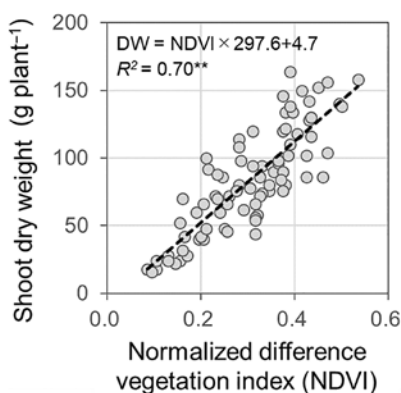


Fig. 2. Correlation between NDVI and observed shoot biomass
Model validation data of 30 yam accessions with 3 plant replications (n=90) were used.
** represents statistically significant at $P = 0.01$ level.

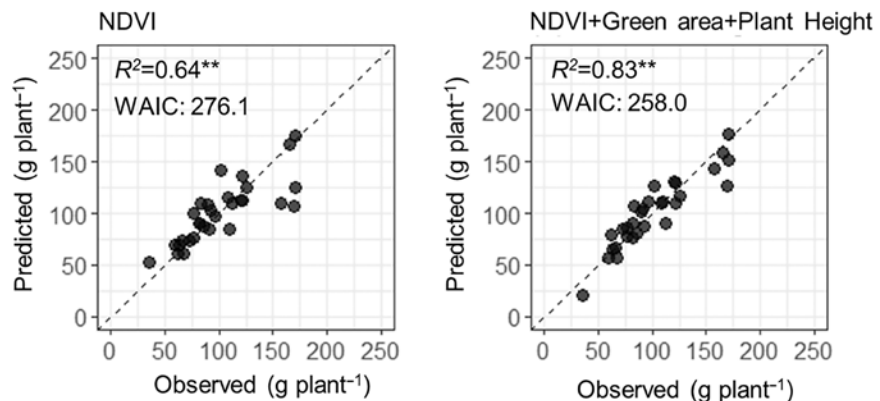


Fig. 3. Improvement of the model prediction using additional parameters of green area and plant height
Data of shoot biomass of the plants from different seed tuber size of same accession were used. Model performance was measured with the widely applicable information criterion (WAIC), where the smaller value represents better fitting.
** represents statistically significant at $P = 0.01$ level.

compared with that needed for the sampling method. The information on shoot biomass is widely available for growth analysis and for the evaluation of stress tolerance and crop models. In addition, the rapid phenotyping method fulfills the phenotypic information demands of a large number of genetic resources and cross populations. In combination with genetic tools, shoot biomass evaluation using NDVI will serve as a key method for accelerating yam breeding programs, as shown in major crops. In addition, good relationships between final tuber yield and

the value of NDVI at middle growth stage were observed, indicating that this method can also be used for early prediction of tuber yield. However, the predictions were not stable among years with different meteorological conditions. Further studies are needed to clarify the relationship between tuber yield and NDVI.

(K. Iseki,
R. Matsumoto [International Institute of
Tropical Agriculture])

TOPIC 2

A farm management model for assisting smallholder farmers in Africa

Most farmers in Sub-Saharan Africa are smallholders. This condition threatens food security in the region as smallholders cultivate only a few hectares of farmlands and face constraints on income generation. Although there is a strong focus on new agricultural technologies and policy interventions, only a few have shed light on farm management strategies that are acceptable and feasible to smallholders for improving their diets and livelihoods. The objective of this research, therefore, is to develop a new farm management model for assisting African smallholders.

Using the linear programming approach, we constructed a farm management model that computes the optimal crop and technology choices along with the optimal scales of introducing these crops and technologies to maximize the

total household income. With the necessary parameters covering farming conditions and indexes, conditions for food subsistence, and non-farm activities, the model gives a true picture of farm management optimized for African smallholders with their principal livelihood needs satisfied. These needs include 1) ensuring the area to produce enough subsistence crops for home consumption, 2) mixed cropping and intercropping as smallholders' coping strategies to production and marketing risks, and 3) ensuring non-farm income and labor distribution of farm and non-farm activities (Fig. 1). As a case study, we applied this model to smallholder farmers in the Nacala Corridor, northern Mozambique, and analyzed the optimal crop combinations in three different agroecological zones and farming scales. The results indicate that risk dispersion based on mixed cropping is effective especially in the eastern zone, which witnesses more frequent droughts and price fluctuations of agricultural products than other zones. Smallholders can also derive improved livelihoods from producing the

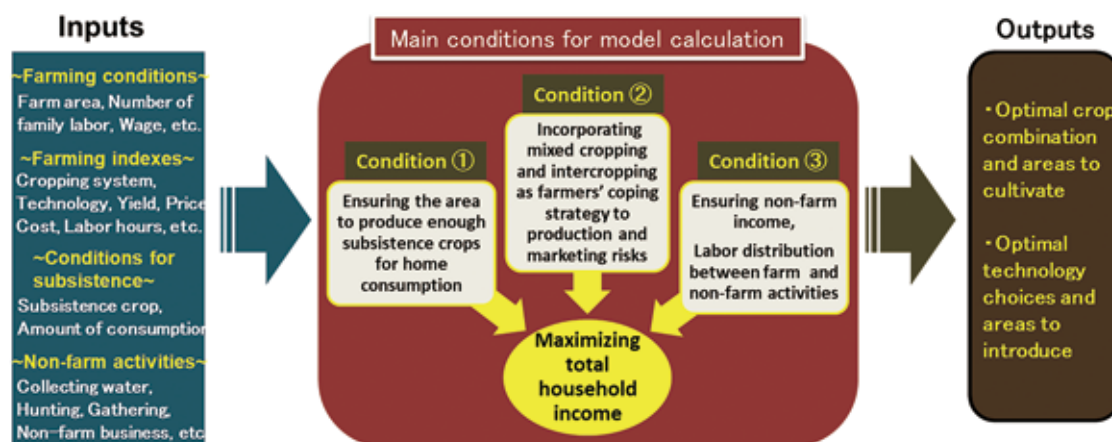


Fig. 1. A farm management model reflecting the conditions of African smallholder farming

Table 1. Optimal crop combinations in three different zones of the Nacala Corridor

		Optimal cropping area (ha)		
		I	II	III
Eastern	Total area	0.68	1.44	3.05
	Cassava+Maize+Cowpea mixed cropping	0.63	0.67	0
	Cassava+Maize+Cowpea+Peanut mixed cropping	0	0.69	2.92
	Sweet potato monocropping	0.05	0.08	0.13
Central	Total area	0.67	1.44	3.6
	Maize monocropping	0.29	0.48	0.54
	Sorghum monocropping	0.03	0.42	0.47
	Sorghum+Pigeon pea mixed cropping	0.32	0	0
	Soybean+Pigeon pea mixed cropping	0	0.54	2.59
	Rice monocropping	0.03	0.04	0.02
Western	Total area	0.71	1.49	3.9
	Maize+Common bean mixed cropping	0.65	0.85	0.95
	Sweet potato monocropping	0.06	0.64	2.95

I: Household category with less than 1 ha of farmlands

II: Household category with 1 to 2 ha of farmlands

III: Household category with more than 2 ha of farmlands

The optimal combinations consist of major crops and cropping systems identified by a field survey of 645 randomly-sampled smallholder farmers. The observed values of their farming conditions and indexes and non-farm activities are reflected into the model.

most lucrative beans (e.g. groundnut, soybean) and tubers (e.g. sweet potato) cultivated in each zone, with the major food staples produced as well, to achieve food self-sufficiency especially among those with more than 1 ha of farmlands (Table 1). As shown in Figure 2, their total income could increase substantially while those with less than 1 ha have little room to increase their income because of the difficulty in meeting food self-sufficiency needs with the actual crop yields. To facilitate the model analyses, we also developed the user-friendly programs named

BFMe (in English) and BFMmz (in Portuguese). Using these programs, the expected local users including agricultural extension agencies can easily implement the model to identify optimal farming plans for smallholders as well as scenarios of their technology uptake.

The model allows not only observed values but also predicted values for computation. One may use, for instance, the yields predicted using a crop model. Samples of smallholder farming in the three zones of Nacala Corridor are also available. Some may derive the optimal farming plans from using these samples for reference or change the parameters for simulation, while others may use original data collected for their own analyses.

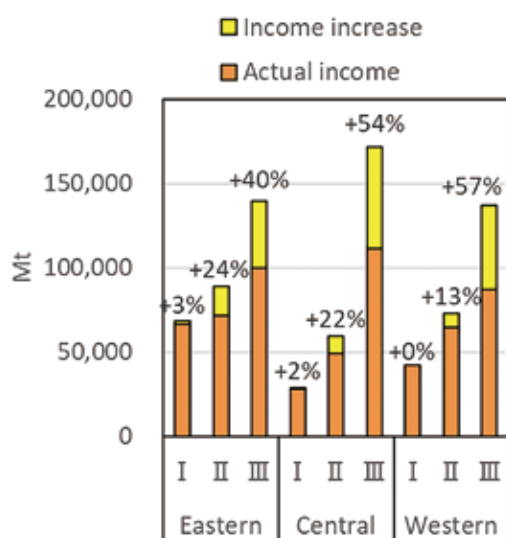


Fig. 2. Income increase by optimizing crop combinations in each zone and farming scale

I, II, III: Same as Table 1

Mt: Metical (currency of Mozambique)

Rate of income increase is indicated above the bars.

(J. Koide,
R. Yamada [Tokyo University of Agriculture],
W. Oishi [University of Tsukuba],
A. Nhantumbo [Agricultural Research Institute
of Mozambique (IIAM)],
V. Salegua [IIAM], C. Sumila [IIAM])

Identification of a quantitative trait locus associated with development of lateral roots in rice employing a genome-wide association study

In recent decades, lowland rice (*Oryza sativa* L.) cultivation practices have shifted away from the standard system of field puddling and transplanting towards direct seeding. Seedling vigor is an important trait for direct-seeded rice but most modern *indica* varieties were developed for transplanted rice cultivation and are therefore not expected to have good early seedling vigor. Rapid mobilization of carbon and nutrient reserves stored in the seed is an important determinant of seedling vigor; however, it needs to be supported by the rapid establishment of a root system that can supply additional nutrients and water to the seedling. In rice, nutrient and

water uptake is dependent on the abundant presence of lateral roots. Our objective in this study was to map quantitative trait loci (QTL) for early lateral root development and to identify associated candidate genes.

A panel of 307 genotypes including 284 *indica* genotypes was grown in low-phosphorus nutrient solution for a 14-day period. Digital images of entire root systems were analyzed using the WinRhizo software, which provided an estimate of total root tip number present in the root system (Fig. 1A). As this figure indicates, the vast majority of root tips are tips of fine lateral roots in rice, highlighted here by yellow dots. Using genome-wide association studies (GWAS), we identified one association on chromosome 11 for root tip number (*qTIPS-11*) (Fig. 1B). The positive haplotype occurred at a low frequency (5.4%) in the panel and increased root tip number by 27.4% (Fig. 1C). The rare nature of the

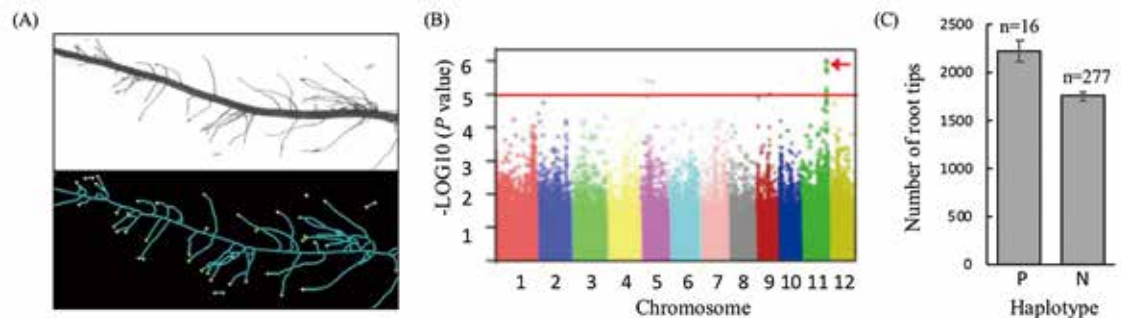


Fig. 1. Detection of a QTL related to lateral root development through GWAS

(A) Example of digital image analysis of a root segment with scanned image (top) and processed image with root tips indicated by yellow dots (bottom). (B) Manhattan plot indicating significant association between SNP markers on all 12 chromosomes of rice and root tip number. The vertical axis indicates the strength of this association with a threshold set at $P = 1.0 \times 10^{-5}$. (C) Difference between positive (P) and negative (N) haplotypes at *qTIPS-11* on root tip number.

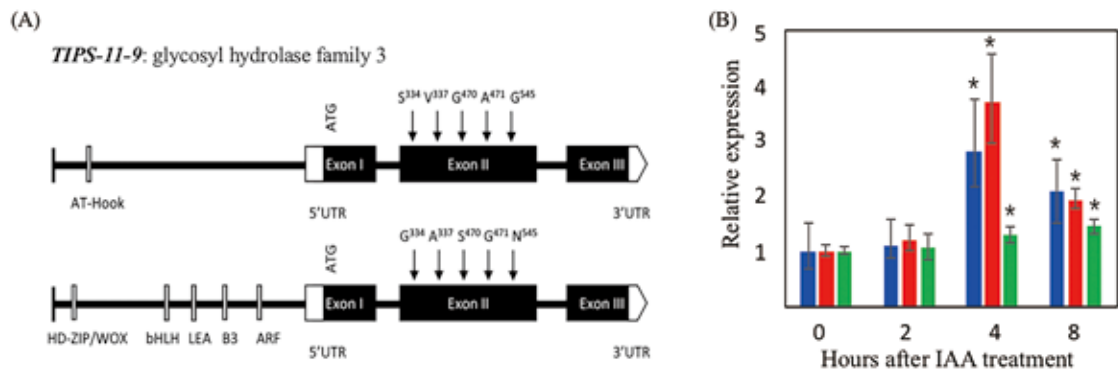


Fig. 2. Characterization of candidate gene *TIPS-11-9* for lateral root development at *qTIPS-11*

(A) Allelic differences for *TIPS-11-9* with negative allele (top) and positive allele (bottom). The positive allele contains an auxin response factor (ARF). (B) Expression of *TIPS-11-9* in roots of *qTIPS-11* positive accessions Milyang 30 (blue) and Kitaake (red), relative to expression in the negative accession Cauvery (green) in response to auxin (IAA) addition to the rooting medium. Gene expression is shown relative to expression in Cauvery at 0 hours.

positive haplotype at *qTIPS-11* was confirmed in silico within the 3,000 sequenced rice genomes (SNP-Seek), of which only 183 accessions, predominantly belonging to the *japonica* subspecies (71.6%), had the positive haplotype. The positive haplotype was largely absent from *indica* type accessions.

The putative auxin-responsive glucosyl hydrolase (*TIPS-11-9*; Os11g44950) was identified as a candidate gene (Fig. 2A) because genes responsible for cell wall hydrolysis are needed to facilitate the growth of laterals through several layers of cortical and epidermal cells during root emergence. A T-DNA knock-out mutant of *TIPS-11-9* had a 25% reduction in root tip number compared to wild-type, confirming the importance of *TIPS-11-9*. Two allelic forms of *TIPS-11-9* were detected of which the negative allele is missing the auxin response factor (ARF)

(Fig. 2A). Expression of *TIPS-11-9* was induced by auxin (IAA) addition only in the positive accessions (Fig. 2B), suggesting an allele-specific response of *TIPS-11-9* to auxin. Auxin has been implicated in lateral root emergence and development, and thus *TIPS-11-9* may be involved in auxin-regulated lateral root formation or development, or both.

Marker-assisted introgression of *qTIPS-11* into modern *indica* varieties will aid in the generation of varieties adapted to direct seeding and to nutrient-limited environments. Clarification of the functions of *qTIPS-11* throughout the life cycle of rice will be required.

(M. Wissuwa, F. Wang, T. Ishizaki, J.P. Tanaka, T. Kretschmar [International Rice Research Institute])

TOPIC 4

Development of wild soybean chromosome segment substitution lines for genetic studies of important traits

Wild soybean (*Glycine soja* Sieb. & Zucc.) is believed to be the progenitor of cultivated soybean (*G. max* (L.) Merr.). It has been revealed that wild soybean has higher genetic diversity than cultivated soybean, presenting a potential genetic resource pool for improvement of the latter. However, the inheritance mode of many important agronomic traits, such as seed quality, grain yield, and tolerance to environmental stresses, is extremely complex, and their performances are greatly affected by the genetic background and growth environment, making it difficult to identify the useful genes possessed by wild soybean. In this study, we created wild soybean chromosome segment substitution lines (CSSLs), in which the cultivated soybean chromosomes were replaced by only one or a few small chromosome segments of wild soybean, and thus these lines have similar genetic background but differ only in the small wild soybean chromosome region(s). We employed the CSSLs for genetic analysis of some important agronomic traits in soybean and demonstrated that the CSSLs might accelerate the identification of useful genes in wild soybean.

A total of 120 BC₃F₅ CSSLs were developed

from a cross between the cultivated soybean variety 'Jackson' and the wild soybean accession 'JWS156-1.' These lines were created by backcrossing of {[(('Jackson' × 'JWS156-1') × 'Jackson') × 'Jackson'] × 'Jackson'} and five successive generations of self-pollination without any selection. A total of 235 SSR soybean markers from all 20 chromosomes were used for genotyping the 120 CSSLs. The proportion of the recurrent parent 'Jackson' alleles in each CSSL ranged from 80.3% to 99.2% with an average of $92.9 \pm 4.0\%$, which corresponded to the expected value, 93.8% (Fig. 1).

To identify the quantitative trait locus (QTL) of seed weight, which is one of the most important traits that control soybean yield, the 120 CSSLs were cultivated in field conditions over three years and the seed weight trait was measured for each CSSL. QTL analysis detected nine QTLs (*qSW8.1*, *qSW9.1*, *qSW12.1*, *qSW13.1*, *qSW14.1*, *qSW16.1*, *qSW17.1*, *qSW17.2*, and *qSW20.1*) on eight chromosomes. Of these, *qSW12.1* was detected over the three successive years on a region of 1,348 kb in chromosome 12 as a novel, stable, and major seed weight QTL (Fig. 2).

In order to identify new flowering time QTLs, we evaluated the 120 CSSLs over two years under field conditions. Four QTLs (*qFT07.1*, *qFT12.1*, *qFT12.2*, and *qFT19.1*) were detected on three chromosomes. Of these, *qFT12.1* showed the highest effect, accounting for 36.37-38.27% of the total phenotypic variation over two years.

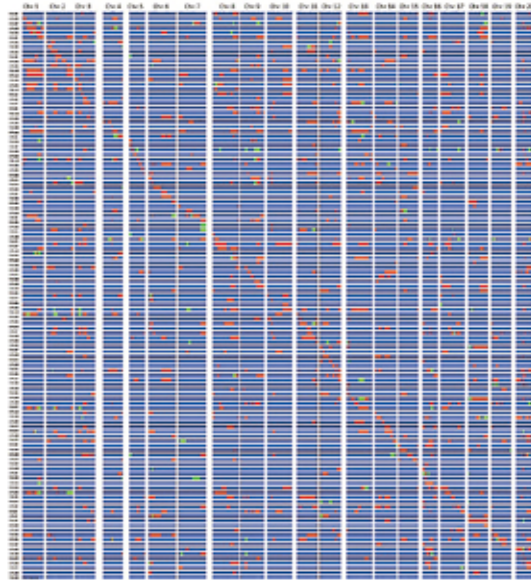


Fig. 1. Graphical genotypes of the wild soybean 'JWS156-1' chromosome segment substitution lines (CSSLs) in the cultivated soybean variety 'Jackson' background

Red: 'JWS156-1' homozygous, blue: 'Jackson' homozygous, green: heterozygous. This figure is modified from Liu D et al. (2018a) (Copyright: Japanese Society of Breeding).

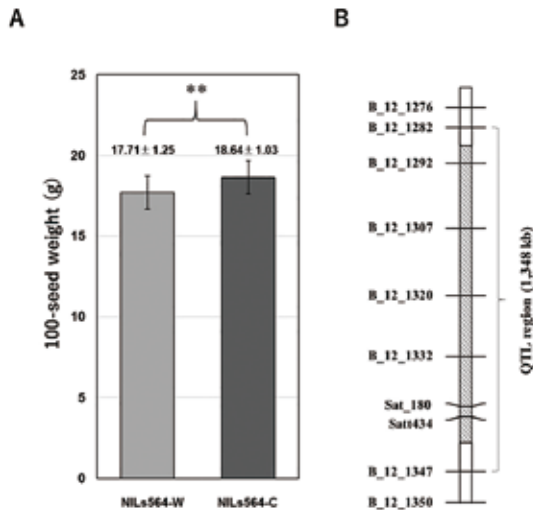


Fig. 2. Seed weight QTL *qSW12.1* detected in the wild soybean CSSLs population

(A) The allele effect of *qSW12.1* in near-isogenic lines NILs564-C ('Jackson' genotype) and NILs564-W ('JWS156-1' genotype). Data are shown as means \pm SD (standard deviation). **: $P < 0.01$. (B) *qSW12.1* was delimited in a 1,348-kb interval on chromosome 12. This figure is modified from Liu D et al. (2018a) (Copyright: Japanese Society of Breeding).

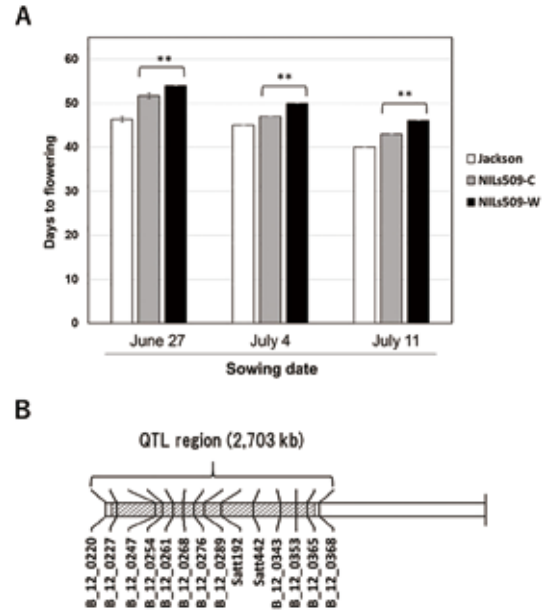


Fig. 3. Flowering time QTL *qFT12.1* detected in the wild soybean CSSL population

(A) Allelic effects of *qFT12.1* in near-isogenic lines (NILs) sown in the field on different dates in 2017. NILs509-C: 'Jackson' genotype, NILs509-W: 'JWS156-1' genotype. Data are shown as means \pm SD (standard deviation). **: $P < 0.01$. (B) *qFT12.1* was delimited in a 2,703-kb interval on chromosome 12. This figure is modified from Liu D et al. (2018b) (Copyright: Springer Science + Business Media B.V.).

qFT12.1 may be a new flowering time gene locus in soybean (Fig. 3).

In our study, a BC_3F_5 CSSL population has been developed. Since some CSSLs still have wild soybean segments or heterozygous regions other than the target wild soybean substitution segment, further backcrossing and DNA marker selection are needed for eliminating such redundant wild segments in the CSSLs. Nevertheless, the developed CSSL population has potential for mining useful genes in wild soybean.

(D. Xu, Y. Fujita, D. Liu)

Accelerating soybean breeding in a CO₂-supplemented growth chamber

Soybean (*Glycine max* L. Merr.) originated in East Asia, including Japan, and is the most important dicot crop worldwide. Soybean is increasingly used as a model legume due to the availability of genomic resources in this species, and the decreasing cost of sequencing has further encouraged plant researchers to shift their focus from model plants to soybean. Nonetheless, the long generation times of this crop pose a major obstacle to soybean research and breeding. Recently, Watson et al. (2018, *Nature Plants*) reported a speed breeding method for reducing the generation times of long-day crops such as

wheat and barley using a prolonged photoperiod; however, no useful methods for speed breeding short-day soybean plants have currently been published.

Here, we demonstrate a method for accelerating soybean breeding in the compact growth chambers (internal volumes of approximately 0.4 m³) with fluorescent lamps (220 $\mu\text{mol m}^{-2} \text{s}^{-1}$ at the canopy level) commonly used for laboratory research, which facilitate soybean breeding and research projects. We utilized the 14-h light (30°C)/10-h dark (25°C) cycle, which reduced flowering time, and the immature seeds to reduce reproductive phase. Additionally, supplementation of carbon dioxide (CO₂) over 400 ppm promoted soybean growth, yield, and number of healthy flowers, and thus our method also facilitates the highly efficient and controlled crossing of soybean plants. Using this approach, the generation time of the best-characterized



Fig. 1. Schematic representation of our method for accelerating breeding in soybean (cv. Enrei) in a growth chamber supplemented with CO₂

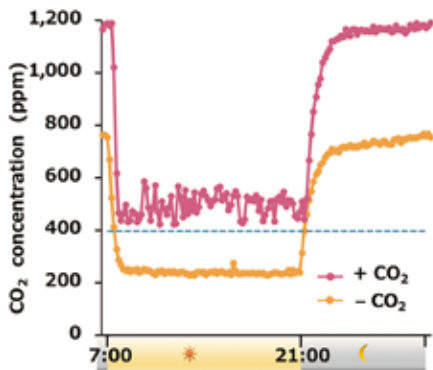


Fig. 2. The internal CO₂ concentrations within growth chambers containing soybean plants are decreased during light periods. The data were collected every 10 minutes over a single day, 25 days after flower initiation in the soybean plants.

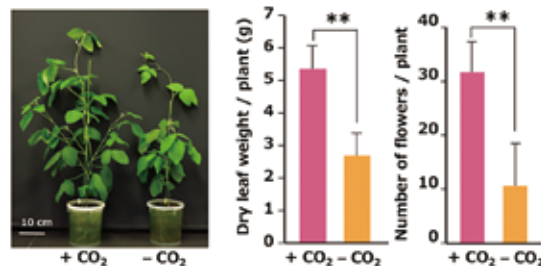


Fig. 3. CO₂ supplementation enhances soybean growth and flower number in growth chambers.

Images show 31-day-old soybean plants.

The graphs show the dry leaf weight per plant at 31 days after sowing, and the number of healthy flowers produced during the first 5 days of flowering in growth chambers. (n = 4, Bar = SD. **P < 0.01).

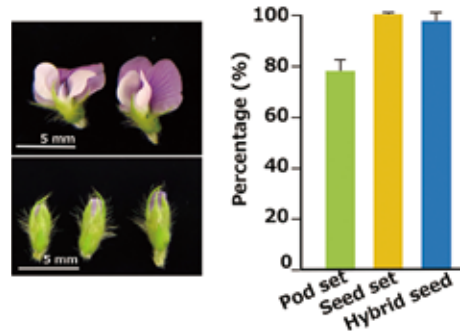


Fig. 4. The soybean flowers grown in the CO₂-supplemented growth chamber are useful for effective crossing.

Images show flowers (upper) and flower buds (lower) of soybean plants grown in the CO₂-supplemented growth chamber. The graph shows the crossing efficiencies in soybean plants grown in CO₂-supplemented growth chambers. (n = 36, Bar = SD.)

elite Japanese soybean cultivar, Enrei, was shortened to just 70 days, thereby allowing up to 5 generations per year with efficient crossing instead of the 1-2 generations currently possible in the field and/or greenhouse.

Thus, CO₂ supplementation and appropriate light and temperature conditions combined with immature seeds enable the acceleration of soybean breeding in the compact growth chambers. Given that each soybean cultivar can be cultivated only in limited latitudes, the

photoperiod conditions among the parameters in our method needs to be adapted for each cultivar. Alongside other protocols for speed breeding and effective phenotyping, the parameters used in our method could be optimized for a variety of species, cultivars, accessions, and experimental designs to facilitate cutting-edge breeding in a wide range of crops.

(Y. Nagatoshi, Y. Fujita)

TOPIC 6

Development of intergeneric F₁ hybrids between sugarcane and *Erianthus arundinaceus* as a new sugarcane breeding material

Sugarcane (*Saccharum* spp. hybrid) is an important crop for food and energy production, and further improvement of its productivity will contribute to promoting food sustainability and energy security around the world. However, its narrow genetic base has hindered the improvement of its productivity through breeding. For further improvement of sugarcane, broadening its genetic base by the introduction of new genetic resources is essential. *Erianthus arundinaceus*, a close relative, shows considerable potential as breeding material for sugarcane improvement owing to its high biomass productivity and exceptional adaptability to biotic and abiotic stresses. The aim of this study was to develop intergeneric F₁ hybrids between sugarcane and *E. arundinaceus*, and to evaluate their cytogenetic and agronomic characteristics for their effective utilization in sugarcane breeding.

From crosses between Japanese sugarcane variety NiF8 (2n = 110, female) and *E. arundinaceus* (2n = 60, male), we identified 39 hybrids by amplification of 5S rDNA markers and 2 hybrids

by morphological characteristics (Fig. 1). The number of *Erianthus* chromosomes in the hybrids varied from 18 to 29, even though “n+n” parental chromosome transmission occurred (Fig. 2). Some hybrids showed intra-clonal variation in *Erianthus* chromosome number between vegetatively propagated clones, and some hybrids could not be identified by 5S rDNA markers owing to the elimination of the *Erianthus* chromosomes with the 5S rDNA loci (Fig. 2). The number of *Erianthus* chromosomes

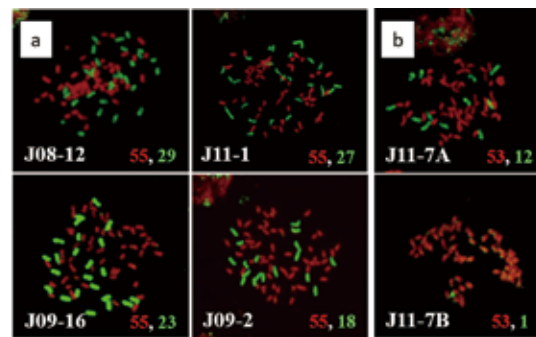


Fig. 2. GISH analysis of intergeneric hybrids

a: Variation of chromosome composition among hybrids. b: Variation of *Erianthus* chromosome number in vegetatively propagated clones of J11-7. J08-12, J11-1, J09-16 and J11-7 were screened by 5S rDNA but J09-2 was identified by morphological characteristics. Numbers in the bottom right corner indicate *Saccharum* (red) and *Erianthus* (green) chromosome number.



Fig. 1. Growth of intergeneric hybrids between sugarcane and *E. arundinaceus*

a: NiF8 (*Saccharum* spp. hybrid, female parent), b: J08-12 (intergeneric hybrid with no hybrid weakness), c: J11-14 (intergeneric hybrid with hybrid weakness), d: J09-2 (intergeneric hybrid selected by morphological characteristics). These pictures were taken on 8 May 2013 in the ratooning field at JIRCAS-TARF.

Table 1. Agronomic characteristics of intergeneric hybrids (New planting)

Characteristic	NiF8 Sugarcane (Female)	JW4 <i>Erianthus</i> (Male)	Intergeneric hybrids				Correlation with <i>Erianthus</i> chromosome no. (n=14) ²⁾
			Average (n=32)	Min. (n=32)	Max. (n=32)	CV _g (n=23) ¹⁾	
Dry matter yield (g/stool)	1621.9	1419.3	591.0	40.3	1713.2	68.6	0.773*
Number of stalks (no./stool)	6.4	43.4	10.8	1.0	22.1	40.2	0.336
Stalk length (cm)	119.5	64.8	67.6	15.0	125.8	39.5	0.457
Stalk diameter (mm)	21.8	10.7	12.1	5.9	16.6	17.4	0.697*
Sucrose content (%)	17.8	3.1	8.5	2.3	18.0	20.4	0.418
Fiber content (%)	10.2	23.4	16.7	8.0	22.4	15.1	-0.409

The evaluation of agronomic characteristics was conducted at JIRCAS-TARF. The seedlings of 32 intergeneric hybrids were transplanted in the experimental field on 22 May 2012 and harvested between the 18 and 22 February 2013. Five stools per plot (2.8 m²) with three replicates placed according to a randomized block design were prepared for 23 intergeneric hybrids and the parental varieties. Six hybrids were replicated twice and three others only once due to difficulties with multiplication. 1): Analysis of the genetic coefficient of variance (CV_g) were performed using data for the 23 hybrids for which three replicates were available. 2): The data of 14 intergeneric hybrids with no intra-clonal variation in 5S rDNA sites were used. *Significance at a 5% level.

in the intergeneric hybrids was strongly correlated with their DNA content, suggesting the possibility of estimating the number of *Erianthus* chromosomes in the hybrids from their DNA content (Fig. 3). Many hybrids showed “hybrid weakness” in yield-related characteristics, and their sucrose and fiber contents were comparable with the mid-parent values (Table 1). The number of *Erianthus* chromosomes in the hybrids was significantly positively correlated with some yield-related characteristics but not quality-related characteristics (Table 1). These hybrids showed high genetic coefficient of variance in agronomic characteristics, so the selection and utilization of hybrids with higher yields or higher sugar contents is possible (Table 1, Fig. 1).

The intergeneric F₁ hybrids developed in this study provide new materials for broadening the genetic base of sugarcane. The detailed information on their cytogenetic and agronomic characteristics will contribute to effective utilization of *Erianthus* in sugarcane breeding.

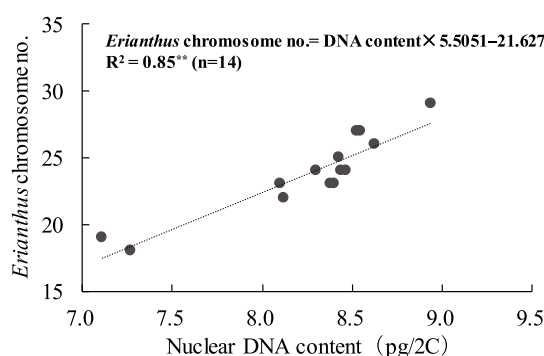


Fig. 3. Correlation between the nuclear DNA content and *Erianthus* chromosome number in intergeneric hybrids

The data of 14 intergeneric hybrids with no intra-clonal variation in 5S rDNA sites were used.

(Y. Terajima, H. Takagi,
P. Babil [Tokyo University of Agriculture],
N. Ohmido [Kobe University],
M. Ebina [National Agriculture and Food
Research Organization],
S. Irei [Okinawa Prefectural
Agricultural Research Center],
H. Hayashi [University of Tsukuba])

TOPIC 7

Spatiotemporal distribution patterns of the desert locust in Africa

The desert locust, *Schistocerca gregaria*, is one of the most destructive pests in the world. Sometimes, desert locust populations grow explosively, forming swarms and causing locust plagues. A plague can affect up to 20% of the earth's surface across Africa, the Middle East, and Southwest Asia. Desert locusts can potentially damage the livelihoods of a tenth of

the world's population. The preventive approach involves monitoring and spraying of locust breeding areas. However, this is difficult in practice as many of the principal breeding zones are in remote areas and difficult to reach. Despite these constraints, we will keep studying the locust and aim for efficient and sustainable control measures with due consideration to environmental well-being. We have learned, for example, that gregarious locusts can form a dense group at certain sites within a

day. If we can understand these spatiotemporal aggregation patterns, we can control locusts efficiently using only small amounts of pesticides. To obtain these ecological data, we have conducted field surveys in Mauritania in collaboration with the Mauritanian National Anti-Locust Center.

In the field, actively marching migratory bands of gregarious nymphs passed some plants before finally roosting and aggregating on patchily distributed trees around dusk (Fig. 1). Migratory bands formed the largest group on the largest tree within the local plant community (Fig. 2). They apparently chose the largest plants. Adults similarly roosted on large trees or medium-sized bushes (Fig. 3). Flight escape was the preferred defense when temperatures were above the minimum threshold for locust flight (22°C). At low temperatures, defense response to predator threat varied with plant size and locust height off the ground: locusts in low bushes dropped to the center of the bush and hid, whereas those above 2 m in trees remained stationary (Fig. 4). These alternative defense behaviors appear to be adaptive under the different environmental conditions. Flight escape is extremely effective



Fig. 1. Night-roosting site choice by gregarious nymphs of *Schistocerca gregaria*
Arrow indicates the largest tree roosted on by the largest locust group.

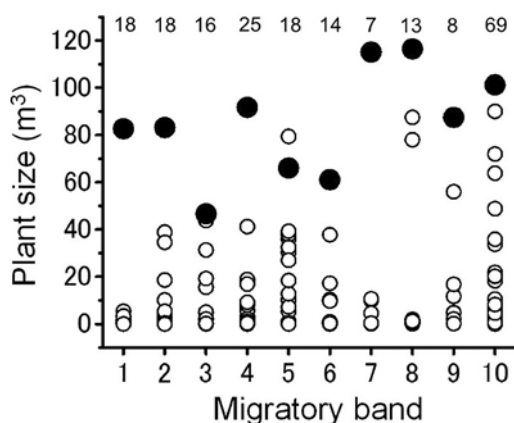


Fig. 2. Plant-size distribution at each site where 10 migratory bands of *Schistocerca gregaria* roosted
Closed circles indicate the plants roosted on by the largest locust group (the center) and open circles indicate other individual plants in the local site (within 20 m from the center). The largest aggregation formed on the largest tree within the plant community in nine of the ten bands. Figures at the top indicate the numbers of plants examined.



Fig. 3. Adult locusts roosting on the branches of a large tree during the night

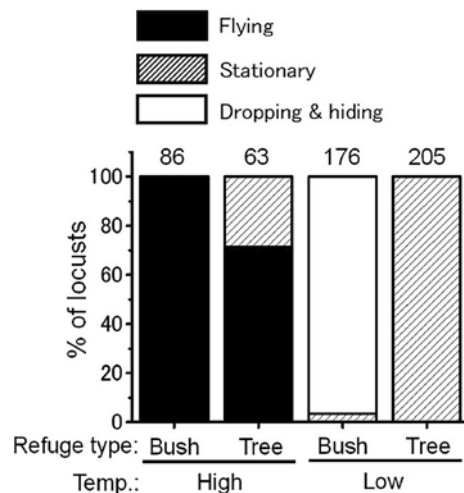


Fig. 4. Defensive responses exhibited by adults including flying, stationary, and dropping and hiding by using plants as a refuge
Adults perched on small bushes (< 1.5 m height) or large trees (> 2 m height) in the morning (07:30–08:30) when the ambient temperature was either higher or lower than their critical body temperature for flight (22°C). Figures at the top indicate sample sizes.

but cannot be performed under 22°C . Hence, alternative defenses (dropping or remaining stationary) are necessary. These defenses are effective at low temperatures because dynamic locomotion is not required.

Our results suggest that desert locusts integrate information about microhabitat, temperature, and threat characteristics to adaptively adjust defense tactics. Control operation and monitoring should consider these ecological characteristics especially because this plant-size-dependent roosting site choice during the night may contribute to the development of artificial trapping systems for locusts and a shift to a new environment-friendly, night control approach.

(K. Maeno,
S. Ould Mohamed [The Mauritanian National
Anti-Locust Centre])

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 aims to solve the problems related to the coordination of effective and sustainable food value chain cycles. The first major research subject relates to food scientific research and is composed of two themes, namely 1) Evaluation of local food resources and 2) Development of a utilization and processing 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 and traditional fermented foods, of which similar products appear widely in the Asian region, to be the main target foods.

A research team composed of scientists from JIRCAS and Kasetsart University (Thailand) elucidated the scientific mechanism causing the liquefaction of fermented rice noodle, *Khanom chin*, and demonstrated that liquefaction could be prevented by controlling the pH of the final product. Furthermore, they developed an intermediate processing material for producing *Khanom chin* by applying the pre-gelatinization technique.

JIRCAS and the National Agriculture and Forestry Research Institute (NAFRI), Lao PDR, collaborated in establishing a method of predicting grain yield in rice by UAV-based spectroscopy. Also, a team of economists from

JIRCAS and counterpart institutes investigated the food production and distribution systems in Thailand, Laos, and China, and clarified the characteristics of consumer behavior. Lastly, a workshop was organized by the Asian Food Resource Network in Bangkok where discussions were held about the food value chain and the practical use of research results.

[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. With an aim toward energy production through application of our technologies, the novel anaerobic thermophilic alkaliphilic microorganism *Herbivorax saccincola* A7 was isolated and has shown a strong lignocellulose-degrading ability.

According to the competitive genome sequencing results of *H. saccincola* A7 and other similar microbes, it was found that this strain possesses all the requisite genes for ammonia assimilation along with the transporters associated with alkaline stress tolerance. The enzyme activity assays revealed that cellulases and xylanases from strain A7 demonstrated greater activity and stability at an alkaline pH. These properties of *H. saccincola* A7 are involved in the use of cellulolytic/xylanolytic microbes in industrial applications.

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

In order to reduce poverty and improve nutritional status in Laos, rice-paddy fish culture and pond fish culture trials using Laotian indigenous species were conducted, with the results showing acceptable productivities with improvement in rice productivity. Furthermore, selection of high yield upland rice varieties has progressed well, and investigations into the potential functionalities of antioxidant contents in colored upland rice varieties are ongoing. Additionally, investigations of the trends in animal protein intake in mountainous rural villages were carried out, confirming the serious deficiency in protein intake particularly among villagers in the northern mountainous area. To improve this situation, detailed nutritional information on principally consumed fishes and shellfishes in rural areas were prepared. Moreover, regarding the efficient utilization of fishery resources, techniques for manufacturing safe fermented fish

products (Pa daek) were developed to reduce or eliminate histamine, a potential allergen.

[Higher Value Forestry]

In northern Thailand, trunk straightness index was applied to planted teak stands, with teak stands that have higher initial densities showing slightly higher trunk straightness. Draft maps showing soil physicochemical diversity and soil suitability for establishing a teak plantation were made based on soil cross section surveys, physicochemical analyses, tree census plots, and topographical data for a part of Luang Prabang Province in Lao PDR.

Gene expression analysis on secondary growth (trunk growth) and stem elongation in dipterocarp species were conducted in Malaysia. We identified some candidate genes for the regulation of leaf flushing, which may respond to temperature. An efficient method of estimating the total leaf area of a juvenile tree on the basis of light penetration process was developed. In addition, genetic diversity assessment and genome wide association studies were conducted in progeny trial forests in Indonesia planted with two dipterocarp species, with the results showing weak genetic structuring and the contribution of a large number of genes linked to growth traits in the tested dipterocarp species.

[Aquatic Production in Tropical Areas]

Development of technologies for sustainable aquatic production was conducted in Southeast Asian countries. In Malaysia, the potential causality of blood cockle culture and ground degradation was investigated by looking at shell morphology and measuring sediment oxidation-reduction potential in the sea bottom. In Myanmar, a cross-sectional environmental survey along the potential oyster habitat as well as biological studies on the edible bivalves were conducted. In Thailand, the co-culture system for giant tiger shrimp was improved by including a seaweed nursery and snails to facilitate self-reproduction. Also, antioxidant functional components in shrimps produced by the system were analyzed. In Laos, the reproductive biology of indigenous freshwater shrimps and the preferable rearing conditions for their larvae were studied in order to develop seedling production techniques. In the Philippines, the efficiency of the modified Integrated Multi-Trophic Aquaculture (IMTA) system for milkfish, seaweeds, and sea cucumber, and the usability of non-fish meal with poultry by-products on the growth of juvenile milkfish, were verified.

TOPIC 1

Estimation of rice grain yield by canopy hyperspectral sensing of paddy fields at the booting stage

Remote sensing is a promising tool for assessing growth status and predicting rice yield. Recent advances in unmanned aerial vehicles (UAVs) and sensor technologies have enabled farmers to frequently observe the paddy fields at low-altitudes. However, the optimal timing of UAV observations and the suitable sensor specifications for yield prediction are not clearly understood. Therefore, with the aim of improving UAV utilization for the future, field hyperspectral (HS) measurement at canopy scale was performed in a paddy field, and the optimum growth stage and spectral waveband for yield prediction were clarified.

The experimental results are summarized as follows:

- Canopy hyperspectral measurements were

conducted at different growth stages (Fig. 1, T1: Panicle initiation, T2: Booting stage, and T3: Milk stage) in an experimental paddy field where six Lao rice cultivars were tested with three replicates at the Rice Research Center (RRC) of the National Agriculture and Forestry Research Institute (NAFRI), Laos. Partial least squares (PLS) regression analyses that were not affected by the collinearity of HS data (400-930 nm, 531 bands) were performed to predict grain yield of rice. The predictive accuracies at three different growth stages were compared.

- Among the three growth stages, the highest values for predictive accuracy ($R^2 = 0.843$) and reproducibility of the model ($RPD > 2.43$) were obtained at the booting stage (Fig. 2).
- Although the predictive accuracy and reproducibility values were low ($R^2 = 0.479$, $RPD = 1.316$), the grain yield was predicted in the panicle initiation stage (Fig. 2).
- Grain yield might be difficult to predict after

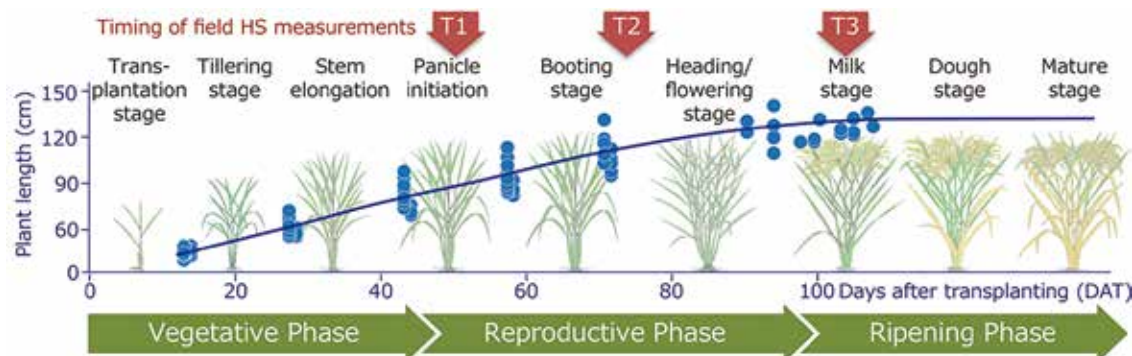


Fig. 1. Plant height and the timing of field HS measurements at different growth stages in a paddy field

Source of rice plant image data: <http://www.knowledgebank.irri.org/decision-tools/growth-stages-and-important-management-factors>

the milk stage when the rice plant's leaf color turns yellow (Fig. 2).

- Based on the selected wavebands in the PLS model at booting stage when the growth reaches its peak, the red-edge (700-760 nm) and near-infrared (810-820 nm) wavelength regions were selected as important wavebands for yield prediction (Fig. 3). These wavelengths are previously known to be closely related to plant aboveground biomass and nitrogen content, and they can be used to estimate the nutritional status of rice.

These results indicated that grain yield of rice could be predicted with practical accuracy by field HS measurement at the booting stage. Such timely and accurate rice yield assessments approximately one month prior to harvest will enable staffs at the regional agriculture and forestry offices and parties concerned with the

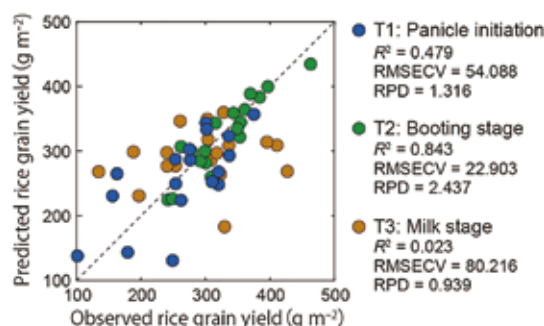


Fig. 2. Observed and predicted values of rice grain yield using PLS regression for datasets T1, T2, and T3 ($n = 18$)

RMSECV: Root mean squared errors of cross-validation using leave-one-out method.

RPD: Residual predictive deviation. The criteria for determination are (1) $RPD < 1.15$: unpredictable, (2) $1.16-1.40$: weakly correlated, (3) $1.41-1.70$: screening with low accuracy, (4) $1.71-2.42$: capable of screening, and (5) >2.43 : possible to estimate with practical accuracy.

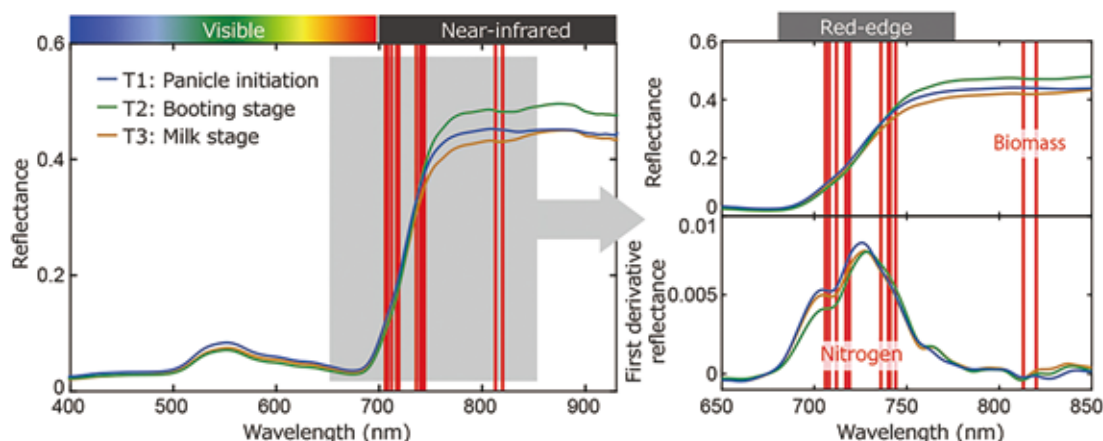


Fig. 3. Canopy reflectance and selected wavebands (red bars) in the ISE-PLS model for booting stage (T2)

rice market to quantify rice production, supply and market prices. Moreover, by installing a camera capable of measuring the red-edge and near-infrared wavelengths on UAVs, it may be possible to forecast yield over a wide area. It should be noted, however, that further analysis is required to verify whether similar results can be

obtained for cultivars in other areas, especially those with large differences in traits (e.g., plant height).

(K. Kawamura, H. Ikeura, S. Phongchanmaixay [National Agriculture and Forestry Research Institute, Laos])

***Herbivorax saccincola* A7, a novel alkaliphilic and thermophilic anaerobe, effectively degrades xylan-rich lignocellulosic biomass**

Highly efficient degradation of lignocellulosic materials (which contain a mixture of cellulose, hemicellulose, and lignin) by biological saccharification is required for developing a cost-effective method of producing fuel and chemicals from biomass. The known thermophilic anaerobes *Clostridium thermocellum* and *C. clariflavum* can degrade and assimilate cellulose. However, these species cannot utilize xylan, which is the main component of hemicellulose contained in lignocellulosic biomass. The amount of cellulose and hemicellulose in lignocellulosic biomass is similar, hence we explored and isolated a novel thermophilic anaerobe for its ability to degrade and assimilate both cellulose and xylan from a cellulose-degrading bacterial community inhabiting bovine manure compost in Ishigaki Island, Japan (Fig. 1A).

This strain was identified as *Herbivorax saccincola* A7 (hereinafter referred to as A7) based on 16S rRNA gene sequence similarity. A7 is closely related to the cellulose-degrading bacteria of *C. thermocellum* and *C. clariflavum*

in the family *Ruminococcaceae* (Fig. 1B). The optimal growth pH of A7 was alkaline pH 9.0, but *C. thermocellum*'s and *C. clariflavum*'s are at around neutral pH (Table 1). The genome size of A7 was 3.76 Mb with a G + C content of 34.9%. The genome contained 3,346 protein-coding regions, nine rRNA genes, and 54 tRNA genes from a total of 3,642 genes (Table 1). The 38 genes encoding glycosyl hydrolase were contained in the A7 genome. The ratio of xylanase to all glycosyl hydrolase was higher in A7 than in *C. thermocellum* and *C. clariflavum* (Table 1). In addition, A7 has genes that encode related protein to the metabolic pathway of xylose and xylooligosaccharide and for their uptake; *C. thermocellum* and *C. clariflavum*, on the other hand, do not possess these genes (Fig. 2). The metabolic pathway and transporters of xylose and xylooligosaccharide would enable A7 to assimilate xylan.

A7 can degrade lignocellulose biomass at alkaline and high temperature conditions, lowering the risk of bacterial contamination. In addition, the alkaliphilic microbe A7 can tolerate pH decrease with organic acid production by fermentation, sustaining the degradation activity longer than neutrophilic cellulose-degrading bacteria. As mentioned earlier, A7 can also assimilate xylan, thus this strain has

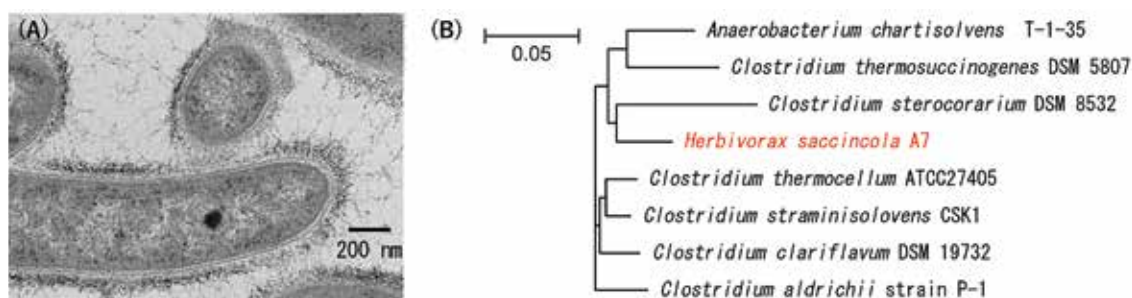


Fig. 1. Electron micrograph (A) and phylogenetic tree (B) of *H. saccincola* A7

Black-colored bar in photograph is 200 nm long.

Black-colored bar at the upper left of phylogenetic tree shows the ration of different base sequence (0.05).

Table 1. Physiological properties and comparative genome analysis of *H. saccincola* A7 with related species

Characteristic	<i>H. saccincola</i> A7	<i>C. clariflavum</i> DSM 19732	<i>C. thermocellum</i> ATCC27405
Optimal growth pH	9	7.5	7
Xylan assimilation	Yes	No	No
Genome size [Mb]	3.76	4.9	3.84
Total number of genes ^{*1}	3,346	3,906	3,204
Total number of glycolytic enzymes ^{*2}	38	47	42
Number of xylanases	8 (21%) ^{*3}	6 (12%) ^{*3}	1 (2%) ^{*3}

^{*1} Total number of protein coding genes

^{*2} Total number of glycosyl hydrolases containing cellulase, xylanase, and other activities

^{*3} Percentages in parentheses show the ratio of xylanase to total glycosyl hydrolases

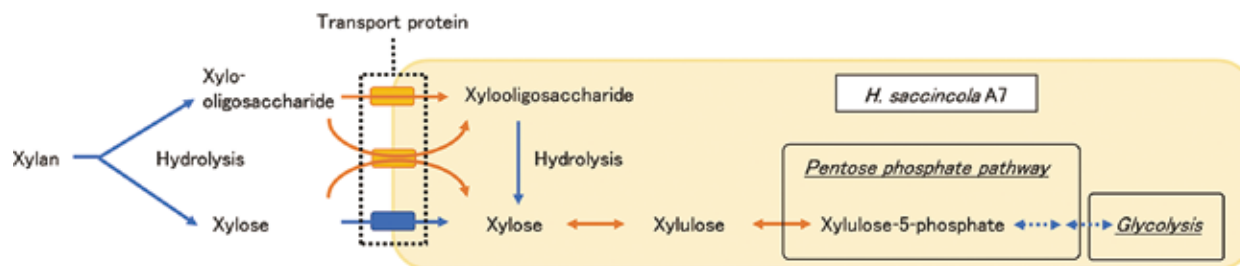


Fig. 2. Metabolic pathway of xylose and xylooligosaccharides in *H. saccincola* A7

Orange-colored pathways are specific genes in A7 and blue-colored pathways are possessed in common among related species.

great potential to effectively degrade xylan-rich lignocellulosic biomass such as empty fruit bunch, oil palm trunk, and corn stover (Patent application number PCT/JP2017/021784). A7 can be obtained from the Leibniz Institute DSMZ - German Collection of Microorganisms

and Cell Cultures (Deutsche Sammlung von Mikroorganismen und Zellkulturen GmbH) and the Japan Collection of Microorganisms (JCM), RIKEN BioResource Center (RIKEN BRC).

(S. Aikawa, A. Kosugi)

TOPIC 3

Climbing perch aquaculture is realizable in rice paddies under non-feeding conditions by rearing at low stocking densities

In Laos, national food demand has been increasing due to population growth, and animal protein deficiency among residents of mountainous rural areas is an important national concern. To improve this situation, fish aquaculture has been promoted but current major targets for aquaculture, e.g., the Nile tilapia and carps, are introduced species and further development of their aquaculture may cause great risks to biodiversity conservation in the area. In addition, the residents in such rural areas are economically deprived and cannot afford to build specific aquaculture infrastructures, e.g., culture cages and ponds. Therefore, we examined the feasibility of fish culture in a rice paddy (rice-fish culture) using a Laotian indigenous fish, the climbing perch (*Anabas testudineus*, Fig. 1), without investing in specific infrastructures, and we analyzed/evaluated several factors relevant to fish productivity in a rice-fish culture system.

Through four experimental culture trials in Nameuang and Napoh villages during 2013-2016, feeding condition (feeding or non-feeding), stocking density of fingerlings (fish/m²), stocking period (days) and fish size at stocking (g/fish) were analyzed as potential contributory factors to the BGI (biomass gain index = total weight of

fish at stocking / total weight of fish at harvest). We conducted linear regression analyses using all the combinations of the above four parameters. Feeding condition (F), stocking density (SD), and stocking period (SP) were eventually selected as contributory factors, while fish size at stocking (BW) was excluded (Fig. 2). Thereafter, we evaluated the contributory effects of each parameter by the regression coefficients of the model as $BGI = -27.9 \cdot SD - 0.53 \cdot SP + 6.07 \cdot F + 108.9$ ($R^2 = 0.96$) and found that stocking density was the most important contributory factor and that high BGI can be expected if reared at



Fig. 1. Rice paddy for fish culture (top) and the harvested climbing perch (bottom)

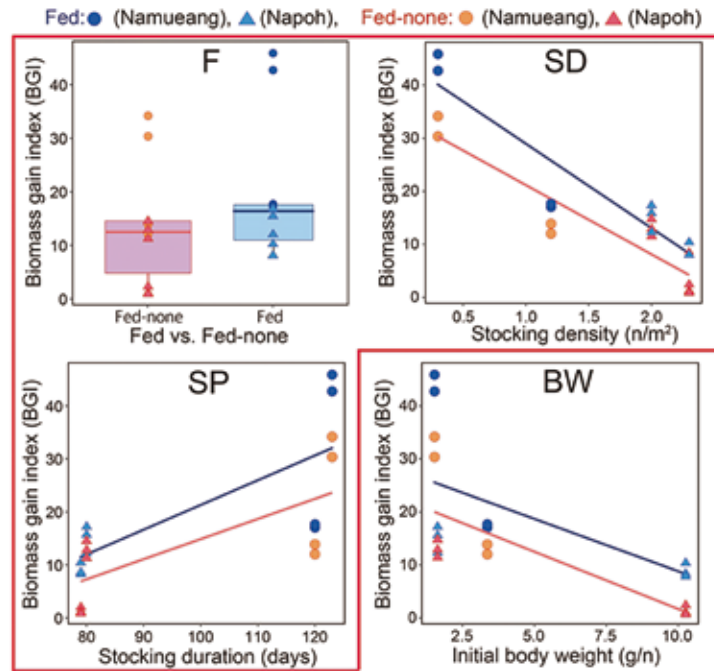


Fig. 2. Potential factors relevant to fish productivity (BGI) in a rice paddy [F: feeding or non-feeding, SD: stocking density of fingerlings, SP: stocking period, BW: weight of fingerling at stocking. F, SD & SP were selected as influential parameters by linear regression analyses, while BW was not selected]

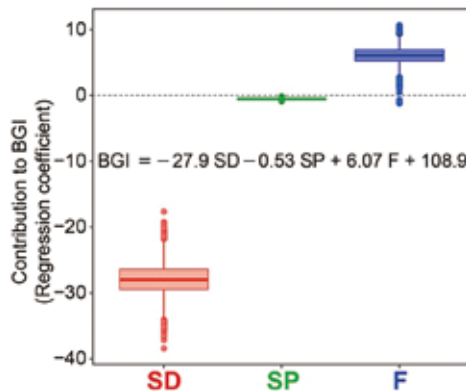


Fig. 3. Evaluation of the contribution of selected parameters [stocking density (SD), stocking period (SP), and feeding condition (F)] to fish productivity (BGI)

a low stocking density even under non-feeding condition (Fig. 3). Feeding condition was revealed to be a secondary contributory factor, with better BGI expectable under feeding condition than non-feeding condition. Stocking period's contribution to the BGI, on the other hand, was limited compared to the above two factors (Fig. 3). Based on the above analyses, high BGI (BGI ca. 40, or 40kg expectable harvest weight over 1kg fingerling weight at stocking) is the realizable fish productivity under feeding condition for the rice-fish (climbing perch) culture system, even as acceptable BGI (BGI ca. 20) is still expectable

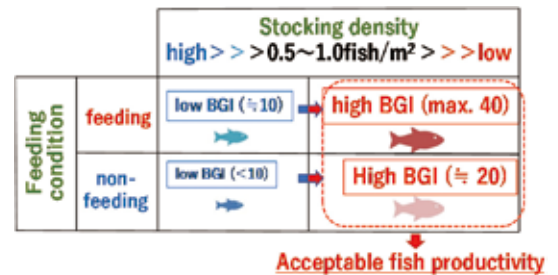


Fig. 4. Schematic image of the effects of stocking density and feeding condition as contributory factors to fish productivity (BGI)

even under non-feeding condition if reared at a low stocking density ($< 1 \text{ fish/m}^2$) (Fig. 4).

Assuming that rice-fish culture can be extended across the country, we have estimated ca. 84,000 ha of full-time ponded rice paddies that may be utilized to produce ca. 21,000-42,000t of fish by rice-fish culture. However, the infrastructures and the number of technical staffs for aquacultural fingerling production are largely insufficient, and obtaining the required quantity/supply of fingerlings is currently not possible in Laos. Prompt enhancements are thus necessary to overcome these constraints.

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

Increasing rainy season lowland rice and dry season crop yields in the semi-mountainous villages of Laos using stored water intended for aquaculture

Agricultural fields in the semi-mountainous villages of Laos depend heavily on rainwater. Past water shortages had delayed transplanting of rainy season lowland rice in the lower parts of the fields (Fig. 1), leading to low yields (www.jircas.go.jp/ja/publication/research_highlights/2015). Moreover, crop cultivation in the dry season has not been conducted due to little precipitation. To complete earlier transplanting and conduct dry season cropping, it is necessary to introduce preparatory irrigation in early rainy season (PIR) and supplemental irrigation in the dry season (SID). Six reservoirs were constructed for aquaculture at N Village in the northwestern part of Vientiane Province, with 8,600 m³ of stored water left unused due to structural issues with the reservoir outlet (Fig. 2). This study aims to formulate a water management plan that includes the introduction of PIR and SID through usage of stored water. It also shows the potential irrigation areas for PIR and SID and the benefits of irrigation.

The stored water is used to irrigate the lower parts of lowland rice fields (Fig. 1) by PIR from July 1 to 15, and the upper parts of lowland fields for soybean (as candidate crop for dry season cropping) by SID four times from December to February. Water balance was calculated under three cases of water management in the reservoirs as follows (Fig. 3): In Case 1, stored water was drained in early April (i.e., conventional use). In Case 2, stored water was drained in

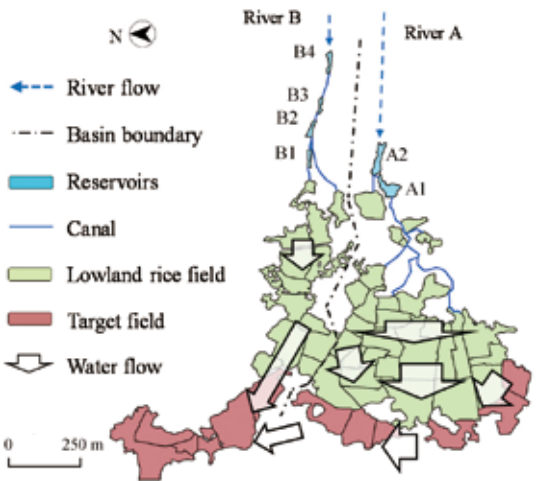


Fig. 1. Overview of river basins A and B in N Village
Note: Transplanting of rainy season lowland rice in the lower parts of lowland rice fields (shown as target field = 14.1 ha) was delayed due to water shortage in the early rainy season.



Fig. 2. Situation at the reservoir (B2)
Note 1: All reservoirs were constructed for aquaculture.
Note 2: Since the outlets were constructed at a high position in the dam body, a large portion of stored water has remained.

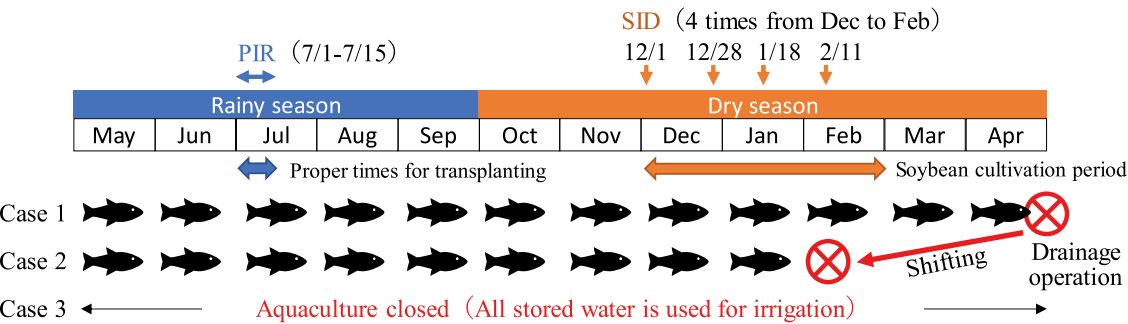


Fig. 3. Water management utilizing the reservoirs constructed for aquaculture
Note 1: In Cases 1 and 2, minimum water level (50 cm) is maintained for fish survival.
Note 2: In Case 1, stored water in the reservoirs is drained using water pump in April (conventional method).
Note 3: In Case 2, stored water in the reservoirs is drained to coincide with the 4th SID.

Table 1. Potential irrigation areas and preliminary calculations of projected increases in gross incomes (from current levels) due to irrigation practices

Water management	Potential irrigation area (ha)		Rice		Soybean production (ton) d (b×1.4 ton ha ⁻¹)	Benefits from irrigation (1,000 KIP)		
			Yield (ton ha ⁻¹)	Increase in production (ton) c (a×(3.9-2.2) ton ha ⁻¹)		Total income (e) (c×2,500 KIP kg ⁻¹ +d×8,000 KIP kg ⁻¹)	Compensation cost f	Net income e-f
	PIR (a)	SID (b)						
Current	No irrigation		2.2	0	0	-	-	0
Case 1	10.40	3.17	3.9	17.68	4.44	79,704	0	79,704
Case 2	10.40	3.37	3.9	17.68	4.72	81,944	720	81,224
Case 3	10.95	3.52	3.9	18.62	4.92	85,850	6,108	79,742

Note 1: As referred to in the study by Ikeura et al. (2016), the yield of rainy season lowland rice increases from 2.2 ton ha⁻¹ to 3.9 ton ha⁻¹ due to on-time transplanting through PIR.

Note 2: The average yield of soybean due to SID is assumed to be 1.4 ton ha⁻¹.

Note 3: In Case 2, reservoir owners are compensated with feeding fees. In Case 3, gross income from aquaculture is paid to reservoir owners as "loss of income compensation."

February when the 4th SID was conducted while maintaining aquaculture. In Case 3, there was no aquaculture, and all stored water was used for irrigation. Finally, potential irrigation areas for PIR and SID were calculated under three water management scenarios. In Cases 1 and 2 where the minimum water level (water depth of 50 cm) for fish survival was constantly maintained, the results showed that potential irrigation area for PIR was 10.40 ha. In Case 3 where there was no aquaculture, it was 10.95 ha (Table 1). PIR enabled on-time transplanting in about 75% of lowland rice fields in the lower parts (14.1 ha). The potential irrigation areas for SID were 3.17, 3.37, and 3.52 ha in Cases 1, 2 and 3, respectively (Table 1). To calculate the benefits from irrigation, the incomes from the increase in rice and soybean yields due to irrigation and aquaculture, and aquaculture expenditures such as feed costs and compensation paid for losses due to the shortened period in Case 2 and compensation costs for excluding aquaculture in Case 3, were considered. The results showed that

revenue growth can be expected from current state (i.e., no irrigation practice) in all Cases (Table 1). From the aspect of securing animal protein resources, it is desirable to maintain aquaculture (Cases 1 and 2).

The results of this research can be applied to other villages where rainy season lowland rice cultivation and aquaculture have been conducted as well as in N Village. However, potential irrigation areas should be calculated according to each village's own water resource and land use. In addition, in case power pumps or siphons are needed to withdraw water from reservoirs, costs related to equipment purchases and fuel should be included in the calculations.

(T. Anzai, H. Ikeura,
A. Chomxaythong [National University
of Laos (NUOL)],
K. Keokhamphui [NUOL],
S. Inkhamseang [NUOL],
H. Fujimaki [Tottori University])

Program D Information Analysis

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

Program D (Information Analysis) collects, analyzes, and disseminates information on current developments and trends in international agriculture, forestry and fisheries that will guide the identification of research priorities and the development of strategic research agendas. The program consists of the following major research activities, namely, the evaluation of the global food supply-demand and nutrition balance; the collection and dissemination of the latest information on global agricultural research agendas; and the implementation of the goal-oriented basic research projects.

The global food supply-demand and nutrition balance research project covers country-level case studies and scenario analyses based on the foresight model of global food supply-demand, with the aim of identifying and guiding areas where intervention is needed to improve the food and nutrition security situation of vulnerable populations. Some highlights of the analyses implemented during fiscal year 2018 are briefly described below. In Madagascar, where rice is the most important staple as well as commercial crop, it turned out that majority of the population suffered from micronutrient deficiency, specifically calcium and vitamin A. Recommendations were made to improve the nutritional value of rice in the country, for example, by promoting its consumption in the form of brown rice, with reference to the experiences of other developing countries. In turn, scenario analyses of the global food and nutrition balance under climate change uncertainties were performed. Updated and improved datasets were applied, reflecting an increase in the variety of food groups (compared to the previous version) by incorporating dairy and oil products. The results indicated that the projected decrease in dietary protein supply in some sub-Saharan African countries would make “hidden hunger” persist in the region for the next 20 years. The impacts of introducing heat-resistant rice varieties were also analyzed using the foresight model with the improved datasets, and the results were presented at international workshops and discussed with researchers and experts who are influential participants in global food demand-supply foresight debates.

Under Program D, JIRCAS actively participates

in international initiatives and forums to discuss research and policy agendas to contribute to global food and nutrition security. For example, JIRCAS is a Steering Committee member of global initiatives launched by the Government of Japan, including the Initiative for Food and Nutrition Security in Africa (IFNA) and the Coalition for African Rice Development (CARD). JIRCAS also collects information on emerging global agendas on agriculture, forestry and fisheries, by assigning scientists to its liaison offices in Southeast Asia (Thailand) and Africa (Kenya), as well as seconding its researchers to international research organizations such as the International Renewable Energy Agency (IRENA) and the CGIAR. These JIRCAS staffs, who are stationed abroad for extended periods, are in charge of communication activities. They provide up-to-date information to research partners and stakeholders in the form of reports and/or web articles while engaged in joint research activities, including the publication of scientific and technical reports, with the host research institutions.

Program D oversees the implementation of the goal-oriented basic research projects, which feature novel research ideas whose outcomes are expected to yield technological innovations and promising business opportunities in the agriculture and food industries. The following five research projects are being implemented under joint research schemes with Japanese and/or foreign research institutions. They include: 1) the characterization of rice germplasms collected by and introduced from the International Rice Research Institute (IRRI) in the Philippines, in terms of their sprouting and yield performance in different agro-ecological conditions (in Tsukuba and Ishigaki), with the aim of developing superior breeding materials; 2) the evaluation of functional components of a non-conventional yeast with its application to cassava residues to explore potential for developing new materials for animal feed supplements, 3) the comprehensive comparative genetic analysis of shrimps and locusts to develop gene discovery systems, 4) the investigation of shrimp ovarian growth systems to enhance efficiency and sustainability of seed production, and 5) the development of heat-tolerant varieties of tropical fruit species, including mango and passion fruit. During fiscal year 2018, some of the above projects attracted strong interest from private companies who were willing to implement research collaboration to expedite social implementation. In turn, some of the projects’ research plans had been modified to overcome the challenges in procuring enough research materials.



**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. Thirty-nine (39) visits to JIRCAS were made during FY 2018 under the Administrative Invitation Program. Invited administrators and their home institutions are listed below.

Administrative Invitations, FY 2018

Derake Tonpayom	Ministry of Agriculture and Cooperatives, Thailand	May 17 - 20, 2018
Sanong Jarintorn	Chiang Rai Horticultural Research Center, Horticultural Research Institute, Department of Agriculture, Thailand	May 17 - 20, 2018
Tom Tiaphet	Office of Agricultural Research and Development, Region 5, Department of Agriculture, Thailand	May 17 - 20, 2018
Mario Antonio Gandarillas Antezana	Fundación PROINPA, Bolivia	Jul. 7 - 15, 2018
Giovanna Rocío Almanza Vega	Instituto de Investigaciones Químicas, Universidad Mayor de San Andrés, Bolivia	Jul. 7 - 15, 2018
Isabel Victoria Morales Belpaire	Biology Department, Universidad Mayor de San Andrés, Bolivia	Jul. 7 - 15, 2018
Manabu Ishitani	International Center for Tropical Agriculture (CIAT), Colombia	Oct. 19 - 27, 2018
Weiming Shi	Institute of Soil Science, Chinese Academy of Sciences, PR China	Oct. 23 - 27, 2018
Masahiro Kishii	International Maize and Wheat Improvement Center (CIMMYT), Mexico	Oct. 23 - 27, 2018
Viktor Maurice Kommerell	International Maize and Wheat Improvement Center (CIMMYT), Mexico and c/o INRA (Paris)	Oct. 23 - 31, 2018
Yiyong Zhu	Nanjing Agricultural University, PR China	Oct. 24 - 27, 2018
Jose Ivan Ortis Monasterio Rosas	International Maize and Wheat Improvement Center (CIMMYT), Mexico	Oct. 24 - 27, 2018
Gideon Kruseman	International Maize and Wheat Improvement Center (CIMMYT), Mexico	Oct. 24 - 27, 2018
Chris Stephen Jones	International Livestock Research Institute (ILRI), Kenya	Oct. 24 - 27, 2018
William L. Rooney	Department of Soil and Crop Science, Texas A&M University, USA	Oct. 24 - 27, 2018
Jean-Christophe Sébastien Frédéric Lata	University of Paris, France	Oct. 24 - 27, 2018

Administrative Invitations, FY 2018

Wolfram Weckwerth	Department of Ecogenomics and Systems Biology, University of Vienna, Austria	Oct. 24 - 27, 2018
James Prosser	University of Aberdeen, UK	Oct. 24 - 27, 2018
George Cadisch	Institute of Plant Production and Agroecology in the Tropics and Subtropics, University of Hohenheim, Switzerland	Oct. 24 - 28, 2018
Timothy Darrow Searchinger	Woodrow Wilson School, Science, Technology, and Environmental Policy Program, Princeton University, USA	Oct. 24 - 28, 2018
Vilas Tonapi	Indian Institute of Millets Research (IIMR), India	Oct. 24 - 29, 2018
Harvinder Singh Talwar	Indian Institute of Millets Research (IIMR), India	Oct. 24 - 29, 2018
Rajeev Gupta	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India	Oct. 24 - 29, 2018
Md. Ismail Hossain	Agricultural Statistics Division, Bangladesh Rice Research Institute (BRRI), Bangladesh	Oct. 28 - Nov. 3, 2018
Wang Xiaohu	Institute of Food and Nutrition Development, MARA, PR China	Oct. 28 - Nov. 3, 2019
Cheng Guangyan	Institute of Food and Nutrition Development, MARA, PR China	Oct. 28 - Nov. 3, 2020
Zhou Lin	Institute of Food and Nutrition Development, MARA, PR China	Oct. 28 - Nov. 3, 2021
Mamadou Billo Barry	Institut de Recherche Agronomique de Guinee (IRAG), Guinea	Nov. 2 - 15, 2018
Evelyn Grace de Jesus Ayson	Southeast Asian Fisheries Development Center / Aquaculture Department (SEAFDEC/AQD), Philippines	Nov. 3 - 9, 2018
Bonnie Waycott	The Fish Site, 5M Publishing, UK	Nov. 3 - 11, 2018
Meryl Williams	Gender in Aquaculture and Fisheries Section, Asian Fisheries Society, Australia	Nov. 4 - 7, 2018
Yumiko Kura	WorldFish Cambodia	Nov. 4 - 14, 2018
David Keith Hebblethwaite	Pacific Community, Geoscience (SPC), Energy and Maritime Division, Australia	Nov. 13 - 21, 2018
Mari (Marutani) Nomura	Agriculture and Life Science Division, University of Guam (UOG)	Nov. 14 - 20, 2018
Thomas Taro	Cooperative Research & Extension, Palau Community College, Palau	Nov. 14 - 21, 2018
Roxanne Yusim Blesam	Environmental Quality Protection Board (EQPB), Palau	Nov. 15 - 20, 2018
Ignacio S. Santillana	Sugar Regulatory Administration, Department of Agriculture, Philippines	Nov. 17 - 23, 2018
Eduardo Jimmy P. Quilang	Agronomy, Soils and Plant Physiology Division, Philippine Rice Research Institute, Philippines	Nov. 25 - 29, 2018
Carolyn Florey	International Rice Research Institute, Philippines	Nov. 25 - 29, 2018

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. Thirty-three (33) researchers were invited under this program during FY 2018. Invited researchers, their affiliated research organizations, and their research activities are summarized below.

Counterpart Researcher Invitations, FY2018

Alimata Arzouma Bandaogo	Institute of Environment and Agricultural Research, Farako-ba Station, Burkina Faso	Enhancement of fertilizing cultivation	Apr. 12 - 29, 2018
Begnileyaon Beatrice Somda	Institute of Environment and Agricultural Research, Farako-ba Station, Burkina Faso	Enhancement of fertilizing cultivation	Apr. 12 - 29, 2018
Tovohery Rakotoson	Laboratoire des Radioisotopes (LRI), University of Antananarivo, Madagascar	Breakthrough in Nutrient Use Efficiency for Rice by Genetic Improvement and Fertility Sensing Techniques in Africa	Jun. 5 - Sep. 2, 2018
Seheno Rinasoa	Laboratoire des Radioisotopes (LRI), University of Antananarivo, Madagascar	Breakthrough in Nutrient Use Efficiency for Rice by Genetic Improvement and Fertility Sensing Techniques in Africa	Jun. 5 - Sep. 2, 2018
Maire Holz	University of Bayreuth, Germany	Establishment of methods for the detection of root-soil interactions for efficient P uptake	Jun. 6 - Aug. 15, 2018
Wu Guosheng	Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, PR China	Development of evaluation methods of value chain for sustainable rural development	Jul. 10 - Oct. 10, 2018
Nithya Rajan	Department of Soil and Crop Science, Texas A&M University, USA	Intensification of research collaboration on biological nitrification inhibition of sorghum	Jul. 22 - Aug. 11, 2018
Njato Mickaël Rakotoarisoa	National Center for Applied Research and Rural Development (FOFIFA), Madagascar	Breakthrough in Nutrient Use Efficiency for Rice by Genetic Improvement and Fertility Sensing Techniques in Africa	Jul. 22 - Sep. 9, 2018
Mbolatantely Fahazavana Rakotondramanana Ep Rakotonandrasana	National Center for Applied Research and Rural Development (FOFIFA), Madagascar	Breakthrough in Nutrient Use Efficiency for Rice by Genetic Improvement and Fertility Sensing Techniques in Africa	Aug. 5 - Oct. 2, 2018
Harisoa Nicole Ranaivo	National Center for Applied Research and Rural Development (FOFIFA), Madagascar	Breakthrough in Nutrient Use Efficiency for Rice by Genetic Improvement and Fertility Sensing Techniques in Africa	Aug. 5 - Oct. 2, 2018
Michel Rabenarivo	Laboratoire des Radioisotopes, University of Antananarivo (LRI), Madagascar	Breakthrough in Nutrient Use Efficiency for Rice by Genetic Improvement and Fertility Sensing Techniques in Africa	Aug. 19 - Sep. 18, 2018
Rose Ann Miagao Diamante	Southeast Asian Fisheries Development Center / Aquaculture Department (SEAFDEC/AQD), Philippines	Demonstration and Verification of Sustainable and Efficient Aquaculture Techniques by Combination of Multiple Organisms	Sep. 9 - 20, 2018

Counterpart Researcher Invitations, FY2018

Raisa Joy Geruldo Castel	Southeast Asian Fisheries Development Center / Aquaculture Department (SEAFDEC/AQD), Philippines	Demonstration and Verification of Sustainable and Efficient Aquaculture Techniques by Combination of Multiple Organisms	Sep. 14 - 19, 2018
Jacobo Arango Mejia	International Center for Tropical Agriculture (CIAT), Colombia	Meeting on Biological Nitrification Inhibition and collaboration between UPMC and JIRCAS	Oct. 20 - 27, 2018
John Moises Garriel Relles	Sugar Regulatory Administration, Department of Agriculture, Philippines	Presentation at the ISSCT Workshop	Oct. 20 - 28, 2018
Ammarawan Tipayawat	Khon Kaen Field Crops Research Center, Department of Agriculture, Thailand	Presentation at the ISSCT Workshop	Oct. 20 - 31, 2018
Nithya Rajan	Department of Soil and Crop Science, Texas A&M University, USA	Attendance to the 3rd International Biological Nitrification Inhibition (BNI) Meeting	Oct. 23 - 27, 2018
Padma Shanthi Jagadabhi	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India	Attendance to the 3rd International Biological Nitrification Inhibition (BNI) Meeting	Oct. 24 - 27, 2018
Cesar Daniel Petroli	International Maize and Wheat Improvement Center (CIMMYT), Mexico	Attendance to the 3rd International Biological Nitrification Inhibition (BNI) Meeting	Oct. 24 - 27, 2018
Sakiko Okumoto	Department of Soil and Crop Science, Texas A&M University, USA	Attendance to the 3rd International Biological Nitrification Inhibition (BNI) Meeting	Oct. 24 - 27, 2018
Santosh Pandurang Deshpande	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India	Attendance to the 3rd International Biological Nitrification Inhibition (BNI) Meeting	Oct. 24 - 28, 2018
Salisa Pituk	Seed Research Development Division, Khon Kaen Seed Research and Development Center, Department of Agriculture, Thailand	Development of an integrated pest management system for sugarcane white leaf disease based on the ecology of the vector insects	Oct. 25 - Nov. 8, 2018
Mamadou Laho Barry	Institut de Recherche Agronomique de Guinee (IRAG), Guinea	Rice improvement in Guinea	Nov. 2 - 15, 2018
Alama Magassouba	Institut de Recherche Agronomique de Guinee (IRAG), Guinea	Rice improvement in Guinea	Nov. 2 - 15, 2018
Stephanie Jane Watts-Williams	The University of Adelaide, Australia	Estimating the impact of arbuscular mycorrhiza (AM) on P uptake of 2 rice genotypes	Nov. 11 - 28, 2018
Adelle Lukes Isechal	Ministry of Natural Resources, Environment and Tourism (MNRET), Palau	Construction of well-balanced water, soil and nutrients cycling, and evaluation of ecosystem functions in watershed of the Babeldaob Island	Nov. 14 - 20, 2018
Yin Yin Nwee	Cooperative Research & Extension Department, Palau Community College, Palau	Development of sustainable resources management systems in Palau	Nov. 14 - 21, 2018
Sengthong Fongchanmixay	Rice Research Center, National Agriculture and Forestry Research Institute, Ministry of Agriculture and Forestry, Laos	Value added lowland production system based on appropriate management of water resources and soil	Nov. 15 - 24, 2018

Counterpart Researcher Invitations, FY2018

Jonas Koala	Institute of Environment and Agricultural Research (INERA), Burkina Faso	Litter fall dynamics in North Sudanian agroforestry parkland in Burkina Faso	Dec. 6 - 22, 2018
Jacques Sawadogo	Institute of Environment and Agricultural Research (INERA), Kamboinse Station, Burkina Faso	National fertilizer development using low grade phosphate rock produced in Burkina Faso	Dec. 7 - 22, 2018
Zaw Myo Hein	Marine Science Department, Myeik University, Myanmar	Comparative study on oyster industries in Japan and Myanmar	Jan. 17 - Feb. 1, 2019
Md Abdus Salam	Agricultural Economics Division, Bangladesh Rice Research Institute (BRRI), Bangladesh	Development and economic evaluation of adaptation measures to extreme weather events in the Bay of Bengal region	Mar. 3 - 23, 2019
Olajumoke Tomiloba Olaleye	Bioscience Center, International Institute of Tropical Agriculture (IITA), Nigeria	Phenotype non-redundant set for tuber quality and other agronomic traits	Mar. 23 - Apr. 16, 2019

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. Thirty-eight (38) invited researchers implemented their programs during FY 2018 as listed below.

Project Site Invitations, FY 2018			
Kanako Suzuki	International Institute of Tropical Agriculture, Zambia Office	Identifying emerging research agendas for nutrition-sensitive agriculture, with a focus on the production of potential high-value crops	Aug. 11 - 17, 2018
Julio César García Rodríguez	Las Huastecas Experimental Station, National Institute of Forestry, Agricultural, and Livestock Research (INIFAP), Mexico	Annual Meeting of the “Development of soybean varieties resistant to Asian soybean rust and other soybean diseases” project (at Colonia)	Aug. 21 - 26, 2018
Miguel Lavilla	National University of Northwestern Province of Buenos Aires (UNNOBA), Argentina	Annual Meeting of the “Development of soybean varieties resistant to Asian soybean rust and other soybean diseases” project (at Colonia)	Aug. 22 - 25, 2018
Adrian Dario De Lucia	Estación Experimental Agropecuaria Cerro Azul, Instituto Nacional de Tecnología Agropecuaria (INTA-EEA Cerro Azul), Argentina	Annual Meeting of the “Development of soybean varieties resistant to Asian soybean rust and other soybean diseases” project (at Colonia)	Aug. 22 - 25, 2018
Monica Isabel Heck	Annual Crops Department, Estación Experimental Agropecuaria-Cerro Azul, Instituto Nacional de Tecnología Agropecuaria (INTA-EEA Cerro Azul), Argentina	Annual Meeting of the “Development of soybean varieties resistant to Asian soybean rust and other soybean diseases” project (at Colonia)	Aug. 22 - 25, 2018
Nathalia Sarahi Bobadilla Gimenez	Instituto Paraguayo de Tecnología Agraria (IPTA-CICM), Paraguay	Annual Meeting of the “Development of soybean varieties resistant to Asian soybean rust and other soybean diseases” project (at Colonia)	Aug. 22 - 25, 2018
Ruth Fabiola Scholz Drodowski	Instituto Paraguayo de Tecnología Agraria (IPTA-CICM), Paraguay	Annual Meeting of the “Development of soybean varieties resistant to Asian soybean rust and other soybean diseases” project (at Colonia)	Aug. 22 - 25, 2018
Anibal Morel Yurenka	Instituto de Biotecnología Agrícola (INBIO), Paraguay	Annual Meeting of the “Development of soybean varieties resistant to Asian soybean rust and other soybean diseases” project (at Colonia)	Aug. 22 - 25, 2018
Rafael Moreira Soares	Embrapa-Soja, Brazil	Annual Meeting of the “Development of soybean varieties resistant to Asian soybean rust and other soybean diseases” project (at Colonia)	Aug. 22 - 25, 2018
Antonio Juan Gerardo Ivancovich	National University of Northwestern Province of Buenos Aires (UNNOBA), Argentina	Annual Meeting of the “Development of soybean varieties resistant to Asian soybean rust and other soybean diseases” project (at Colonia)	Aug. 23 - 25, 2018

Project Site Invitations, FY 2018

Mohammad Ashik Iqbal Khan	Bangladesh Rice Research Institute, Bangladesh	Workshop and annual meeting of the JIRCAS Blast Research Network in 2018	Sep. 15 - 19, 2018
Jonathan Niones	Philippine Rice Research Institute, Philippines	Workshop and annual meeting of the JIRCAS Blast Research Network in 2018	Sep. 16 - 19, 2018
Jennifer Niones	Philippine Rice Research Institute, Philippines	Workshop and annual meeting of the JIRCAS Blast Research Network in 2018	Sep. 16 - 19, 2018
Aris Hairmansis	Indonesian Center for Rice Research, Indonesia	Workshop and annual meeting of the JIRCAS Blast Research Network in 2018	Sep. 16 - 19, 2018
Jaehwan Roh	National Institute of Crop Science, Rural Development Administration, Republic of Korea	Workshop and annual meeting of the JIRCAS Blast Research Network in 2018	Sep. 16 - 19, 2018
Xue Wentong	College of Food Science & Nutritional Engineering, China Agricultural University, PR China	In Celebration of the 50th Anniversary of IFRPD, Kasetsart University International Seminar on: Future Food for Well-Being, Asian Network for Future Food	Sep. 25 - 29, 2018
Yin Lijun	College of Food Science & Nutritional Engineering, China Agricultural University, PR China	In Celebration of the 50th Anniversary of IFRPD, Kasetsart University International Seminar on: Future Food for Well-Being, Asian Network for Future Food	Sep. 25 - 29, 2018
Cheng Yongqiang	College of Food Science & Nutritional Engineering, China Agricultural University, PR China	In Celebration of the 50th Anniversary of IFRPD, Kasetsart University International Seminar on: Future Food for Well-Being, Asian Network for Future Food	Sep. 25 - 29, 2018
Liu Haijie	College of Food Science & Nutritional Engineering, China Agricultural University, PR China	In Celebration of the 50th Anniversary of IFRPD, Kasetsart University International Seminar on: Future Food for Well-Being, Asian Network for Future Food	Sep. 25 - 29, 2018
Luan Guangzhong	College of Food Science and Engineering, Northwest A&F University, PR China	In Celebration of the 50th Anniversary of IFRPD, Kasetsart University International Seminar on: Future Food for Well-Being, Asian Network for Future Food	Sep. 25 - 29, 2018
Ma Hongyu	College of Economics and Management, Northwest A&F University, PR China	In Celebration of the 50th Anniversary of IFRPD, Kasetsart University International Seminar on: Future Food for Well-Being, Asian Network for Future Food	Sep. 25 - 29, 2018
Philavanh Boutsavath	Planning and Cooperation Division, National Agriculture and Forestry Research Institute, Laos	In Celebration of the 50th Anniversary of IFRPD, Kasetsart University International Seminar on: Future Food for Well-Being, Asian Network for Future Food	Sep. 25 - 29, 2018

Project Site Invitations, FY 2018

Xaypunya Mahathilath	Planning and Cooperation Division, National Agriculture and Forestry Research Institute, Laos	In Celebration of the 50th Anniversary of IFRPD, Kasetsart University International Seminar on: Future Food for Well-Being, Asian Network for Future Food	Sep. 25 - 29, 2018
Souphachay Phouphasouk	Faculty of Agriculture, National University of Laos, Laos	In Celebration of the 50th Anniversary of IFRPD, Kasetsart University International Seminar on: Future Food for Well-Being, Asian Network for Future Food	Sep. 25 - 29, 2018
Vipa Surojanametakul	Institute of Food Research and Product Development, Kasetsart University, Thailand	Attending the International Rice Research Conference 2018	Oct. 13 - 17, 2018
Prajongwate Satmalee	Institute of Food Research and Product Development, Kasetsart University, Thailand	Attending the International Rice Research Conference 2018	Oct. 13 - 17, 2018
Raisa Joy G. Castel	The Southeast Asian Fisheries Development Center, Philippines	Annual meeting on “Development of technologies for sustainable aquatic production in harmony with tropical ecosystems”	Dec. 9 - 16, 2018
Rose Ann Diamante	The Southeast Asian Fisheries Development Center, Philippines	Annual meeting on “Development of technologies for sustainable aquatic production in harmony with tropical ecosystems”	Dec. 9 - 16, 2018
Dusit Aue	King Mongkut’s Institute of Technology Ladkrabang, Thailand	Annual meeting on “Development of technologies for sustainable aquatic production in harmony with tropical ecosystems”	Dec. 10 - 13, 2018
Masazurah binti A Rahim	Fisheries Research Institute Batu Maung, Malaysia	Annual meeting on “Development of technologies for sustainable aquatic production in harmony with tropical ecosystems”	Dec. 10 - 14, 2018
Teoh Hong Wooi	China-ASEAN College of Marine Sciences, Xiamen University Malaysia, Malaysia	Annual meeting on “Development of technologies for sustainable aquatic production in harmony with tropical ecosystems”	Dec. 10 - 14, 2018
Lai Zhen Wei	Institute of Ocean and Earth Sciences, University of Malaysia, Malaysia	Annual meeting on “Development of technologies for sustainable aquatic production in harmony with tropical ecosystems”	Dec. 10 - 14, 2018
Aloun Khounthongbang	Fishes and Aquatic Animal Production Unit, Living Aquatic Resources Research Center (LARReC), Laos	Annual meeting on “Development of technologies for sustainable aquatic production in harmony with tropical ecosystems”	Dec. 10 - 14, 2018
Phonenaphet Chanthasone	Fishes and Aquatic Animal Production Unit, Living Aquatic Resources Research Center (LARReC), Laos	Annual meeting on “Development of technologies for sustainable aquatic production in harmony with tropical ecosystems”	Dec. 10 - 14, 2018

Project Site Invitations, FY 2018

Nerissa Diaz Salayo	The Southeast Asian Fisheries Development Center, Philippines	Annual meeting on “Development of technologies for sustainable aquatic production in harmony with tropical ecosystems”	Dec. 10 - 15, 2018
Roger Edward P. Mamauang	The Southeast Asian Fisheries Development Center, Philippines	Annual meeting on “Development of technologies for sustainable aquatic production in harmony with tropical ecosystems”	Dec. 10 - 15, 2018
Weerakorn Saengsai	Khon Kaen Field Crops Research Center, Field and Renewable Energy Crop Research Institute, Department of Agriculture, Thailand	Participation in the Plant & Animal Genome XXVII Conference	Jan. 10 - 19, 2019
Sid' Ahmed Ould Mohamed	The Mauritanian Desert Locust Centre, Morocco	13th International Congress of Orthopterology	Mar. 23 - 29, 2019

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, which aims 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 2018, a total of five researchers were selected and invited to conduct research at JIRCAS HQ in Tsukuba but none in Okinawa (i.e., no public call was issued for Okinawa-type in FY 2018).

JIRCAS Visiting Research Fellowship at Tsukuba (October 2018 - September 2019)

Trang Thi Nguyen	Genetics Engineering Division, Agricultural Genetics Institute, Vietnam	Improvement of soybean salt tolerance using molecular breeding techniques	Oct. 1, 2018 - Sep. 27, 2019
Xiang Gao	Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, PR China	Analysis on the effects of ratios of NH ₄ -N and NO ₃ -N in the rhizosphere on nitrification inhibitors secretion and growth in sorghum	Oct. 1, 2018 - Sep. 30, 2019
M M Emam Ahmed	Plant Breeding Division, Bangladesh Rice Research Institute, Bangladesh	Developing rice breeding lines to improve nitrogen use	Oct. 1, 2018 - Sep. 25, 2019
Luciano Nobuhiro Aoyagi	Soybean Research Center, Brazilian Agricultural Research Corporation (Embrapa Soybean), Brazil	Characterization of new soybean genetic resources resistant to Asian soybean rust disease	Oct. 1, 2018 - Sep. 28, 2019
Sirilak Baramée	Department of Biology, Faculty of Science, King Mongkut's Institute of Technology Ladkrabang, Thailand	Elucidation of lignocellulosic biomass degradation mechanism in alkali-thermophilic anaerobic bacteria <i>Herbivorax saccincola</i> A7	Oct. 3, 2018 - Sep. 30, 2019

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 2018, no public call was issued for the Project Sites-type.

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)

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 NRDA's affiliated with MAFF. The visiting scientists who resided at JIRCAS in FY 2018 are listed below.

JSPS Postdoctoral Fellowship for Overseas Researchers (April 2018 to March 2019)			
Getnet Dino Adem	University of Tasmania, Australia	Functional characterization of candidate genes for PUE and mining their allelic variants in rice	Jul. 15, 2018 - Jul. 14, 2020
Patrick Enrico Hayes	University of Western Australia, Australia	Optimising the allocation of phosphorus fractions in rice to improve nutrient-use efficiency	Jul. 18, 2018 - Jul. 17, 2020
Divya Balakrishnan	ICAR - Indian Institute of Rice Research, India	Exploring genetic architecture of blast resistance in chromosome segment substitution lines using standard differential blast isolates	Jan. 27, 2019 - Jul. 13, 2019

Workshops

ISSCT Joint 12th Germplasm & Breeding and 9th Molecular Biology Workshops

The International Society of Sugar Cane Technologists (ISSCT) is an international organization engaged in sugarcane research, composed not only of researchers but also sugar mill workers and cane growers. It holds a world congress once every three years and workshops in-between congresses to discuss key issues concerning sugarcane research. In the lead-up to the 2019 world congress, the ISSCT Joint 12th Germplasm & Breeding and 9th Molecular Biology Workshops were held in Okinawa from October 22 to 26, 2018. One hundred and thirteen (113) researchers from 20 countries and regions attended, and 41 oral and 18 poster presentations were given.

The ISSCT and the Japanese Society of Sugar Cane Technologists (JSSCT) organized the workshops, with JIRCAS, the Okinawa Prefectural Agricultural Research Center, and the Kyushu Okinawa Agricultural Research Center of the National Agriculture and Food Research

Organization (NARO) as co-organizers.

In the germplasm & breeding section of the workshop, the discussion focused on the utilization of genetic resources including wild sugarcane and related genera such as *Erianthus*, and the development of breeding techniques such as genomic selection. The discussion was aimed at breaking the trend of stagnant sugarcane yields, which was attributed to the narrow genetic basis of sugarcane varieties, and at further improving sugarcane's adaptability to unstable environments.

In the molecular biology section, in light of the recent registration of a genetically modified sugarcane variety in Brazil, the actual status, future prospects, and problems related to the practical use of genetically modified sugarcane in each country were introduced, and the establishment of an international network for sugarcane research was discussed.



Group photo of workshop participants

In Celebration of the 50th Anniversary of IFRPD, Kasetsart University, International Seminar on: Future Food for Well-Being

On September 26-27, 2018, the international seminar titled “Future Food for Well-Being” was organized and held in Kasetsart University in Bangkok, Thailand, to celebrate the 50th anniversary of the Institute of Food Research and Product Development (IFRPD), which is one of the principal counterparts of JIRCAS in its Food Value Chain (FVC) project. The seminar consisted of two parallel forums, themed “Future Food and Trend” and “International Industry

Forum on Latest Development in Extrusion.” There were approximately 250 attendees belonging to 90 sectors, including 47 foreigners from Korea, China, the Philippines, Malaysia, Singapore, Laos, France, Switzerland, Australia, Norway, Pakistan, and Japan.

JIRCAS organized the first session titled “Asian Network for Future Food” of the Future Food and Trend forum. Dr. Kazuhiko Nakahara, FVC project leader at JIRCAS, introduced

the research scheme, followed by eight oral presentations and five poster displays by JIRCAS and counterparts from China, Laos, and Thailand. In the general discussion, Dr. Yukiyo Yamamoto, program director of the Value-adding Technologies Program at JIRCAS, summarized the viewpoints on the construction of FVCs in developing countries and the establishment of a collaborative research network. The significance of standardization in food science was also

discussed.

The Future Food and Trend forum was concluded by a panel discussion, with Thai food industry executives sharing their experiences and product development activities, and Dr. Sombat Chinawong, director of IFRPD, suggesting the importance of building a platform to accelerate information exchange and enhance collaboration among industry, academia, and government.



Participants of the “Asian Network for Future Food” session organized by JIRCAS

International Symposiums and Workshops, FY 2018

Technical Coordinating Committee Meeting: Establishment of the model for fertilizing crop cultivation promotion using Burkina Faso phosphate rock	May 29, 2018	Ougadougou, Burkina Faso
JIRCAS-NAFRI-NUOL Joint Research Annual Meeting	May 29, 2018	Vientiane, Laos
JIRCAS-NAFRI Joint Research Steering Committee Meeting	May 30, 2018	Vientiane, Laos
Technical Committee Meeting: African Water Resources Utilization Efficiency Survey	June 12, 2018	Arusha, Tanzania
JIRCAS Project Kickoff Meeting: Development of technologies to prevent salt damage in India	June 15, 2018	Karnal, India
Annual Meeting: Development of breeding materials and varieties of soybean resistant to Asian soybean rust, Cercospora leaf blight, and charcoal rot	August 23-24, 2018	Colonia, Uruguay
Workshop titled “Durable protection and approaches to biotic stress resistance in tropical rice production” and Annual Meeting of the JIRCAS Rice Blast Research Network	September 17-18, 2018	Hanoi, Viet Nam
JIRCAS-CTU Climate Change Project Workshop 2018	September 21, 2018	Can Tho, Viet Nam

International Symposiums and Workshops, FY 2018		
Annual Meeting of the “Development of a Sustainable Resource Management System in Palau” Project	September 24, 2018	Koror, Palau
Parallel forums titled “International Seminar on Future Food for Well-Being,” held in celebration of the 50th Anniversary of IFRPD, Kasetsart University	September 26-27, 2018	Bangkok, Thailand
ISSCT Joint Germplasm & Breeding and Molecular Biology Workshops	October 22-26, 2018	Okinawa, Japan
The 3rd International BNI Meeting 2018	October 25-26, 2018	Tsukuba, Japan
Review of Project Outcomes and Stakeholders’ Meeting	October 29-30, 2018	Ougadougou, Burkina Faso
Technical Coordinating Committee Meeting: Establishment of the model for fertilizing crop cultivation promotion using Burkina Faso phosphate rock	November 2, 2018	Ougadougou, Burkina Faso
JIRCAS International Symposium 2018, themed “Women in Fisheries: Sustainable Development Goals and Contributions to Research and Industry”	November 6, 2018	Tokyo, Japan
JIRCAS-IRAG Workshop titled “Rice improvement in Guinea”	November 7, 2018	Tsukuba, Japan
Satellite Workshop: Sustainable Resource Management and Environmental Conservation in Pacific Islands (JIRCAS Project)	November 16, 2018	Ishigaki, Japan
NARO-MARCO International Symposium: Nitrogen Cycling and its Environmental Impacts in East Asia	November 19-22, 2018	Tsukuba, Japan
Annual Meeting: Development of Technologies for Sustainable Aquatic Production in Harmony with Tropical Ecosystems (JIRCAS project)	December 11-13, 2018	Myeik, Myanmar
Workshop for the research project titled “Plant Genetics Resources in Asia (PGRAsia),” a collaborative effort between Japan and Lao PDR	February 14-15, 2019	Vientiane, Laos
2nd Technical Committee Meeting: Study on improving water efficiency in irrigation schemes in Africa (WEIRS for Rice)	February 22, 2019	Kilimanjaro, Tanzania
JIRCAS-CTU Workshop: Policy suggestions for mitigating greenhouse gas (GHG) emissions from rice cultivation in the Mekong Delta, Vietnam	February 28, 2019	An Giang, Vietnam
FY 2018 FRIM-JIRCAS Project Steering Committee Meeting	March 8, 2019	Kuala Lumpur, Malaysia
FY 2018 RFD-JIRCAS Project Steering Committee Meeting	March 12, 2019	Bangkok, Thailand
Joint Annual Meeting for the project titled “Development of agriculture risk management for climate change adaptation in Myanmar”	March 12, 2019	Naypyidaw, Myanmar
Knowledge Transfer Seminar: Estimation of stand volume using aerial photographs taken by drones	March 14, 2019	Bangkok, Thailand
3rd Research Network Meeting: Reducing Greenhouse Gas Emissions in Livestock	March 30, 2019	Sagamihara, Japan

The background of the page is a full-page marbled pattern. It consists of intricate, swirling, and wavy lines in various shades of purple, ranging from light lavender to deep, dark violet, set against a white or very light cream background. The pattern is organic and fluid, resembling traditional marbling techniques.

Appendix

Publishing at JIRCAS

English

1) JARQ (Japan Agricultural Research Quarterly)

Vol. 52 No. 3, No. 4

Vol. 53 No. 1, No. 2

2) Annual Report 2017

3) JIRCAS Newsletter

No.84, No.85, No.86

Japanese

1) Koho JIRCAS

Vol. 2, Vol. 3

2) JIRCAS News

No.84, No.85, No.86

3) JIRCAS Working Report

No. 87

Refereed Journal Articles 2018-2019

Program A

- Alamgir, M. S., Furuya, J.*, Kobayashi, S., Binte, M.R. and Salam, M.A. (2018) Farmers' Net Income Distribution and Regional Vulnerability to Climate Change: An Empirical Study of Bangladesh. *Climate*, 6 (3): 55, DOI: 10.3390/cli6030065.
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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

March 31, 2016 (Revision: March 26, 2019)

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.
- c) To promote the practical utilization of R&D results and create innovations through commercialization, JIRCAS shall, and if necessary, provide support, human resources, and technical assistance to parties who will use or pursue the application of these R&D results in business activities, in accordance with the Act on Activation of Science, Technology and Innovation (Act No. 63 of 2008). JIRCAS will appropriately implement the abovementioned support and assistance upon formulating the necessary rules according to the guidelines on contributions etc. of the National Research and Development Agency (Director General for Science, Technology and Innovation Policy, Cabinet Office, January 17, 2019).

(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.

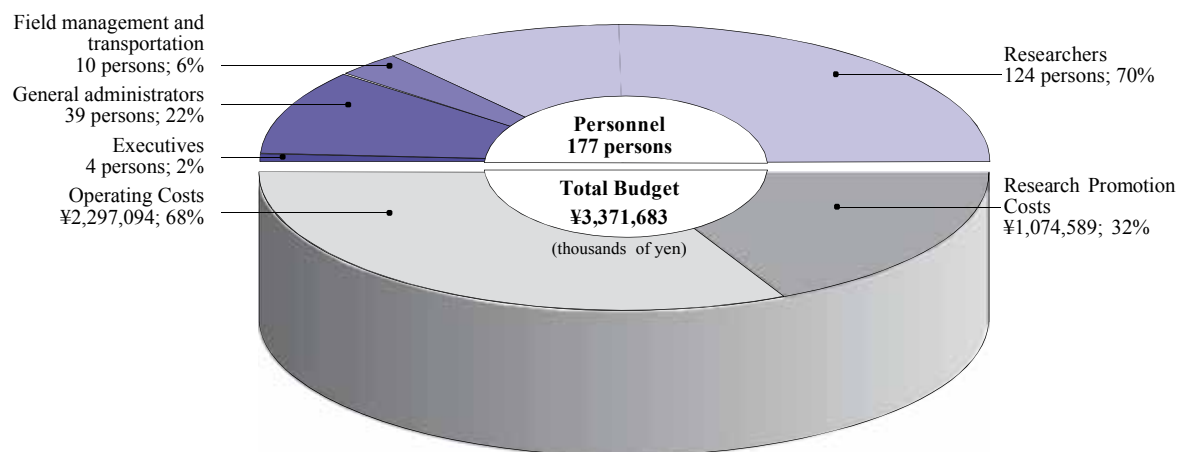
Financial Overview

Fiscal Year 2018

thousands of yen

TOTAL BUDGET	3,371,683
OPERATING COSTS	2,297,094
Personnel (177)	1,974,255
President (1), Vice-President (1), Executive Advisor & Auditor (2)	
General administrators (39)	
Field management (10)	
Researchers (124)	
* Number of persons shown in ()	
Administrative Costs	322,839
RESEARCH PROMOTION COSTS	1,074,589
Research and development	501,398
Overseas dispatches	207,431
Collection of research information	83,046
International collaborative projects	255,527
Fellowship programs	27,187

Budget FY 2018 (Graph)



Members of the External Evaluation Committee

Members of the JIRCAS External Evaluation Committee

Hiroto ARAKAWA	Former Advisor, Sumitomo Corporation
Hiroko ISODA	Director/Professor, Alliance for Research on the Mediterranean and North Africa, University of Tsukuba
Toshihiko KOMARI	Science Advisor, Corporate Strategy Division, Japan Tobacco Inc.
Shin-ichi SHOGENJI	Professor, Faculty of Agricultural and Food Sciences, Fukushima University
Hisayo YASUDA	Attorney-at-law, Yasuda International Law Office

JIRCAS Staff in FY 2018

President

Masa Iwanaga

Vice-President

Osamu Koyama

Executive Advisor & Auditor

Hisaya Kakiuchi
Mari Inoue

Research Strategy Office

Research Coordinators

Miyuki Iiyama, Development Economics
Toshimasa Masuyama, Bioenergy
Norihito Kanamori, Plant Molecular Biology

Regional Representative for Southeast Asia

Shotaro Ando, Representative of Southeast Asia
Office (Thailand)

Researcher

Sakiko Shiratori, Agricultural Economics

Program Directors

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

Taro Izumi, Head

Research Management Section

Mie Kasuga, Head
Katsunori Kanno, Intellectual Property Expert

Field Management Section

Takashi Komatsu, Field Operator
Hiroyuki Ishiyama, Field Operator

Research Support Office

Takayoshi Takeda, Head

Research Coordination Section

Koichi Iioka, Head
Keiko Ikeda, International Affairs Expert
Toshiki Kikuchi, Coordination Subsection Head
Daisuke Abe, Overseas Travel and Invitation
Program Subsection Head
Kenji Iwasa, Overseas Affairs Subsection Head
Jun-ichi Irino, Overseas Affairs Subsection
Specialist

Research Support Section

Akira Urushibara, Head
Koichi Fuse, Budget Subsection Head
Takayuki Yamamoto, Support Subsection Head

Information and Public Relations Office

Eizo Tatsumi, Head

Senior Researcher

Masaki Morishita, Rural Development

Public Relations Section

Kazuhiko Okada, Head

International Relations Section

Kunimasa Kawabe, Head

Publications and Documentation Section

Akira Hirokawa, Head
Hiromi Miura, Network Subsection Head
Takanori Hayashi, Information Management
Subsection Head (Librarian)

Administration Division

Katsuhiko Nomiya, Director

General Affairs Section

Noriaki Nishimura, Head
Hakumi Kumagai, General Affairs Assistant
Head
Takashi Oosato, Personnel Management Assistant
Head
Gaku Takeda, Personnel Subsection Expert
Hitomi Ogamino, Welfare Subsection Officer
Sachiyo Tatebe, Personnel Subsection 1 Officer
Kumi Ehara, Personnel Subsection 2 Head

Accounting Section

Tadao Yatabe, Head
Kiyoyuki Sunaoka, Accounting and Examination
Assistant Head
Toru Shimura, Procurement and Asset Managing
Assistant Head
Ryoichi Mise, Financial Subsection Head

Noriko Osonoe, Accounting Subsection Officer
 Aki Tamura, Audit Subsection Officer
 Yuka Takatsuto, Procurement Subsection 1 Officer
 Yuki Hibiya, Procurement Subsection 2 Head
 Shoko Yoshida, Supplies/Equipment Subsection Officer
 Tadahisa Akiyama, Facilities Subsection Head

Administration Section (Tropical Agriculture Research Front)

Kengo Uemura, Head
 Hiroe Nagatomo, General Affairs Subsection Head
 Takashi Ichimi, Accounting Subsection Head

Risk Management Office

Yasuyuki Nakanishi, Head

Compliance Management Section

Shota Miyai, Management Subsection Officer

Safety Management Section

Masakazu Yamada, Head

Inspection Section

Gen-ichiro Hanaoka, Inspection Subsection Officer

Audit Office

Osamu Kato, Head

Rural Development Division

Nobuyoshi Fujiwara, Director

Subproject Leader

Naoki Horikawa, Hydrology

Senior Researchers

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 Mamoru Watanabe, Rural Development
 Haruyuki Dan, Rural Development
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 Shutaro Shiraki, Rural Development
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Akihiro Imaiya, Soil Science

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Shinkichi Gotoh, Soil Science

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Ken Okamoto, Agricultural Engineering

Hiroshi Matsuda, Tropical Pomology

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Masato Shimajiri, Machine Operator

Masakazu Hirata, Machine Operator

Yasuteru Shikina, Machine Operator

Masashi Takahashi, Machine Operator

Masahide Maetsu, Machine Operator

Yuto Hateruma, Machine Operator

Takaya Shinmori, Machine Operator

The Japanese Fiscal Year and Miscellaneous Data

The Japanese Fiscal Year and the Annual Report 2018

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) 2018 covers the period from April 1, 2018 through March 31, 2019.

The Annual Report 2018 summarizes the full extent of JIRCAS activities that occurred during this period. The subsequent Annual Report will detail events and programs from April 1, 2019 through March 31, 2020 (FY 2019).

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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