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Annual Report 2019 (Apr. 2019– Mar. 2020)

JAPAN INTERNATIONAL RESEARCH CENTER FOR AGRICULTURAL SCIENCES

JIRCAS

Japan International Research Center for Agricultural Sciences

Annual Report 2019

(April 2019-March 2020)

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JIRCAS Annual Report 2019

Message from the President

President
Dr. Masa Iwanaga
(FY2011-)

The role of international collaboration in agricultural research to address challenges in the post-COVID-19 global food system

The year 2019, the fourth year of the Fourth Medium to Long-Term Plan for FY 2016-2020, was also the time to review our accomplishments so far, and to start preparing for our plan in the next five years. In the annual program review meeting for FY 2019, there was a general consensus that the four programs have already delivered more than what was initially committed under the current Plan, and ensured that the modalities for dissemination of our research outputs were in place to achieve the expected outcomes and impacts beyond the term of various projects. In preparation for the Fifth Medium to Long-Term Plan for FY 2021-2025, we have set up a Working Group to give recommendations to the senior management staff and scientists of JIRCAS on formulating more efficient and innovative strategies. The Working Group was tasked to evaluate the research outputs in the context of the changing environment and circumstances since 2016, both domestic and international, which have driven agricultural research agendas. The evaluation indicated that JIRCAS should continue to strengthen its comparative advantage of developing agricultural technologies in the areas of natural resource management, stable food production, and value addition, in collaboration with our counterparts in developing countries. It also recommended that JIRCAS should invest in smart/digital technologies in order to respond to ever-accelerating changes affecting the global food system.

Turning our eyes to the most urgent global issue at present, it was mid-January 2020 when the coronavirus (SARS-CoV-2) outbreak was first reported in Wuhan, China. The outbreak was then declared by the World Health Organization (WHO) as a Public Health Emergency of International Concern (PHEIC) on 30 January and a pandemic on 11 March. By early July, the novel coronavirus has been detected in every country, infecting more than 11 million people around the world. The implementation of lockdowns and movement restrictions to control the pandemic has inevitably led to the suspension of economic activities, accompanied by an unprecedented global economic crisis. As a result, the pandemic has shifted the international community's priority away from other global agendas and into responding to the immediate health and economic crises. It is especially notable to recall that at the beginning of year 2020, climate crisis was perceived as the most imminent risk that humanity and the planet Earth need to address (World Economic Forum).

The COVID-19 pandemic crisis has since been providing lessons and insights on how to manage the global climate change crisis. In an article published in the journal *Science of the Total Environment*, Manzanedo & Manning (2020) identified some similarities between the COVID-19 and climate crises, including high momentum trends and irreversible changes, while highlighting the differences in speed and degree/scale of impacts at which they evolve. While the COVID-19 pandemic spreads rapidly and synchronically throughout the world, climate crisis evolves more slowly and unevenly, yet with more grave consequences. While both crises require immediate actions to prevent from escalating, climate change has no silver-bullet solution unlike the concerted efforts to develop vaccines for the coronavirus.

Another common feature of the COVID-19 and climate crises is associated with socio-spatial inequalities, in which vulnerable populations in food-importing developing countries suffer most. By early July 2020, as many governments across the world began to ease lockdown restrictions and started to slowly reopen their economies, the COVID-19 epicenter has shifted to developing countries where the agriculture sector has been already stressed due to climate change. Given the magnitude of health and economic emergencies, the UN has predicted a worsening humanitarian crisis with the rise in the number of people suffering from food insecurity.

The triple crises of climate change, COVID-19, and food insecurity in developing countries are indeed intricately interlinked. The agriculture, forestry, and other land use (AFOLU) sector is not only a victim of climate change, but also among its major contributors, accounting for 23% of anthropogenic GHG emissions and 70% of freshwater use. Currently, the industrial agricultural sector is mainly responsible for emissions, while the subsistence smallholder sector in developing countries is subject to the vagaries of climate variabilities. For the latter, increasing demand to feed the growing population under conditions where agricultural productivity is chronically low and unstable due to the lack of appropriate technological breakthroughs has driven land-use change to expand areas for crop cultivation. Consequent deforestation and environmental degradation in turn led to the emergence of zoonotic diseases, including COVID-19. Under this scenario, reversing climate change, preventing disease outbreak, and addressing food security in developing countries have to go hand-in-hand through developing and scaling up climate-smart sustainable agricultural intensification technologies, which contribute to improving yields and resource-use efficiencies while conserving the environment.

Since its establishment as the Tropical Agricultural Research Center (TARC) in 1970, JIRCAS has been a front-runner in Japan's efforts to collaborate with partners from developing regions and international organizations through joint agricultural research projects. Today's global challenges of climate crisis and zoonotic disease pandemic are evolving too fast, becoming increasingly too complex, and affecting too many dimensions of our planet as well as our lives to sustain the resilience of the global food system for food and nutrition security for all. JIRCAS is geared to deal with these challenges by taking advantage of its strength based on its 50-year experience of research with partners in developing countries. At the same time, in order to achieve the SDGs, JIRCAS will keep looking for an even more effective, impact-oriented mode of international research collaboration, both to adopt smart tools through working with cross-disciplinary teams and to develop/disseminate/scale-up technologies swiftly and widely through strengthening of ties with implementing partners.

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

The four Programs

The Fourth Medium to Long-Term Plan consists of four research programs, retaining the previous medium-term plan's overall structure of program-based management with some modification of the project level components. 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 the four "Programs" (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. The projects under each program collectively and coherently contribute to the major goal of their respective programs.

Partnership is the center of our activities

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

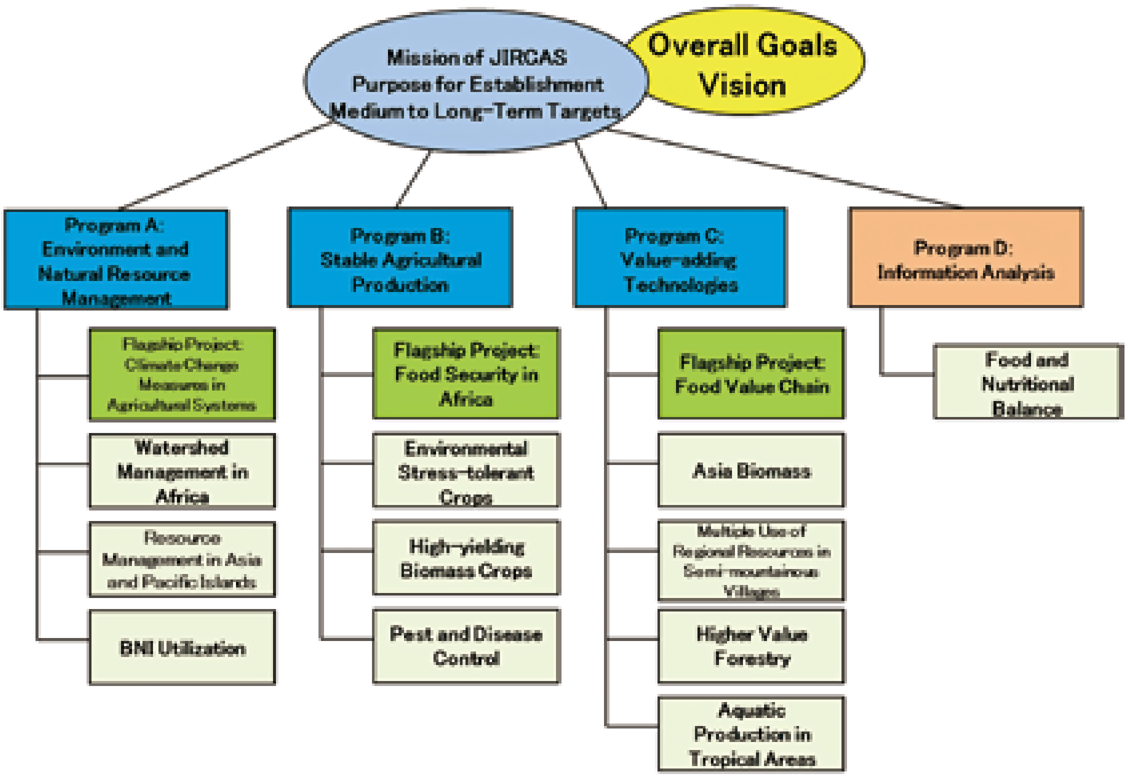


Fig. 1. Program-Project Research Framework

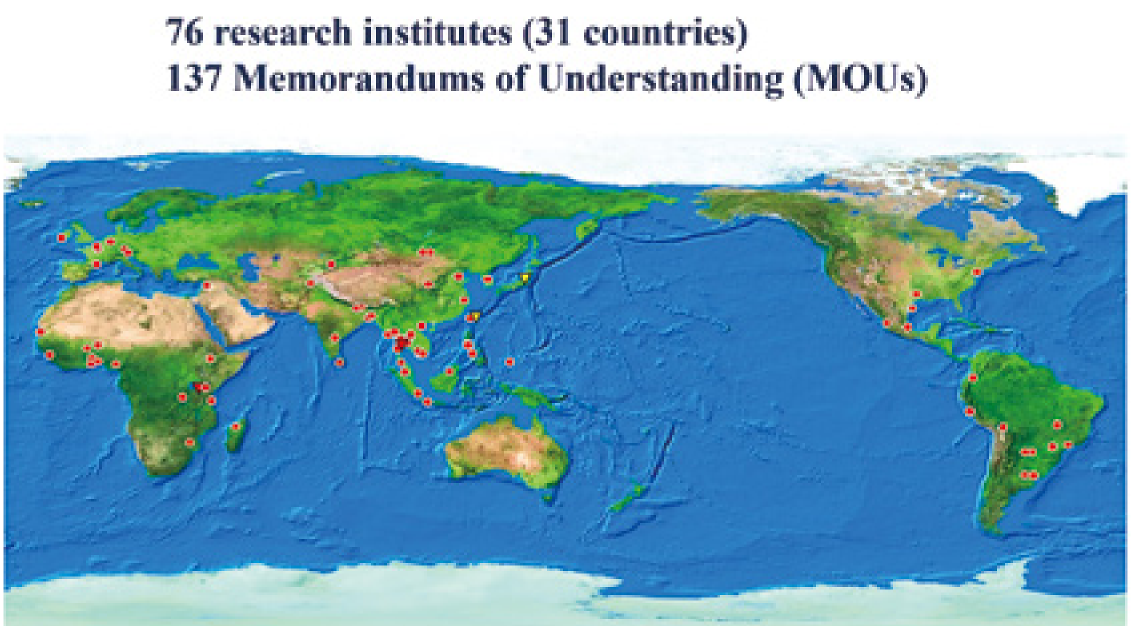


Fig. 2. Locations of our current activities based on 137 MOUs with partner institutions

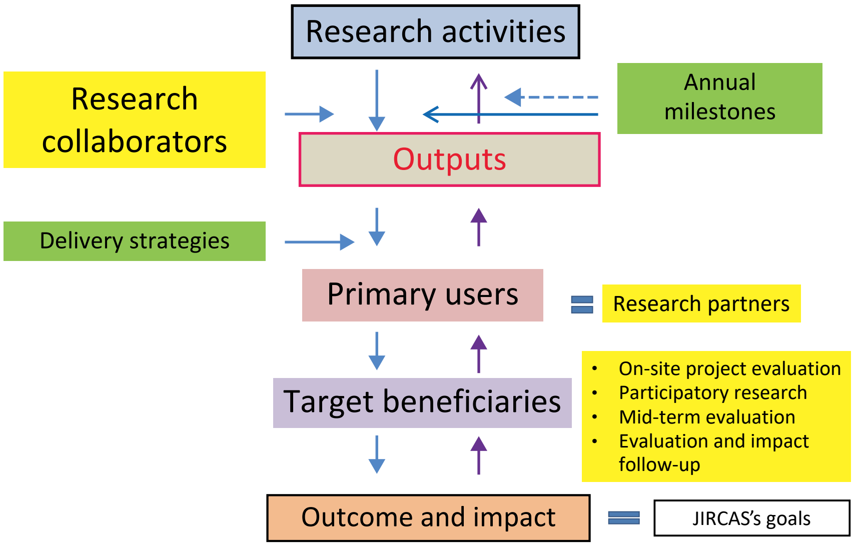


Fig. 3. Impact-oriented research for development (Operational Cycle)

Strive for impacts

By introducing the program-based system for output development and delivery, JIRCAS was able to depict more succinctly its mission and target beneficiaries, not only to taxpayers and Japanese citizens but also to people in developing countries. 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 "research for development" tradition encompassing almost five decades, hoping to produce deliverables that will be used by our target beneficiaries, resulting in significant and positive social impacts.

With Niger President Mahamadou Issoufou at TICAD 7

Highlights from 2019

JIRCAS President at the G20 Niigata Agriculture Ministers' Meeting

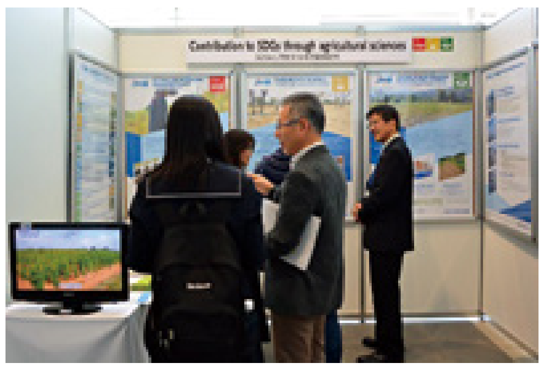
The G20 Agriculture Ministers' Meeting, one of the eight ministerial meetings taking place in Japan alongside the G20 Osaka Summit, was convened on May 11-12, 2019 in Niigata. In this meeting, JIRCAS President Masa Iwanaga reported the key outcomes of the G20 Meeting of Agricultural Chief Scientists (G20 MACS) to the agriculture ministers of the G20 countries. President Iwanaga was the chairman of the 2-day G20 MACS held in Tokyo on April 25-26.

The G20 MACS members are responsible for making strategic advice on global agricultural research agendas to their decision makers, including their respective ministers of agriculture. Dr. Iwanaga reported to the G20 agriculture ministers some of the key outcomes of the 2019 G20 MACS, including the two main themes discussed, namely, transboundary plant pests and social experiment-like approaches to facilitating on-site adoption of climate-smart technologies. The report also mentioned the support of G20 MACS members for Japan's proposal to organize international workshops on the above two themes later in 2019, and the proposal for the ministers to provide support to activities that would enhance international research collaboration on the issues discussed at G20 MACS.

As part of the exhibits at the meeting venue, JIRCAS presented posters and communication materials under the theme "Contribution to SDGs through agricultural sciences," which highlighted JIRCAS's research programs and projects aiming at enhancing income earning opportunities, stable food supply, and climate change adaptation in developing regions.

President Iwanaga with the G20 agriculture ministers
Photo by the Agriculture, Forestry and Fisheries Research Council, MAFF

Reporting on issues for joint action by G20
Photo by the Agriculture, Forestry and Fisheries Research Council, MAFF



JIRCAS exhibit booth at G20 Niigata

JIRCAS International Symposium 2019
International research collaboration to tackle transboundary plant pests: Contributions to Sustainable Development Goals

From the perspective of contributing to the Sustainable Development Goals (SDGs), the JIRCAS International Symposium 2019 focusing on international research collaboration to tackle transboundary plant pests was held at the Tsukuba International Congress Center on November 26, 2019. The symposium was co-organized by the National Agriculture and Food Research Organization, in cooperation with the Ministry of Agriculture, Forestry and Fisheries (MAFF), the Phytopathological Society of Japan, the Japanese Society of Applied Entomology & Zoology, the FAO Liaison Office in Japan, and the Japan Forum on International Agricultural Research for Sustainable Development.

There were two keynote speeches, two sessions, and a panel discussion. The first keynote speaker was Dr. Jingyuan Xia, Secretary to the International Plant Protection Convention Secretariat (IPPC). He talked about recent challenges in fighting against transboundary plant pests and the FAO's strategies for helping farmers in dealing with those pests. The second keynote speaker was Dr. Ulrich Kuhlmann, Executive Director for Global Operations, CABI. His keynote talk focused on CABI's experiences of transboundary plant pest management particularly in strengthening plant health systems and the importance of advisory services.

The theme of Session 1 was "Important Transboundary Insect Pests" and three speakers were invited, focusing on migration analysis and forecasting of migratory insect pests, the development of insecticide application technology to rice planthoppers, and fall armyworm damage in African smallholder maize fields and its impact on yield. Session 2 was entitled "Important Migratory Diseases and Quarantine" and three speakers were invited, focusing on the international collaborative network for rice blast, the Brazilian experiences on the invasion of soybean rust and its management, and plant quarantine and risk management. The tail end of the symposium was devoted to a panel discussion, with six speakers expressing their opinions on effective international research cooperation, the necessity of sharing information across countries, and innovations in alerting, monitoring, diagnosis, and capacity building in developing regions, for coping with the problems of transboundary plant pests from the perspective of contributing to the SDGs.

The symposium was a good opportunity to emphasize that mitigation of transboundary plant pests should involve sharing information, establishing networks to promote researches, conducting research cooperation such as joint research projects, and strengthening collaboration with international organizations such as the IPPC, FAO, and CGIAR centers.

Opening Remarks: Masa Iwanaga (President, JIRCAS)

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

JIRCAS International Symposium 2019
Tsukuba International Congress Center, Japan
November 26, 2019

2019 Japan International Award for Young Agricultural Researchers

JIRCAS, in cooperation with the Agriculture, Forestry and Fisheries Research Council (AFFRC) Secretariat, held the 13th commendation ceremony of the Japan International Award for Young Agricultural Researchers (Japan Award) on November 26, 2019 at Convention Hall 200, Tsukuba International Congress Center in Tsukuba City, Ibaraki Prefecture. The Japan Award is given by the chairman of the AFFRC, Ministry of Agriculture, Forestry and Fisheries (MAFF), to recognize and honor young foreign researchers (under 40 years old) whose outstanding achievements promote research and development of agricultural, forestry, fishery and other related industries in developing regions.

The awardees and guests were welcomed by Mr. Yoshio Kobayashi (Chairman of the AFFRC). Congratulatory remarks were delivered by Dr. Isamu Takahara (Deputy Director General for Science, Technology and Innovation, Cabinet Office) and Mr. Hideya Yamada (Vice President of the Japan International Cooperation Agency, JICA), while the selection process was explained by Dr. Mutsuo Iwamoto (Chairperson of the Selection Committee).

The awarding ceremony was facilitated by Mr. Kobayashi, who read and presented the commendation certificates (AFFRC Chairman's Award), and Dr. Masa Iwanaga (President of JIRCAS), who presented the monetary incentives (MOTAI-JIRCAS Award). The three winners delivered lectures of their respective research achievements following the presentation of prizes.

2019 Japan Award commemorative photo

The 2019 Japan Award recipients and their research achievements

Awardee: Dr. Jacobo ARANGO MEJIA

International Center for Tropical Agriculture (CIAT)
Nationality: Colombian
Research Achievement: Research on tropical forage grasses to mitigate greenhouse gas emissions and combat climate change

Outline of Research Achievements

The mitigation of climate change (CC) is a major and crucial challenge for humanity. This phenomenon has profound effects on agricultural production and food security, and CC effects are projected to become worse. As a young Colombian scientist, Dr. Arango is highly focused on developing tools and technologies to mitigate CC through reduced greenhouse gas emissions. He has conducted strategic research to demonstrate how tropical forages can reduce the environmental footprint of livestock production. One concrete example is the exploitation of the Biological Nitrification Inhibition (BNI) capacity of *Brachiaria* and *Panicum* tropical forage grasses. The BNI concept was conceived by JIRCAS in collaboration with CIAT more than a decade ago. Long-term collaborative research between JIRCAS and CIAT has provided direct evidence for inhibition of soil nitrification by plants via root exudation. The high BNI potential found in these forage grasses increases nitrogen use efficiency and reduces nitrous oxide emissions. A major outcome from his research is the development and application of accurate phenotyping tools for this key BNI trait. Another significant outcome is the development of a feeding strategy/technology through identification of superior diets for cattle, based on a combination of tropical forage grasses and tree legumes. Since these nutritious forages are more efficiently utilized by target animals, methane emissions from enteric fermentation are effectively reduced.

Awardee: Ms. MAI Thi Ngan

Vietnam National University of Agriculture
Nationality: Vietnamese
Research Achievement: Development of a simple, accurate, and economical diagnostic test and pooled testing system for detection of porcine epidemic diarrhoea virus

Outline of Research Achievements

There is an adage that says "prevention is better than cure" but the truth is that we do not invest sufficiently in prevention. Prevention is a difficult but important message for the control of transboundary animal diseases (TADs), including porcine epidemic diarrhoea (PED). PED is an emerging and re-emerging epizootic swine disease that causes massive economic losses with high morbidity and mortality in piglets worldwide. In Vietnam, PED was first observed in 2009 and has developed to an endemic stage. PED prevention and control are expected to have a positive impact on food security; thus, early detection of PED virus-infected herd through active surveillance is necessary. However, surveillance is applied only to individuals using the 'gold standard' polymerase chain reaction (PCR) method, which is difficult to use for developing countries like Vietnam due to cost and most laboratories in the country being under-equipped and unable to meet the sophisticated requirements for PCR.

To solve this problem, we successfully developed an innovative test for diagnosing PEDV infections. This test, which uses the loop-mediated isothermal amplification (LAMP) method, has high sensitivity and specificity, and is cheap, rapid, and simple. Furthermore, our new system can be used not only on individual animals but also on several animals at once. The system is practical and has high applicability in unequipped laboratories and developing countries. It also supports the design and implementation of large-scale epidemiological surveys and enables active surveillance for the effective control of PED and other diseases.

Awardee: Dr. Rebijith KAYATTUKANDY BALAN

Plant Health and Environment Laboratory, Ministry for Primary Industries, New Zealand
Nationality: Indian
Research Achievement: Molecular approaches in identification, diversity and management of important insect pests in India

Outline of Research Achievements

The accurate identification and management of insect pests has been a herculean task for several decades. Dr. Rebijith has successfully developed several DNA barcodes and species-specific markers that can identify various insect pests of agricultural crops independent of life stages, color morphs and sex. His exceptional work on molecular diversity has revealed the existence of cryptic species and genetic groups in various insects such as aphids, thrips and whiteflies, and his collaborative research on insecticide resistance status in *Bemisia tabaci* genetic groups has been widely appreciated. Furthermore, Dr. Rebijith demonstrated the utility of RNA interference in the management of *Aphis gossypii*, *B. tabaci*, *Helopeltis antonii*, *Plutella xylostella,* etc. for the first time in India. His work on small RNAs and RNAi has revealed the differentially expressed microRNAs in the juvenile hormone biosynthetic pathway in *Spodoptera*. Lastly, his work on artificial miRNA-mediated gene silencing is the basis behind novel pest management strategies that are being developed.

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 2019, JIRCAS signed new MOUs with Nepal Agricultural Research Council (NARC), Thailand Institute of Science and Technological Research (TISTR), and Texas A&M AgriLife Research, bringing the total number of active MOUs to 137 as of March 2020. Based on the work plans elaborated in the respective MOUs, JIRCAS carried out joint research projects with 76 research institutions in 31 developing countries, and implemented commissioned research activities with 7 research institutions in 6 countries. The signing ceremony of the MOU between JIRCAS President Masa Iwanaga and NARC Acting Executive Director Tek Bahadur Gurung in Kathmandu, Nepal, was attended by the Japanese Ambassador to Nepal Masamichi Saigo and government officials of the two countries. The local media also reported the ceremony.

JIRCAS also promotes collaboration with international organizations, including CGIAR, in order to contribute to solving global challenges. JIRCAS continued the secondment of its scientist to the CGIAR System Council to support the operation of CGIAR Research Program 2 (CRP 2). Conversely, JIRCAS continued hosting one visiting scientist from AfricaRice. JIRCAS also created a new capacity development scheme that would allow JIRCAS to send junior scientists such as graduate students and postdoc scientists to CGIAR research centers under the existing JIRCAS Fellowship Program, to which one candidate made an application.

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 such as sugarcane and tropical fruits, (4) improvement of Indica group rice cultivars, and (5) introduction of useful traits into rice by biotechnology.

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 study proved that nitrogen load to the underground can be reduced without sacrificing sugarcane yield by modification of timing and doses of the nitrogen fertilizer. Based on the results, our counterpart organization, the Sugar Regulatory Administration (SRA), initiated a commercial-scale field experiment to accelerate social implementation of the new fertilization method. We also proved that a soil-crop simulation model (APSIM) can reproduce sugarcane growth and yield and NO_3-N leaching in lysimeter experiments in Ishigaki. The APSIM model could reproduce the results of the field experiment in Negros Island after tuning the model for the local climate, soil, and sugarcane variety. It was proven that we could use the model for ex-ante analysis of the new fertilization practices in the islands.

To develop countermeasures against soil erosion in the island-nation of Palau in western Pacific Ocean, we constructed a series of field experiments in Palau and Ishigaki. These experiments showed that a modified conservation agriculture technology — a combination of minimum tillage with handy auger and organic mulch — more than doubled the taro corm (root) yield and reduced soil erosion by 10% to 50% in agricultural fields in Palau. Based on the results, we launched new activities at three experimental sites and six farmers' fields, applying the farmer participatory approach (mother-baby trial) in order to verify and disseminate the technology developed.

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* into sugarcane. We have developed intergeneric F_1 hybrids between sugarcane and *Erianthus* and their backcrossing populations (BC_1, BC_2, BC_3). We are currently evaluating their agronomic traits such as dry matter and sugar content, root characteristics, and cytogenetic characteristics to develop new breeding materials.

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 advantages of those phenotypic characteristics against abiotic stresses. Breeding materials for blast resistance developed at JIRCAS were shared with the Philippines, Bangladesh, and Africa Rice Center, and we are also planning to send them to Indonesia, Vietnam, and Laos.

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 CCCH-tandem zinc finger protein isolated from rice had higher grain yields than original non-transgenic varieties under drought conditions in field environments. Regarding genome editing, JIRCAS has succeeded in establishing a system for genome editing that is applicable to local rice cultivars in Madagascar and Laos. We are currently working on generating genome-edited rice that can maintain grain yield under nutrient-deficient conditions or can accumulate a greater number of components.

Contribution to domestic agriculture

TARF contributes to domestic agriculture through the following activities:

1) Generation advancement

An early generation rice population consisting of 138 accessions from NARO breeding stations all over Japan were grown two times.

2) Conservation of genetic resources

As a sub-bank for tropical and subtropical crops, the NARO Genebank maintained 596 accessions of sugarcane, *Erianthus* and its relatives; 150 of tropical fruit trees; and 125 of pineapple, vegetatively in the field or in a greenhouse.

3) Development of varieties for Nansei Islands

Passion fruit breeding at TARF started in 2008, culminating in the variety registration of 'Sunny Shine' on February 12, 2019. '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 passionfruit cultivars are being eyed for future development.

An application for registration of the *Urochloa* (syn. *Brachiaria*, forage grass) candidate variety 'Isan' has been filed in Japan 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 the cultivar's performance and evaluate other possibilities for domestic use in Okinawa of the Indica Group breeding materials developed under the international collaborative research. Many panelists showed positive reactions to an Awamori produced using a breeding material developed under such collaboration and harvested in 2018 and 2019 (Photo 1).

The new high ratoon yield cultivar 'Harunoogi' was jointly developed by JIRCAS and the National Agriculture and Food Research Organization (NARO) from a crossing between fodder sugarcane cultivar KRFo93-1 (by interspecific hybridization between sugarcane cultivar NCo310 and *S. spontaneum* Glagah Kloet) and high-sugar-content sugarcane cultivar NiN24. Harunoogi produces an extraordinarily large number of stalks and has excellent ratooning ability (Photo 2). The cane yield and sugar yield in 1st and 2nd ratoon crops of Harunoogi are much higher than in NiF8's.

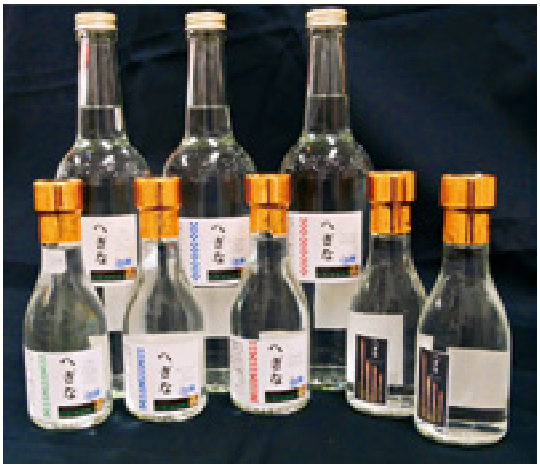


Photo 1. Local distilled beverage/spirits (called "Awamori") in Ishigaki Island were produced and tested for performance.

4) Development of a low-cost,high-performance plant factory for tropical and subtropical regions

Integrated research focusing on a plant factory is being conducted at TARF, supported by grants from the NARO Bio-oriented Technology Research Advancement Institution (via R&D matching funds under the Field for Knowledge Integration and Innovation [FKII] platform). The project is a cross-sectoral collaboration among private companies, universities, and NARO to develop cultivation systems that are adapted to tropical/subtropical regions. We have achieved an average of 30 tons of tomatoes per 10 ares (1 are=100 sq. m.) and, as a final product, built a multi-span greenhouse costing less than 200 million yen/ha to demonstrate the results of technology integration in 2019 (Photo 3).

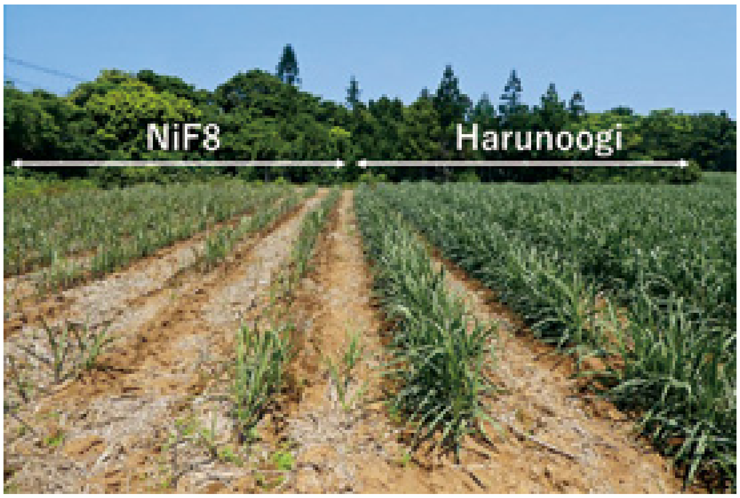


Photo 2. The new variety 'Harunoogi' and conventional variety 'NiF8' in early growth stage of the ratoon crop
Photo was taken in May 2019 in Nishinoomote, Japan (provided by NARO).

Photo 3. A newly built multi-span greenhouse to demonstrate the results of technology integration

ACADEMIC PRIZES AND AWARDS

“Best Paper Award” from the Farm Management Society of Japan (FMSJ)

Dr. Junji Koide (Researcher, Social Sciences Division) received the ‘Best Paper Award’ from the Farm Management Society of Japan (FMSJ) in a ceremony held on September 7, 2019 in conjunction with the Annual Meeting of the Farm Management Society of Japan held in Sendai, Miyagi Prefecture. The award is given to a paper with remarkable achievements among the papers published in the *Japanese Journal of Farm Management*.

The award-winning paper entitled “Development of An Improved Farm Management Model for African Smallholders: Case of the Nacala Corridor in Northern Mozambique” and published in October 2018 (Vol. 56, No. 3) was co-authored with Dr. Ryuichi Yamada (Tokyo University of Agriculture) and Dr. Wataru Oishi (University of Tsukuba). The farm management model was constructed using a linear programming approach based on the measured and actual values of production and livelihoods of small-scale farms collected in the three areas of the Nacala Corridor with different agricultural ecological environments.

Awarding ceremony

FMSJ Best Paper Award certificate

“Green Asia Award” at the Asian Conference on Remote Sensing 2019

Dr. Akira Hirano (Senior Researcher, Social Sciences Division) was honored with the “Green Asia Award” at the 40th Asian Conference on Remote Sensing (ACRS 2019) held in Daejeon, Korea on October 14-18, 2019. The ACRS is an annual event hosted by member countries of the Asian Association on Remote Sensing (AARS) in Asia to promote remote sensing technology through the exchange of information, mutual cooperation, international understanding, and goodwill amongst the members. Every year, the conference brings in approximately 800 participants from around the world. The “Green Asia Award” is given to an outstanding paper among all presented papers at the conference that directs Asia towards a greener future using remote sensing technology.

The paper entitled “On the applicability of satellite-based rainfall estimates for the determination of Monsoon onset date: Case study in the Ayeyarwady Delta, Myanmar” was co-authored with Dr. Swe Swe Mar and Ms. Hla Moe Khaing of the Yezin Agricultural University, and Ms. May Toe Aung Myint of the Department of Agriculture Labutta Township, all in Myanmar. The paper examined the compatibility between the historical ground-based rainfall measurements and satellite-based rainfall estimates, and then presented a revised method to identify the monsoon onset dates in a specific region using the satellite-based rainfall data. As a result, it was shown that a more detailed analysis is necessary to address the common perception that the onset dates of monsoon are constantly being delayed due to climate change.

The award certificate was presented to Dr. Akira Hirano by Dr. Yi-Hsing Tseng, president of the Chinese Taipei Society of Photogrammetry and Remote Sensing (CTSPRS) on behalf of the ACRS 2019 organizers during the closing ceremony on October 18.

Awarding Ceremony

Green Asia Award

Certificate of Appreciation from the Director of Burkina Faso's National Institute of Science and Technology

The director of Burkina Faso's National Institute of Science and Technology (CNSRT), Dr. Roger H. Ch. Nébié, presented a certificate of appreciation to Dr. Fujio Nagumo (Director, Crop, Livestock and Environment Division) in recognition of the joint research projects of JIRCAS that have contributed to research in science and technology and human resource development in the country. The ceremony was held at the CNRST Headquarters in the capital city of Ouagadougou on March 5, 2020.

JIRCAS has been conducting several joint research projects with the Environmental Institute for Agricultural Research (INERA), which is under the CNSRT of the Ministry of Higher Education, Scientific Research and Innovation. Dr. Nagumo has led three of these joint projects so far. Among the projects are as follows:

1) Establishment of agricultural technology for sustainable production in the African savanna area (2011-2015)

2) Development of intensive watershed management models for soil erosion prone areas in Sub-Saharan Africa (2016-present)

3) Development of stable production technology for rice and field crops to solve food problems in Africa (2016-present)

4) SATREPS project on the development of a model for fertilizer cultivation promotion using Burkina Faso phosphate rock (2017-present)

During the ceremony, Dr. Nébié and Dr. Hamidou Traoré (INERA Director) expressed profound gratitude to JIRCAS as well as strong expectations for the continuation and further development of the research collaboration.

Dr. Nébié of CNSRT (right) presenting the Certificate of Appreciation to Dr. Nagumo (left)

Group picture of attendees

"Young Scientist Award" from the Crop Science Society of Japan (CSSJ)

Dr. Kotaro Iseki (Researcher, Biological Resources and Post-harvest Division) received the 24th Japanese Society of Crop Science Young Scientist Award. This award is given to a young scientist of the Crop Science Society of Japan with outstanding research achievements that contribute to the development of crop science. The title of the commended research was "Characterization of Plant Genetic Resources to Improve Crop Production under Environmental Stresses in Asia and Africa." Dr. Iseki has been advancing the characterization of genetic resources of rice, cowpea, and yam to identify accessions with excellent environmental stress tolerance and improved productivity. He also has developed several high-throughput evaluation techniques for that purpose. The research was targeted not only for cultivars but also for crop wild relatives that have not been used so far in developing countries. He was presented a medal and certificate dated March 26, 2020.

Medal and certificate presented to Dr. Iseki

Dr. Iseki with local staff in Nigeria

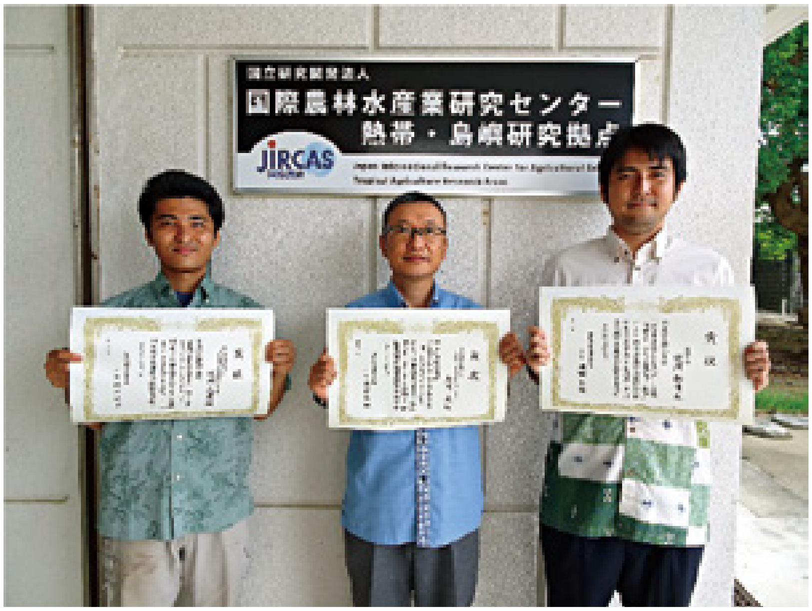
Awards from the Japanese Society for Tropical Agriculture (JSTA)

Dr. Hide Omae (Director, Tropical Agriculture Research Front [TARF]) and Dr. Hiroshi Matsuda (Researcher, TARF) accepted the "Award for Academic Excellence in Tropical Agriculture" and "Promotional Award for Achievement in Tropical Agriculture," respectively, from the Japanese Society for Tropical Agriculture (JSTA) on March 17, 2020.

Dr. Omae was awarded for his studies on the physiological traits of leguminous crops and the adoption of sustainable crop production technologies in adverse environments such as the Sub-Saharan Africa (SSA), where high temperature and drought are critical to crop production. He developed simple physiological indexes to evaluate high temperature or drought tolerance of common bean or cowpea after examining plant physiological responses to environmental stresses. For the Sahel, he developed several technologies to improve the fertility of sandy soils in pearl millet/cowpea intercrops and promote the application of organic materials (millet husk, manure, or both) available from an adjacent village. For the Savanna, he elucidated the contribution of intercropping pigeon pea with cereals to stable crop production, both as residual mulch and as nitrogen source, when it was applied across seasons.

Dr. Matsuda, meanwhile, was awarded for his research article titled “Studies on cultivation management for stable fruit set in subtropical fruit trees: cherimoya and lychee.” He clarified the thermal response of cherimoya floral organs and recommended temperature management during flowering to prevent fruit set failure. He also established methods for germination test, collection, and storage of lychee pollen, and identified lychee cultivars that can achieve a stable fruit set and produce high quality fruits.

In addition to Dr. Matsuda, Dr. Hiroo Takaragawa (Researcher, TARF) was also awarded the “Promotional Award for Achievement in Tropical Agriculture” for his study, titled “Sustainable sugarcane production through effective use of varietal diversity,” which he carried out during his previous stint at the University of the Ryukyus in Okinawa.



JIRCAS-TARF Director Omae (center) with Dr. Matsuda (left) and Dr. Takaragawa (right)

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 2019 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 2020.
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 2020.

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 2020.

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 2019 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 137 MOUs or JRAs remained in force at the end of FY 2019.

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

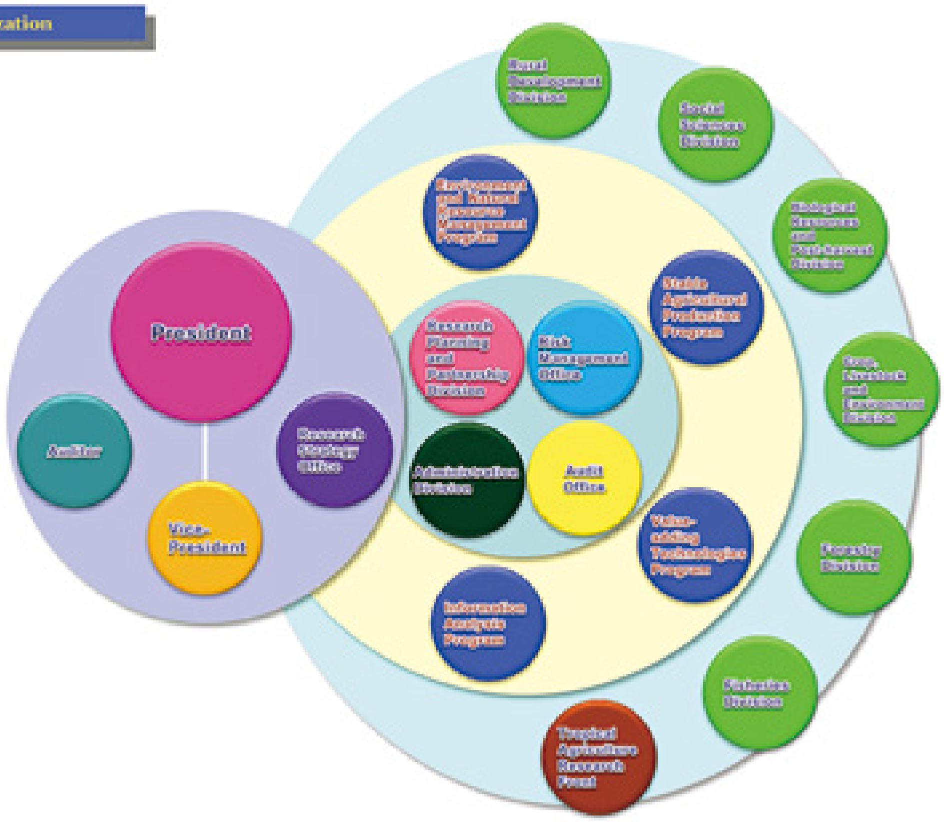
The organizational structure of JIRCAS for the Fourth Medium to Long-Term Plan period is summarized in the figure below.

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 Resource 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]

We are conducting experimental studies in Vietnam and Thailand on new technologies to mitigate GHG emissions from agricultural activities. Generally speaking, mitigation techniques are not always attractive to farmers who prioritize tangible benefits. Therefore, we will integrate various mitigation techniques into one package.

A technology that links biogas production and rice cultivation is being developed, using biogas effluent (anaerobic digestion effluent) as nitrogen fertilizer in rice paddies to reduce environmental burden and inorganic fertilizer input. In a pot experiment, we have shown a farmer-friendly method that optimizes the timing and amount of biogas effluent application using a simple leaf color chart (Topic 1). We are currently demonstrating in fields that applying biogas effluent that has been preheated and sterilized can achieve rice yields comparable to conventional inorganic fertilizer application.

Field trials for the alternating wetting and drying (AWD) irrigation technique in triple paddy cropping sites were carried out in six districts in An Giang Province in the Mekong Delta. The results indicated that the mean rice yield increased by 24% while the mean methane gas emissions decreased by 40%. The increased yield can be a good incentive for farmers to apply AWD. For further dissemination of AWD, a policy suggestion paper based on the results of experiments was handed over to the local government of An Giang Province. One of the disincentive factors in AWD adoption, however, is the various water management difficulties encountered by farmers. We are working on the development of low-cost ICT devices for measuring the water level in paddy fields, thus enabling farmers to easily know which ones are in a flooded state. The influences of AWD on farmers' profit and GHG emissions (estimated with a life cycle assessment) were evaluated by comparing AWD farmers and non-AWD farmers. In a pot experiment, the effect of reducing methane gas generation was confirmed in the waterlogged straw decomposing during fallow periods in the double-cropping rice system. Regarding low rice yield during wet season in the Mekong Delta, we are close to proving our assumption that it is chiefly caused by hydrogen sulfide generated in the soil in the wet season, in addition to unfavorable climate conditions such as higher temperatures and lower sunshine as compared with the dry season.

Concerning carbon sequestration in the soil, our long-term field experiment in Thailand showed that crop (maize) residues had higher retention under rice straw mulching and rice husk char application, and that the accumulation rate of soil organic carbon (SOC) was increased by char application and no-tillage. Analysis of SOC data from six long-term field experiments (also in Thailand) showed that compost application had higher yield and accumulation rate of the applied carbon, and that clay + silt content of the soil had a positive correlation with SOC. These results would contribute to technology development to increase SOC under tropical conditions.

In the field of livestock science, results confirming that cashew nut shell liquid (CNSL) feeding can mitigate enteric methane emissions from local Vietnamese cattle Lai Sind by 20% were reproduced.

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 in Myanmar, we designed and tested the adaptability of weather index insurance to offset the loss of agricultural products to extreme events. In order to depict the underlying climatic conditions for rice farming, we analyzed the trend in satellite-based rainfall data and observed no significant delay in monsoon onset over the past twenty years, contrary to common perception. Furthermore, we compared decadal changes in Normalized Difference Vegetation Index (NDVI) from satellite images of the Ayeyarwady region since 1981, and noted that considerable areas of farmland near the coast decreased because of upward saline intrusion associated with sea level rise, and that rice yields also decreased even in rainy seasons when the salts are washed out from the farmland. On the other hand, the results of the stated preference survey of farmers in Labutta township indicate that there is a strong demand for disaster insurance to cover losses due to floods, but little demand due to salt damages. The results suggest that selection of the target region for index insurance is critical. Finally, the results of a farm model analysis for a rainfall index-based flood insurance revealed that for floods that occur once every five years, the optimum insurance premium will be 21,600 kyat or around 1,650 Japanese yen.

For the inland area of Myanmar, we developed a numerical model to evaluate reservoir operations. Application of the model at a test area gave results indicating that the two major functions of the reservoir, say, flood control and irrigation water supply, did not significantly contradict each other. In Bangladesh, we refined our multiscale statistical model to estimate the impacts of climate change on rice yield. The model helped identify and evaluate the adaptation technologies to be applied against extreme events.

In the study on water use practices in the Central Dry Zone (CDZ) of Myanmar, we made draft measures to improve irrigation efficiencies, such as estimating irrigation demand, improving the distribution system, and allocating between irrigation and domestic use in the dry season. Furthermore, we have conducted studies about a perennial rice cropping method through appropriate ratoon management for water-saving irrigation systems in Myanmar. Selection of suitable rice varieties has been commenced for higher ratooning and better on-farm performance.

Regarding WeRise, a seasonal climate prediction-based decision support tool for rainfed-rice farmers in monsoon areas developed through an IRRI-Japan collaborative research project, its predictability was validated in on-farm trials in the Philippines. Prior to the rainy season, WeRise advised collaborating farmers on the best practices for a given variety. The grain yields of the WeRise-advised farmers were compared with those of surrounding farmers who did not receive advice. The actual grain yields were similar to predictions, whereas the yields of surrounding farmers were lower than the predictions. This is proof of grain yield improvement achieved by applying WeRise predictions and advice.

[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 Burkina Faso, in collaboration with INERA (Institut de l'Environnement et Recherches Agricoles), several prominent soil and water conservation technologies were studied. The obtained results indicated that *Piliostigma reticulatum* and *Guiera senegalensis* were confirmed as suitable native shrub species for promoting greening practices on the eroded upper slopes in the watershed. Runoff water speed and earthen wall collapse were reduced by the combination of earthen wall and row planting of *Andropogon gayanus*. A two-year, on-station experiment in runoff plots revealed that the "Fallow Band System (FBS)" reduced annual runoff by 29% and water erosion by 86%, and that 60% of farmers (n=78) were impressed by the results of FBS adoption. A land cover map of individual crops was created using the color information and height estimates derived through UAV (drone) surveys over multiple transects. To overcome feed shortage during the dry season, good quality, fresh sorghum stover silage and total mixed ration (TMR) were prepared. Proposed optimal fertilizer management practice was validated through participation of 54 farmers in on-farm experiments on Lixisols and Plinthosols, the two dominant soil types in the Sudan Savanna. Validation of an annual grain yield fluctuation-based technology for dissemination became possible by integrating income distribution fluctuations and through simulation to generate stochastic predictions.

In the Ethiopian Highlands, the obtained results showed that an eroded sediment clay soil from the dam was applicable as culture soil for saplings of *Vachellia etbaica* (=*Acacia etbaica*) in an improved composition with sand and organic matter. Accelerated growth and nutrient uptake and an increase in chlorophyll content for *V. etbaica* and *Faidherbia albida* were confirmed by the application of biochar. Using a UAV to map the whole watershed, the difference in tree shape parameters were obtained and a three-dimensional model was created for biomass estimation of *V. etbaica* using the structure from motion (SfM) method. Evaluation was done on the use of "low-cut" wheat residue as an effective soil conservation practice. Vegetable production in a reclaimed farmland was tested after estimating the sediment volume of the micro-dam (Topic 3). Results obtained through questionnaire surveys and economic experiments involving the farmers showed the effectiveness of farmers' training in enhancing their awareness on the importance of communal land conservation.

The result of a dietary intake survey of Tigray farmers indicated insufficient nutrition intake caused by the decrease in resource availability and livestock production.

[Resource Management in Asia and the Pacific Islands]

For the application of Soil and Water Assessment Tool (SWAT) model, we have collected most of the necessary data on water quality, quantity, and weather in the watershed of Ngerikil River, Babeldaob Island in the Republic of Palau. Thalli of sea grapes (*Caulerpa lentillifera*), which are expected to absorb water impurities, were collected in the reef shores around Babeldaob and experimentally cultured in a laboratory at Palau Community College (PCC) for two months. The combination of minimum tillage with handy auger and organic mulch, a modified conservation agriculture technology for taro (*Colocasia esculenta*) cultivation in Palau, reduced soil erosion by 10%–50% and doubled the taro corm (root) yield. To verify and disseminate this technology, we launched a participatory mother-baby trial at experimental sites and farmers' fields in Babeldaob Island.

APSIM, a soil-crop simulation model, reproduced sugarcane growth and yield as well as NO_3-N leaching, which was monitored by a lysimeter at JIRCAS-Tropical Agricultural Research Front (TARF) in Ishigaki, Okinawa. This model also reproduced the sugarcane yield in Negros Island, Philippines, adopting local parameters (climate conditions, soil properties, and sugarcane varieties) as model input. Therefore, APSIM can be utilized by the Sugar Regulatory Administration (SRA) to formulate a new environment-friendly sugarcane practice with reduced N-application in various sites in the Philippines.

In collaboration with the Central Soil Salinity Research Institute (CSSRI) of the Indian Council of Agricultural Research (ICAR), it was shown that the growth of mustard plants (*Brassica juncea*) in saline soil was increased by subsurface drainage constructed using the "Cutsoiler," a machine introduced from Japan. The salt was thought to have been removed through the drainage during the rainy season. For the development of salt-tolerant soybean varieties, F_3 and BC_3F_1 plants with *Ncl* gene were obtained from Indian and Vietnamese varieties, respectively. DNA marker-assisted selection was commenced for the progenies in Vietnam.

[BNI Utilization]

Incorporating 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 loads such as NO_3-N leaching and N_2O emissions. International collaborations were started with United States, Austrian, and Swedish research organizations in 2019. Wheat lines carrying chromosome translocations containing BNI-traits of wild-wheat (*Leymus racemosus*) into elite-wheat varieties are undergoing field evaluations to determine their yield potential and response to nitrogen fertilizer applications in Japan, India, and Mexico. Using an *ex-ante* life cycle assessment of BNI wheat, potential changes in fertilizer application rates, GHG emissions, and nitrogen use efficiency in 2030 and 2050 were evaluated based on several scenarios. We have found that sorgoleone was continuously released during sorghum growth, with increased levels at the newer root zone. The abundance of AOA (ammonia-oxidizing archaea) and potential nitrification decreased with increasing levels of sorgoleone, indicating that the AOA are the main actors of nitrification in the soil (Topic 5). Field experiments were conducted at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India, where sorghum genetic stocks that differ in sorgoleone production from root systems are evaluated for influence on nitrification in the soil. Tetraploid *Brachiaria* F_1 progeny was scored on BNI ability, heading periods, and 13 morphological traits. Dense linkage map was also constructed for the paternal genome using a high-throughput SNPs genotyping system. Field experiments were conducted at the International Center for Tropical Agriculture (CIAT) in Colombia to clarify the impact of high-BNI *Brachiaria* pastures on subsequent maize productivity and agronomic nitrogen use efficiency (NUE). The docking and molecular dynamics simulation of brachialactone revealed stronger BNI activity in acidic conditions. We discovered zeanone, 1,4-naphthoquinone, as the strongest BNI active compound from a dichloromethane-wash concentrate of maize roots.

Variable-timing, fixed-rate application of cattle biogas effluent as fertilizer for rice using a leaf color chart

Small-scale biogas production from farmyard manure for domestic usage is popular in Vietnam. However, there are cases when untreated effluents from biogas digesters (i.e., anaerobic digestion effluents), including plant nutrients such as nitrogen (N), are discharged to river systems, causing environmental problems such as water pollution. To solve it, we proposed using the biogas effluent as fertilizer for rice, the major local crop. In practice, farmers need to know N concentration in the effluent to determine the application amount and timing. Although the application amount can be roughly estimated using a test paper for N concentration, the application timing plays the main role in adjusting the deficiency and excess of the estimated amount. Here we examined the performance of variable-timing, fixed-rate application of biogas effluent from cattle manure for rice production (cultivar: OM5451) using a leaf color chart (LCC) that was developed by the International Rice Research Institute (IRRI, Fig. 1). Two microcosm experiments were carried out at a plastic film house in Can Tho, Vietnam, in different seasons in 2018.

We set several LCC threshold values (Table 1), below which we applied a fixed amount of the effluent as illustrated in Figure 2. By each incremental raising of the LCC threshold, the application timing and the resultant total amount were increased (Table 1). There was a positive linear relationship between LCC values and Soil Plant Analysis Development (SPAD) values, an indicator of leaf chlorophyll content, regardless of the seasons (Fig. 3). This relationship indicates that a cheap LCC can substitute for an expensive SPAD meter to estimate leaf color even in the case of using effluent as fertilizer. Rice grain yield and straw biomass were also increased by raising the LCC threshold, suggesting that determining the application timing based on LCC threshold is feasible under microcosm conditions. There were positive linear relationships between the mean LCC values during 21 to 81 days after sowing and the grain yields in both seasons (Fig. 4). The optimum LCC threshold for effluent application was 3.75 under microcosm conditions.

The proposed method can achieve yield levels comparable to those from inorganic fertilizers. However, when determining the application amount based on N concentration in the effluent,

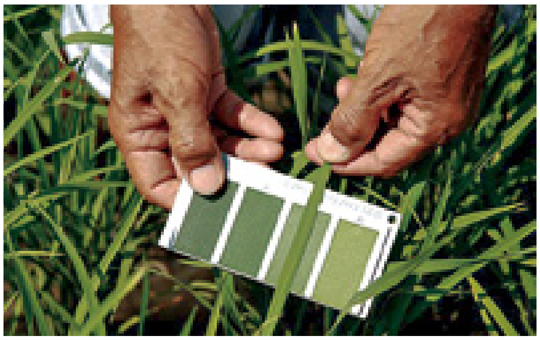


Fig. 1. Measuring the LCC value
(Photo courtesy: Mr. Ariel Javellana, IRRI)

Table 1. The method and the total rate (kg N ha^{-1}) of N application for eight treatments in two experiments

Treatment	Application method	Experiment 1	Experiment 2
Zero	No nitrogen	0	0
Estd	Split-application, for three times at conventional timings	150 (30-50-70)	150 (30-50-70)
E2.75	60 kg N ha^{-1} as effluent whenever LCC value goes below 2.75	90 (30-60)	90 (30-60)
E3.00	60 kg N ha^{-1} as effluent whenever LCC value goes below 3.00	90 (30-60)	90 (30-60)
E3.25	60 kg N ha^{-1} as effluent whenever LCC value goes below 3.25	90 (30-60)	90 (30-60)
E3.50	60 kg N ha^{-1} as effluent whenever LCC value goes below 3.50	150 (30-60-60)	150 (30-60-60)
E3.75	60 kg N ha^{-1} as effluent whenever LCC value goes below 3.75	150 (30-60-60)	210 (30-60-60-60)
U3.25	60 kg N ha^{-1} as urea whenever LCC value goes below 3.25	150 (30-60-60)	90 (30-60)

Experiment 1 mainly in dry season and Experiment 2 mainly in wet season.
The first N application was conducted 10 or 11 days after sowing at 30 kg N ha^{-1}, except for Zero treatment.
P and K (only in Zero and U3.25 treatments) were split-applied as inorganic fertilizers at conventional timings.

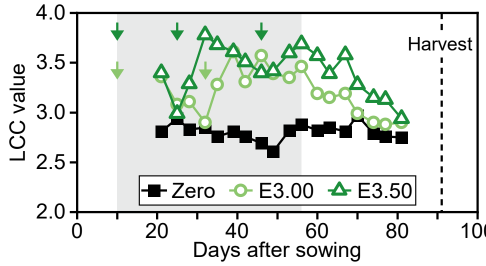


Fig. 2. An example of seasonal shifts in LCC values in Experiment 2
Arrows indicate the timings of N application in respective treatments. Grey shade indicates the target period for N application.

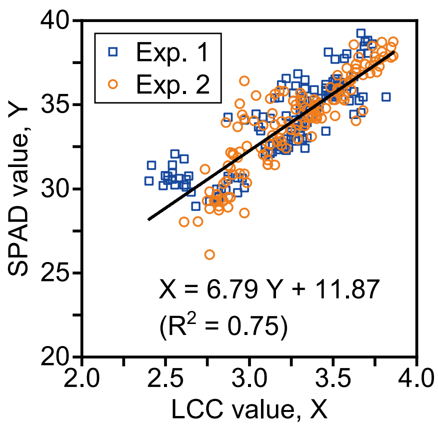


Fig. 3. Relationship between LCC values and SPAD values in two experiments

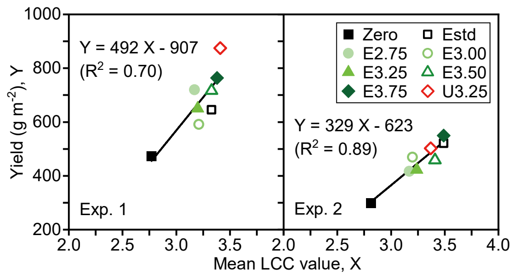


Fig. 4. Relationships between the mean LCC values and rice grain yields in two experiments
Yield is expressed as 14% moisture content.

the application amounts of phosphorus (P) and potassium (K) from the effluent may become deficient or excessive due to the imbalance of NPK concentrations. The optimum LCC threshold in terms of rice grain yield may change depending on the cultivar and environment, therefore farmers need to determine it independently. Because the use of effluent as fertilizer requires additional labor and cost compared to that of inorganic fertilizers, financial administrative support is essential in order to mitigate the environmental problems.

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TOPIC 2

Oxygenation of flooded paddy soil and inhibition of methane production through irrigation with water containing bulk oxygen nanobubbles

Rice cultivation is one of the major anthropogenic sources of methane (CH_4), a potent greenhouse gas. Methane is produced in flooded paddy soils under reductive conditions, thus surface water drainage, such as midseason drainage and alternate wetting and drying (AWD), is effective in reducing CH_4 emission through soil oxidation. However, the feasibility of drainage practices is limited spatiotemporally in wet seasons and lowlands with poor drainage. To reduce CH_4 emission from flooded paddy soils, we proposed an irrigation scheme using water containing bulk nanobubbles (NBs) (Minamikawa et al. 2015). NBs are tiny bubbles (<1 μm diameter) made of various gases that have unique properties including a long lifetime in water. We had demonstrated that oxygen NB water (i.e., water with NBs made of pure oxygen) significantly reduced the direct CH_4 emission by 21% in a pot experiment, but the mechanisms underlying the emission reduction had remained unclear. This study hypothesized that the emission reduction is caused by the oxygenation of flooded soil through the leaching of oxygen NB water. To test it, we carried out three soil-column experiments using a Fluvisol under flooded and rice-unplanted conditions (Fig. 1).

Oxygen NB water prepared by the swirling flow method using a commercial NB generator had a mean particle size of 185 ± 57 nm (standard deviation) and a particle density of 7.0×10^7 mL^{-1}. We used aerated tap water as control water, and

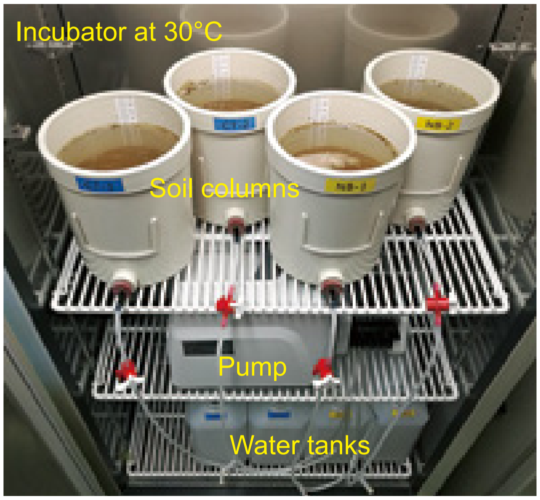

Fig. 1. Apparatus consisting of soil column systems for the three experiments
Water is leached at a fixed rate (1.73 cm day^{-1}) by the pump.

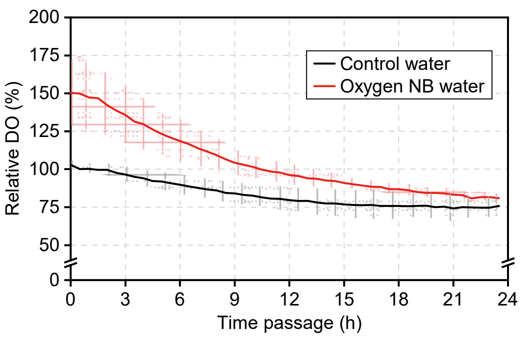

Fig. 2. Temporal shifts in surface water DO in Experiment 2
Values relative to that equilibrated with ambient air at a given temperature.
Solid lines indicate the means of four measurements, and bands indicate the standard deviations.

the initial dissolved oxygen (DO) concentration in surface water was comparable to that equilibrated with ambient air at a given temperature (Fig. 2). On the other hand, the initial DO in oxygen NB water a few hours after the preparation was still 1.5 times that in control water and the DO remained higher within 24 hours. Under different soil conditions in labile carbon content (i.e., high in experiment 1, middle in 2, and low in 3), the total CH_4 emission dissolved into leaching water for 56 days was 20%-28% lower in oxygen NB water than in control water (Fig. 3). Measuring DO profile at 1-mm intervals at the soil-water interface using an oxygen microelectrode and a micromanipulator, we found that oxygen depletion at shallow depths (4-15 mm from the soil surface) was ameliorated by oxygen NB water on day 35 of experiment 2 (Fig. 4). The result confirms that irrigation with oxygen NB water reduces CH_4 production in a flooded paddy soil through oxygenation of shallow soil.

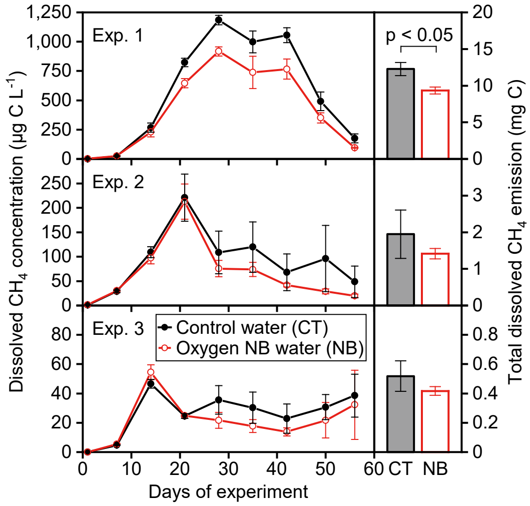

Fig. 3. Temporal shifts in dissolved CH_4 concentrations (left panels) and the total emissions (right panels) in the three experiments
Vertical bars indicate the standard errors (n = 3).

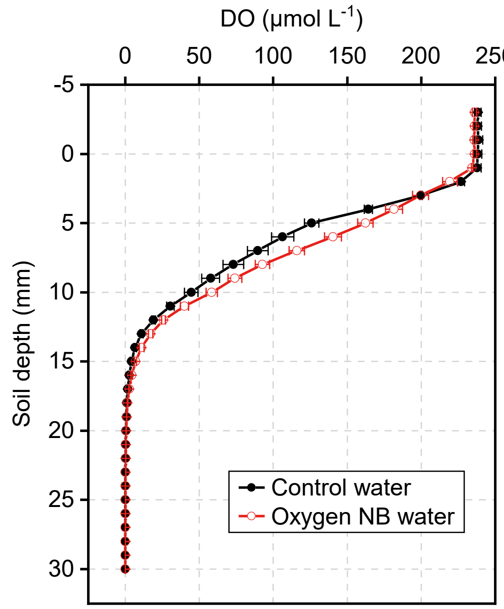

Fig. 4. DO profiles at the soil-water interface on day 35 of Experiment 2
Horizontal bars indicate the standard errors (n = 3).

The results provide researchers with the scientific basis for the use of oxygen NB water as a measure to control redox conditions in various aquatic environments, including flooded paddy soils. There is still room for improvement in soil oxygenation by raising the irrigation frequency. Further study is necessary to elucidate whether the oxygen is in dissolved form and/or as intact particles when delivered to a flooded soil through oxygen NB water.

(K. Minamikawa, T. Makino [Tohoku University, Japan])

Farmland reclamation using micro-dam sediments in the Ethiopian Highlands

The Ethiopian Highlands in the eastern part of sub-Saharan Africa typically experience semi-arid climatic conditions, with rainfall during rainy seasons causing severe soil erosion. Ninety-two (92) micro-dams have been constructed at micro-watersheds in Tigray, Ethiopia, more than half of which undergo sedimentation due to gully erosion, consequently decreasing the amount of available water. Sediment accumulation in micro-dams is considered a serious problem affecting irrigation water supply and crop cultivation (Berhane et al., 2016). Although it is an urgent challenge to remove the sediments from micro-dams, it is difficult to deal with, thus the problem remains unsolved. The purposes of this research are to estimate the storage water and sediment volume in a typical micro-dam at a micro-watershed in this region and to test the feasibility of using the sediments for farmland reclamation.

The Adizaboy micro-dam is located at the outlet of the steep Adizaboy micro-watershed (8.5 km^2). Weather conditions and water depths in Adizaboy micro-dam were automatically recorded. The storage volume change was assumed to be zero (0) for one year. Potential available water was calculated using the water balance analysis of Adizaboy micro-dam (Fig. 1). A new bathymetric survey method was applied to estimate the sediment volume in the micro-dam. The geographic coordinates along the water surface perimeters and the storage water depths were noted (Fig. 2, top). Sediment volume between observed sediment surface and estimated bottom surface was calculated (Fig. 2, bottom). Bare lands were cleared at the end of dry season (an agricultural off-season), when there was no storage water in the micro-dam. Sediments were excavated manually and transported using farm animals. A farmland was reclaimed by forming layers of stones and sediments (Fig. 3).

The reclaimed farmland will be managed by Wareda (the villagers' group) and provided for free to some young landless farmers to create employment opportunities. By cultivating

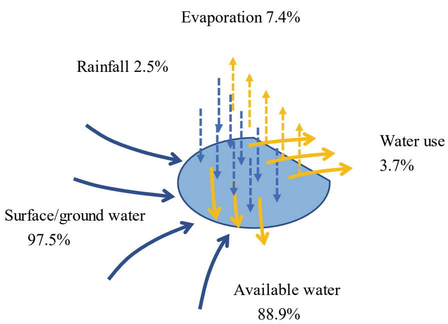

Fig. 1. Water balance of Adizaboy micro-dam
The storage volume of the micro-dam is 200,000m^3. Available water is assumed to be the sum of water leakage through the foundation rock and the embankment, the flood water over the spillway, and the spring water downstream.

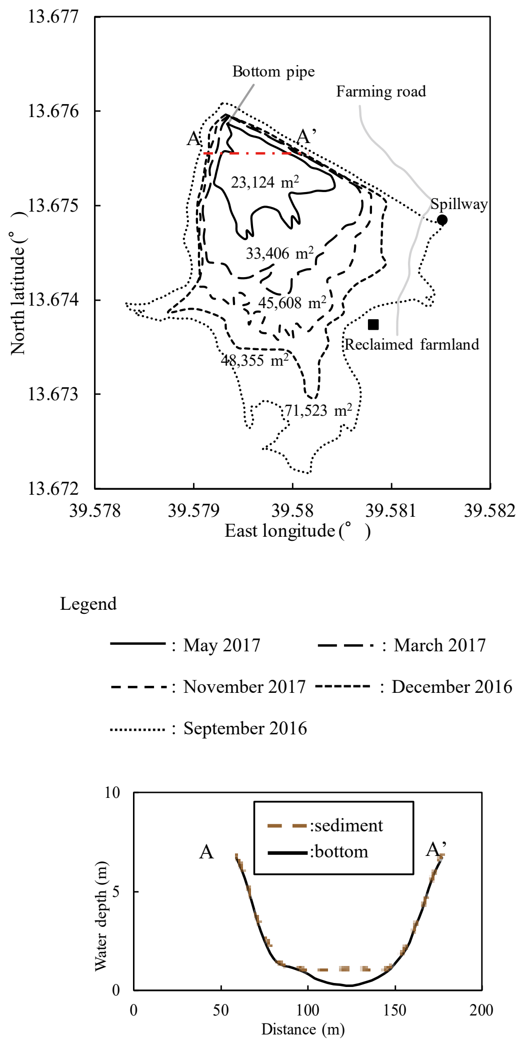

Fig. 2. Changes in water storage area and cross-sectional view of Adizaboy micro-dam
Top: changes in water storage area, Bottom: cross sectional view
The numbers in the top figure show the water storage areas (in m^2). The water depth in the bottom figure displays the height from the lower edge of the bottom pipe inlet. The sediment volume of Adizaboy micro-dam is estimated to be 6,400 m^3. In case the thickness of the reclaimed farmland is 0.2 m, the reclaimable farmland area is 3.2 ha. It would also be effective if some of the sediments are removed and used for reclamation before the bottom pipe gets buried and malfunctions.

Fig. 3. The reclaimed farmland using sediments from Adizaboy micro-dam
Top: before reclamation, Bottom: after reclamation

vegetables with high market value, the reclaimed farmland is expected to generate a cash income source and improve the living standard of residents. Onion yield in the reclaimed farmland of 11.93 t/ha is almost same as the national average (10.38 t/ha). It is thus necessary to construct a farm pond for irrigation to enable vegetable cultivation during the dry season. To extend the technology, it would be practical to use past experiences and knowledge of participants in cooperation with local governments, universities, and residents in the selection of sites, earth works, and construction of additional facilities etc. This method of estimating the volume of sediments is applicable to other micro-dams.

(K. Koda,
G. Girmay [Mekelle University],
T. Berihu [Mekelle University])

TOPIC 4

Assessing nanoparticulate lime and phosphate rock and increasing their efficiency as a liming agent and phosphorus source, respectively

Acid soils occupy approximately 43% of the world's tropical land area. Although they have high potential for agriculture production, plant growth is hindered by the low availability of P, Ca, and Mg, and the acidity-related toxicity of Al, Fe, and Mn. Application of conventional lime and soluble P fertilizer is considered general practice for correcting acidity and nutrient deficiencies in acid tropical soils. As the prices of lime and P fertilizers have increased markedly worldwide, there is an urgent need for new materials that achieve goals at a reduced cost.

Nanoparticulate lime (NL) or phosphate rock (NPR) can be used as an alternative by increasing its efficiency. Reducing the particle to nanoscale (Fig. 1) and thus increasing the total surface area could offer a mechanism to increase the efficiency of lime and phosphate rock (Devnita et al. 2018, Liu and Lal 2015). This study was, therefore, conducted to assess NL and NPR to increase their efficiency as a liming agent and phosphorus source, respectively.

Applying NL to the top 5 cm at 40 and 80 kg ha^{-1} was effective at increasing the downward movement of Ca and the neutralization of soil acidity (in terms of pH) to 20 cm depth, as well as rectifying Al toxicity (in terms of exchangeable Al) to ≤ the critical limit to 10 cm (Fig. 2). The NL at 80 kg ha^{-1} was most economically justified

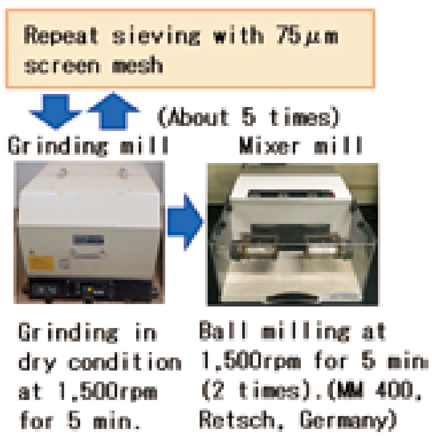

Fig. 1. Nanoparticulation process
Burkina Faso phosphate rock was used.

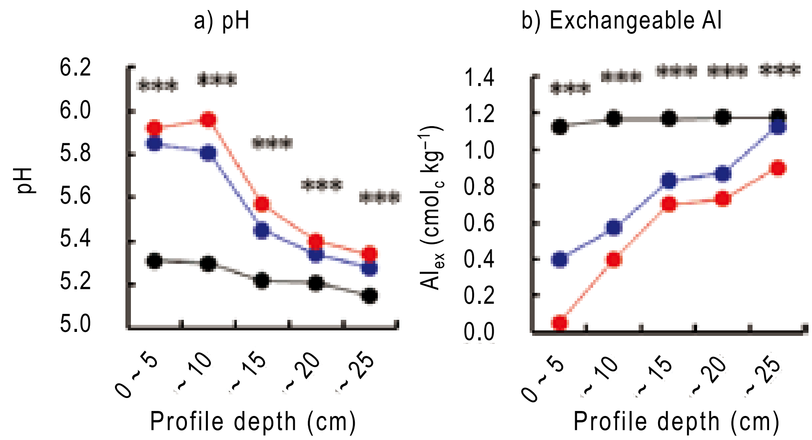

Fig. 2. pH and exchangeable Al of the simulated plough layer with a different nanoparticulate lime (NL)
NL leached with 28cm of water over 40 days; ***: $p<0.001$ (ANOVA)
—●— 0 kg ha^{-1} —●—8 kg ha^{-1} —●—80 kg ha^{-1}

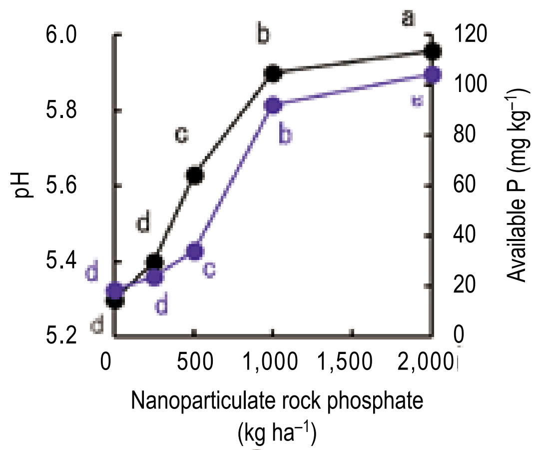

Fig. 3. Effects of nanoparticulate phosphate
Data were collected at the end of the growth period (49 days) after pre-incubation (21 days). Different letters show significant difference (Tukey's HSD).
—●—pH —●—Available P

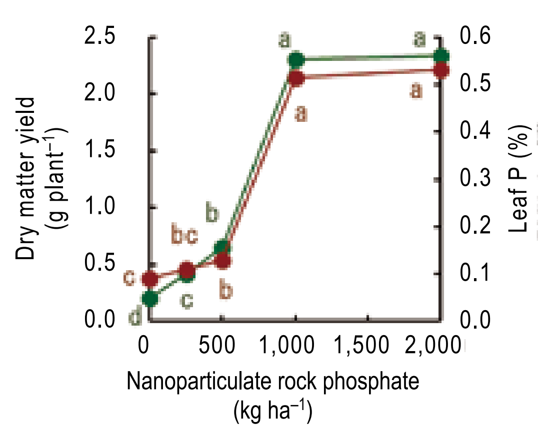

Fig. 4. Effects of nanoparticulate phosphate rock on spinach dry matter yield and leaf P concentration
Data were collected at the end of the growth period (49 days) after pre-incubation (21 days). Different letters show significant difference (Tukey's HSD).
—●—Dry matter yield —●—Leaf P

in terms of rectifying Al toxicity throughout the profile.

NPR (Fig. 1) significantly affected soil pH after harvest (Fig. 3). NPR at 250 kg ha^{-1} and 500 kg ha^{-1} increased soil pH, though not to the levels required to promote spinach growth, while NPR at 1,000 and 2,000 kg ha^{-1} increased soil pH within the optimum range (typically 6.4-6.8). Increasing NPR significantly increased available P after harvest. NPR at 2,000 kg ha^{-1} released 56 mg P kg^{-1} (upper limit for spinach), while NPR at 1,000 kg ha^{-1} released 35 kg P ha^{-1} (target limit).

NPR significantly increased dry matter yield (DMY, Fig. 4). NPR at ≥1,000 kg ha^{-1} increased DMY by ≤11.5x the initial value, while NPR at <1,000 kg ha^{-1} increased DMY by ≤3x. DMY did not increase significantly from 1,000 to 2000 kg ha^{-1}. Therefore, the critical threshold or application rate that produced the maximum yield (2.3 g DMY plant^{-1}) is 1,000 kg ha^{-1}. NPR also significantly increased leaf P. NPR at 2,000 kg ha^{-1} increased leaf P the most, but not significantly more than at 1,000 kg ha^{-1}. The leaf P concentration varied from 0.1% to 0.53% among NPR rates. When NPR rate was ≥1,000 kg ha^{-1}, leaf P was about ≤5.8x the initial value. According to the diagnostic range for P in spinach leaf, NPR at ≥1,000 kg ha^{-1} increased available soil P to at least the upper limit.

In summary, the soil and plant parameters increased to the same degree at 1,000 and 2,000 kg ha^{-1}. Therefore, the use of 1,000 kg ha^{-1} is more economically justified. Regular application of NPR and further research for economic comparison between NPR and both of lime and superphosphate will be needed.

(H. Omae,
A. A. Abd-El Halim [Tanta University])

Biological nitrification inhibition of sorghum is related to the inhibition of ammonia-oxidizing archaea

To increase crop production, farmers often apply high amounts of nitrogen fertilizers in agricultural lands. The resulting high nitrification activity greatly contributes to global warming due to the release of the potent nitrous oxide (N_2O) gas. Furthermore, this practice not only causes environmental water pollution due to leakage of nitrate nitrogen, but also lower use efficiency of the fertilizer nitrogen and reduced crop yields. Biological nitrification inhibition (BNI), a crop-mediated complex molecular mechanism in which the crop suppresses soil nitrification by itself, is gaining much attention as a suitable technique to mitigate the above problems. Here we look at sorghum, the world's fifth-ranked cereal in terms of production area. Sorghum secretes sorgoleone, a compound that has shown BNI ability, from its roots.

In this study, we clarified the relationships between the amount and the location of sorgoleone secretion from the plant's roots, and the rhizosphere soil microbial communities through a pipe cultivation test (Fig. 1). 296B shows the least sorgoleone secretion, followed by IS32234 then IS20205 (Fig. 2). The secretion increases towards deeper layers at the newer root zone. The application of 120 kg ha^{-1} nitrogen as ammonium sulfate solution to the topsoil, greatly enhances the nitrification activity in the 0-10 cm soil layer, which remained low in the deeper layers (Fig. 3). In the 0-10 cm soil layer, 296B showed the highest nitrification activity, followed by IS32234 and IS20205, which opposes with the sorgoleone secretion. These results indicate that sorgoleone plays a substantial role in sorghum's ability to exert BNI. The number of ammonia-oxidizing bacteria (AOB) and archaea (AOA) in the 0-10 cm soil layer was determined by qPCR, targeting the ammonia monooxygenase

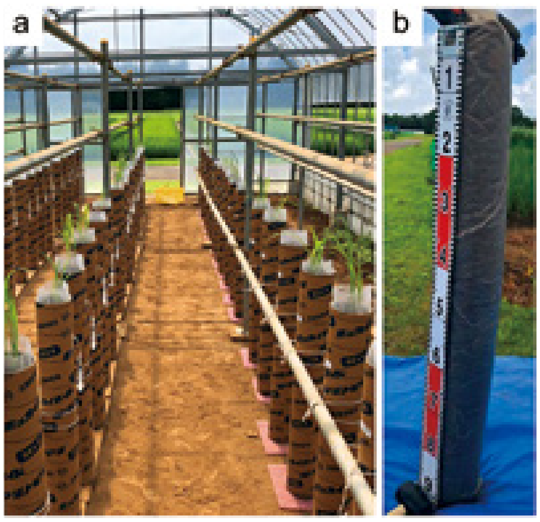

Fig. 1. Sorghum pipe (12 cm x 1 m) cultivation test in greenhouse at 31 days after seeding (a), and soil column removed from pipe at the first soil and plant root sampling (b)

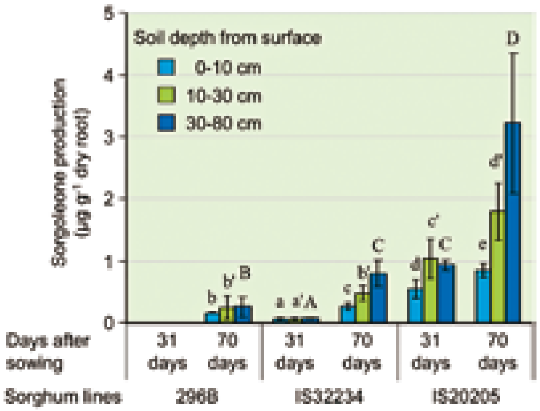

Fig. 2. Dynamics of sorgoleone secretion from roots of sorghum along the soil profile under nitrogen fertilizer application (120 kg ha^{-1})
Bars in the figure indicate standard deviations. The same type of letter (x, x′, X) compares the differences of sorgoleone secretion between sorghum lines by soil depth, and values with the same letter are not significantly different at p<0.05.

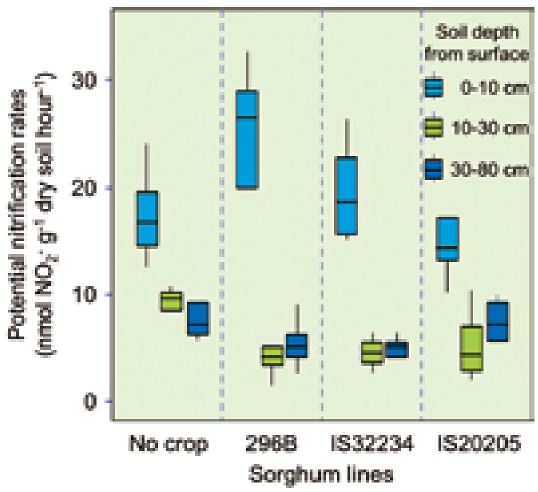

Fig. 3. Nitrification activity in bulk (no crop) and sorghum rhizosphere soils along the soil profile at 70 days after seeding, under nitrogen fertilizer application (120 kg ha^{-1})
The boxes in the figure indicate the interquartile range, and the bars indicate the maximum and minimum values. Soil layers below 10 cm depth have less ammonium applied, so their nitrification activity does not increase and the effect of sorgoleone does not appear.

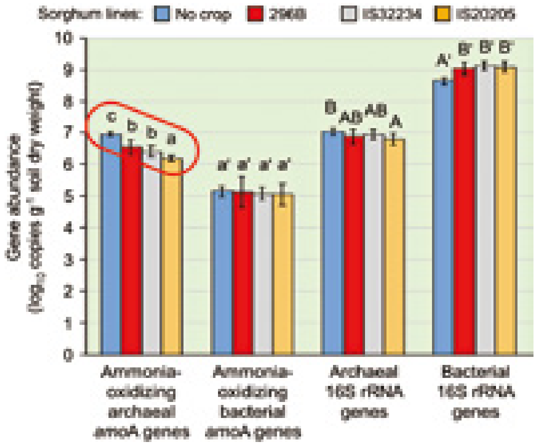

Fig. 4. Gene abundance in bulk (no crop) and rhizosphere soils (0-10 cm layer) of sorghum lines cultivated for 70 days under nitrogen fertilizer application (120 kg ha^{-1})
amoA: Ammonia monooxygenase α subunit gene. Bars in the figure indicate standard deviations. The same type of letter (x, x′, X, X′) compares the differences of the abundance of each gene, and values with the same letter are not significantly different at $p<0.05$. The gene abundance below 10 cm showed a similar trend.

(*amoA*) gene. The number of AOA was inversely related to the amount of sorgoleone and was proportional to the nitrification activity. However, we observed no change in the number of AOB (Fig. 4). This shows that the nitrification in sorghum rhizosphere soil is related to the effect of sorgoleone secreted from the roots of sorghum, which suppresses AOA among the microorganisms harboring the *amoA* gene. The study also shows the contribution of other factors, such as soil pH, water content, organic and inorganic nitrogen content, to the ability of sorghum to exert BNI.

These findings demonstrate the great influence of the suppression of AOA on sorghum BNI. In addition, the ease of handling of root and soil samples by soil depth, makes this pipe cultivation test useful for BNI research of other plants.

(P.S. Sarr, Y. Ando, S. Nakamura, G.V. Subbarao, S. Deshpande [International Crops Research Institute for the Semi-Arid Tropics])

TOPIC 6

Solubility improvement of African low-grade phosphate rock through calcination with potassium carbonate

Although many phosphate deposits have been found in sub-Saharan Africa, farmers are facing high prices of P fertilizers because of the low solubility of the African low-grade phosphate rocks (PRs). We have previously reported that PR calcination with Na carbonate improves the solubility of these PRs, but their application showed limited crop growth, especially in upland conditions. It was speculated that Na accumulation in the soil caused plant growth inhibition. Therefore, we tried to elucidate the effect of calcination with potassium carbonate (K_2CO_3) on PR solubility and its application effects for lowland rice and maize through pot experiments.

We used Kodjari PR produced in Burkina Faso for the calcination. Fine powdered PRs were mixed with K_2CO_3 in five doses to achieve the target K_2O compositions of 200, 250, 300, 350, and 400 g kg^{-1}. The mixtures were pressed with distilled water to form coin-shaped pellets. Then, the pelletized PR-K_2CO_3 mixtures were calcined at 900, 1000, 1050, and 1100 °C for 10 min using a muffle furnace. The pot experiments were conducted for 56 days, monitoring the growth of rice and maize under several application rates.

As a result, the solubility reached about 100% in 20 g L^{-1} citric acid and about 40% in water. This shows that K carbonates behave like Na carbonate in the solubilization of low-grade PRs in Burkina Faso. The calcinated Burkina PR (CB) application in the application rates up to 1 g P_2O_5 pot^{-1} yielded comparable plant growth to that of triple super phosphate (TP). K carbonate calcination deterred Na accumulation in the soil, and it was effective for soil P fertility improvement and plant growth. The calcination technology can be conducted by external heating U-turn rotary kiln using solar power.

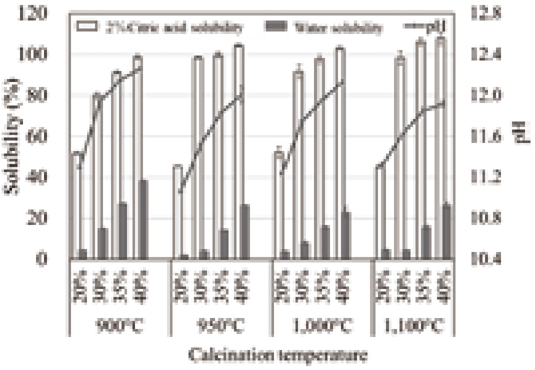

Fig. 1. Solubility changes of Burkina Faso phosphate rock through calcination with several compounding rates of potassium carbonate under four levels of temperature
Error bars are standard errors (n=3)

Fig. 3. External heating U-turn rotary kiln for calcination (Burkina Faso, INERA-Kamboinse)

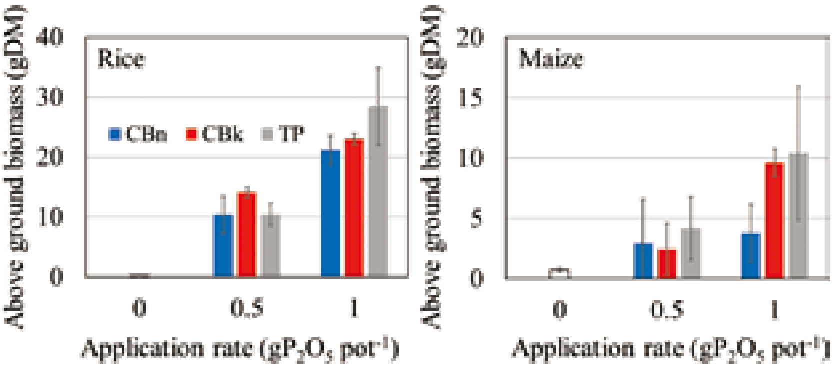

Fig. 2. Application effects of phosphate rocks calcinated with Na carbonate and K carbonate on rice and maize
Error bars are 95% confidence intervals (n=3). CBn: Calcinated PR with Na carbonate, CBk: Calcinated PR with K carbonate, TP: Triple super phosphate

Table 1. Soil chemical properties after several phosphate fertilizer applications

Crop/Soil water condition	Fertilizer	pH		EC		Available P				Exchangeable cation							
						Bray I		Bray II		Ca		Mg		K		Na	
				mS m^{-1}		mgP kg^{-1}				cmolc kg^{-1}							
Rice/ Submerged	None	5.84	c	108	c	0.08	b	6.39	d	3.31	c	0.70	bc	0.28	b	0.15	c
	BP	5.72	c	110	c	0.16	b	107	c	3.18	c	0.64	c	0.24	b	0.16	c
	CBk	6.45	a	183	a	6.34	a	141	a	10.2	a	0.78	b	6.67	a	0.28	a
	TP	6.10	b	141	b	4.94	a	117	b	5.42	b	1.09	a	0.47	b	0.24	b
Maize/ Upland	None	5.85	a	114	b	0.09	b	6.77	c	3.39	c	0.69	b	0.3	b	0.14	c
	BP	5.70	a	123	b	0.17	b	96.1	b	3.56	c	0.69	b	0.33	b	0.15	c
	CBk	5.97	a	189	a	5.81	a	158	a	9.36	a	0.73	b	6.39	a	0.21	b
	TP	6.28	a	168	a	5.69	a	107	b	5.90	b	1.11	a	0.49	b	0.24	a

None: No P application, BP: Burkina Faso PR, CBk: Calcinated PR with K carbonate, TP: Triple super phosphate. Bray I, and Bray II are available P content determined by Bray I method and Bray II method, respectively. Alphabet difference indicates significant differences (p<0.05) by Tukey HSD method.

(S. Nakamura, F. Nagumo, T. Kanda,
T. Imai [Taiheiyo Cement Corp.],
J. Sawadogo [INERA])

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. To achieve our goals, we conduct the following four research projects.

[Food Security in Africa]

For the development of sustainable technologies to increase agricultural productivity and improve food security in Africa, we conducted three sub-projects for rice production enhancement, regional crop utilization, and crop-livestock integration. We focused on the following research in FY 2019. Regarding rice production enhancement, we further advanced the field evaluation of breeding materials and cultivation techniques with superior productivity and the verification of the conditions necessary for the dissemination of the developed techniques. Regarding regional crop utilization, we have been proving and utilizing the useful trait evaluation method for yam and cowpea and have begun to provide it to our partner institutions. Regarding crop-livestock integration, we advanced the verification of dairy farming technology using silage and total mixed ration (TMR). We also conducted a comparative evaluation of multipurpose crops for feed and food in terms of yield responses to cultivation methods like fertilization and irrigation.

[Environmental Stress-tolerant Crops]

For the development of breeding materials and basic breeding technologies for highly productive crops adaptable to adverse environments, we focused on the following research in FY 2019. We continued backcrossing to introduce genes involved in root length and nitrogen utilization efficiency. At the same time, we selected excellent lines from the gene-fixed lines. In addition, we have started an adaptation test for introgression lines of a gene related to phosphate utilization efficiency in an IR64 genetic background. Furthermore, we continued backcrossing and selection for introducing the salt tolerance gene into soybean cultivars in developing countries. Lastly, we have identified useful germplasms and mutants in quinoa.

[High-yielding Biomass Crops]

For the development of technologies for the breeding and utilization of promising high-yielding biomass crops in unstable environments, we focused on the following research in FY 2019. We selected breeding materials with excellent cane yield in ratoon cultivation from the intergeneric hybrid BC_1 of sugarcane and *Erianthus*. We also created a high-density linkage map of *Erianthus* by analysis using SNPs and SSR markers. Furthermore, the mechanical harvesting characteristics of versatile sugarcane variety were clarified.

[Pest and Disease Control]

For the development of technologies for the control of migratory plant pests and transboundary diseases, we focused on the following research in FY 2019. We investigated the possession status of resistant genetic resources against rice planthoppers in Vietnam. We also revealed mating behavior and oviposition characteristics of the desert locust. In Thailand, we evaluated the healthy seed cane production technology for controlling sugarcane white leaf disease in a field demonstration test. For rice blast, we evaluated the effect of partial resistance genes and selected hybrid lines with resistance genes in leading cultivars in Asian countries. In soybean diseases, we continued backcrossing to breed varieties that had accumulated resistance genes to Asian soybean rust and searched for breeding materials to develop varieties resistant to Cercospora leaf blight and to perform a genetic analysis.

Soil phosphorus availability for rice plants can be rapidly estimated by laboratory visible and near-infrared spectroscopy

Phosphorus (P) deficiency is a major constraint to rice production in highly weathered soils of tropical agroecosystems. Therefore, rapid evaluation of soil phosphorus availability is crucial toward realizing efficient fertilizer management for increasing crop production. As a laboratory proximal sensing technique, the capability of visible and near-infrared (Vis-NIR) spectroscopy with partial least squares (PLS) regression to determine soil properties has been demonstrated. However, the evaluation of soil P is still a challenging task. Thus, we aimed to develop a model for estimating oxalate-extractable P (Pox), which represents the soil P supply capacity for rice crops in lowland and upland fields in the central highlands of Madagascar.

Pox content was measured for soil samples (n = 51) collected from the surface layer (0–15 cm depth) in rice fields in the central highlands of Madagascar. Large spatial variations in Pox were observed in soil samples collected from a wide range of soil types over a wide area and even in soil samples from a village (Fig. 1). This highlighted the importance of developing a prompt assessment method for P availability in multiple soil samples. Soil samples were scanned by a portable spectroradiometer (FieldSpec, ASD Inc.) in a dark room to measure spectral reflectance in the Vis-NIR region (400–2400 nm), and subsequently a calibration model was developed for estimating Pox using selected wavebands on first derivative reflectance spectra with genetic algorithm-based PLS regression (GA-PLS). With this PLS model, Pox content in soil can be rapidly estimated with high accuracy and reproducibility (Fig. 2). The selected wavebands in the GA-PLS model were found to be relevant to chemical associations of Pox in soils bound to Al and Fe oxides and organic compounds (Fig. 3).

The Pox content can be accurately and rapidly predicted from laboratory Vis-NIR spectroscopy with GA-PLS regression; it takes only one minute to measure the spectral reflectance for one soil sample. Therefore, the calibration model can be applied to assess the P deficiency level with high spatial variation in lowland and upland rice fields for appropriate fertilizer management. Research institutes, such as regional agricultural research centers or universities, can help handle the measurement because the portable spectroradiometer is not affordable for local farmers. An alternative cheap edition of the spectroradiometer using specific wavebands relevant to soil chemical associations of Pox

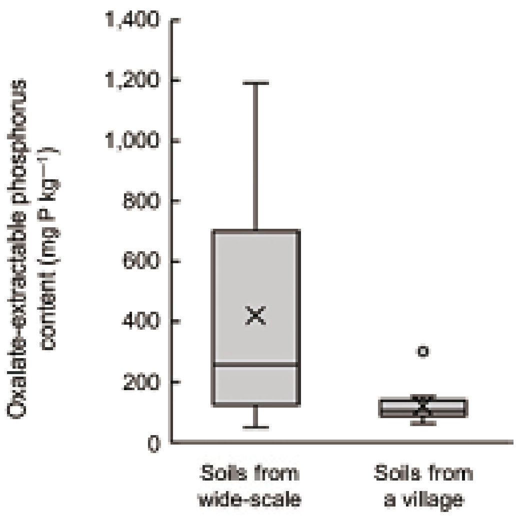

Fig. 1. Spatial variation of oxalate-extractable P
The bar on the left indicates Pox content of soil samples collected within an area of 100 km radius (n = 35), and the bar on the right indicates Pox content of soil samples collected within a village (n = 16). The coefficients of variance are 0.85 and 0.45, respectively.

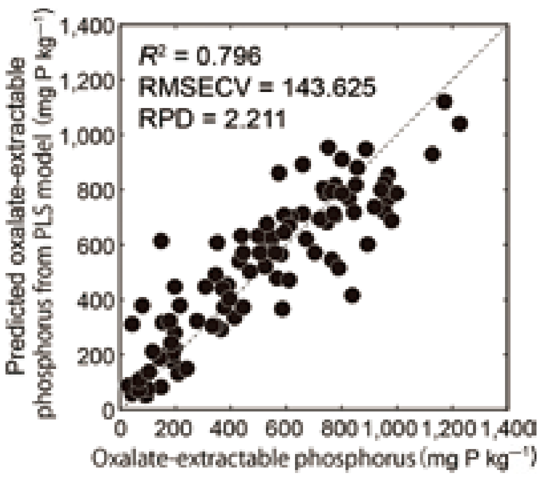

Fig. 2. Relationship between observed and predicted values of soil oxalate-extractable P using the PLS model
RMSECV: Root mean squared errors of cross-validation using the leave-one-out method.
RPD: Residual predictive deviation. The criteria for determination are (1) RPD < 1.15: unpredictable, (2) 1.16–1.40: 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.

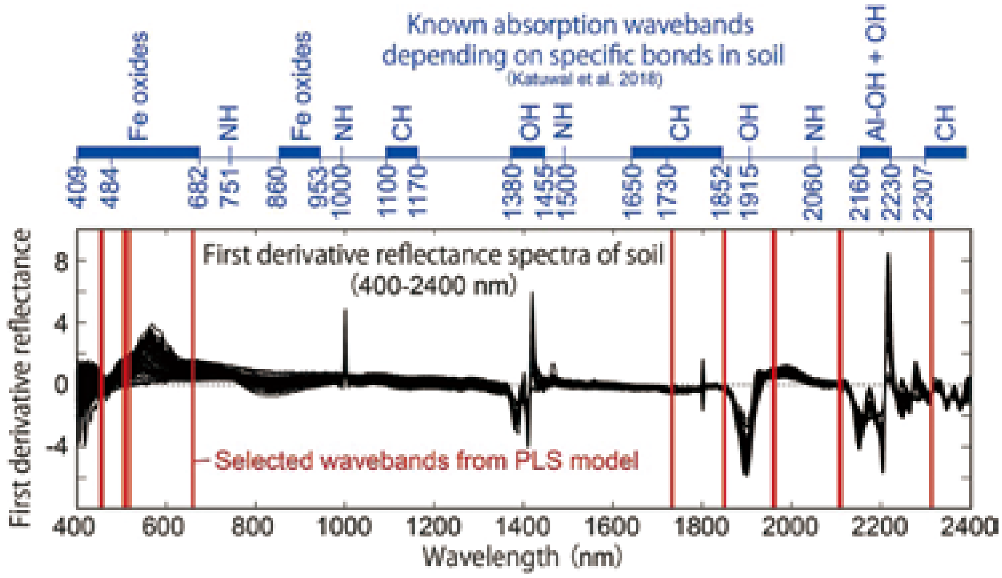

Fig. 3. Selected wavebands (red bars) in the PLS model

in soils is needed. Further applicability of this model should be tested particularly in soils with high pH and Ca-associated P content, and in soils with high sand content.

(T. Nishigaki, K. Kawamura, Y. Tsujimoto, A. Andriamananjara [Antananarivo University], M. Rabenarivo [Antananarivo University], T. Rakotoson [Antananarivo University], T. Razafimbelo [Antananarivo University])

TOPIC 2

A new indicator of leaf stomatal conductance based on thermal imaging

Stomatal conductance is a major regulator of water vapor and carbon dioxide exchange between the leaf and the surrounding air, directly affecting plant growth and leaf water status. To rapidly evaluate the stomatal conductance, indicators from infrared thermal imaging are available as an easy and simple method. However, a difficulty with these indicators is that the relationship between leaf temperature and stomatal conductance may vary strongly with variations in solar radiation, air temperature, humidity, and wind speed, and thus it is difficult to estimate stomatal conductance from leaf temperature over a wide range of different meteorological conditions.

In this study, a new indicator of stomatal conductance (GsI) with environmental robustness was developed. This indicator is calculated from leaf temperature and other meteorological variables of solar radiation, air temperature, and relative humidity (Fig. 1). The equation is the result of a modification of the theoretical equation of stomatal conductance, simplified by making several assumptions. To validate the robustness of the GsI under varied meteorological conditions, thermal image was obtained for cowpea plants every week from two to eight weeks after sowing. Four cowpea varieties were grown at the experimental field of the International Institute of Tropical Agriculture (IITA) in 2016 and 2017. Compared to the existing indicator of stomatal conductance (air-leaf temperature difference), the GsI showed stable relationship with measured stomatal conductance using leaf porometer over the different meteorological conditions (Fig. 2).

GsI was calculated using a simplified equation with four variables, namely, leaf temperature, air temperature, relative humidity, and solar radiation. Except for leaf temperature, all other variables can be obtained from continuous-measurement devices installed near the field; thus, an evaluator only needs to take a thermal image for each measurement. As GsI calculation does not require any reference temperature, the time for photographing is much shorter than that for evaluations with reference temperatures. Therefore, this new method is suitable for rapidly

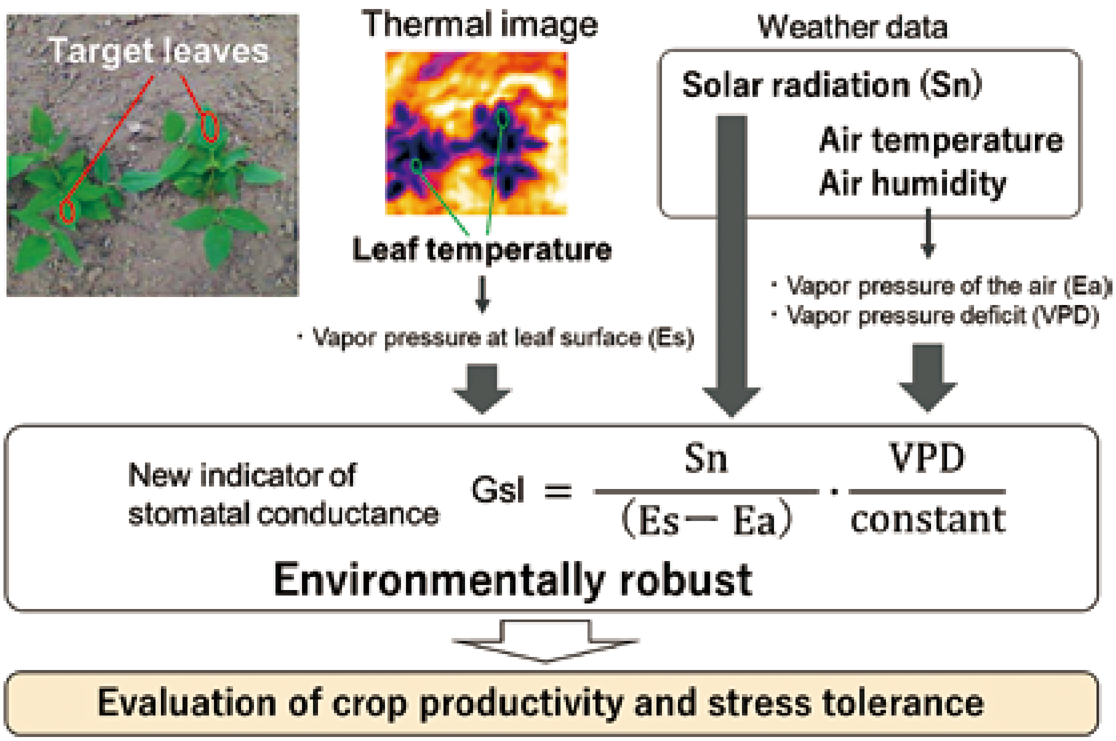

Fig. 1. A new indicator of stomatal conductance (GsI)

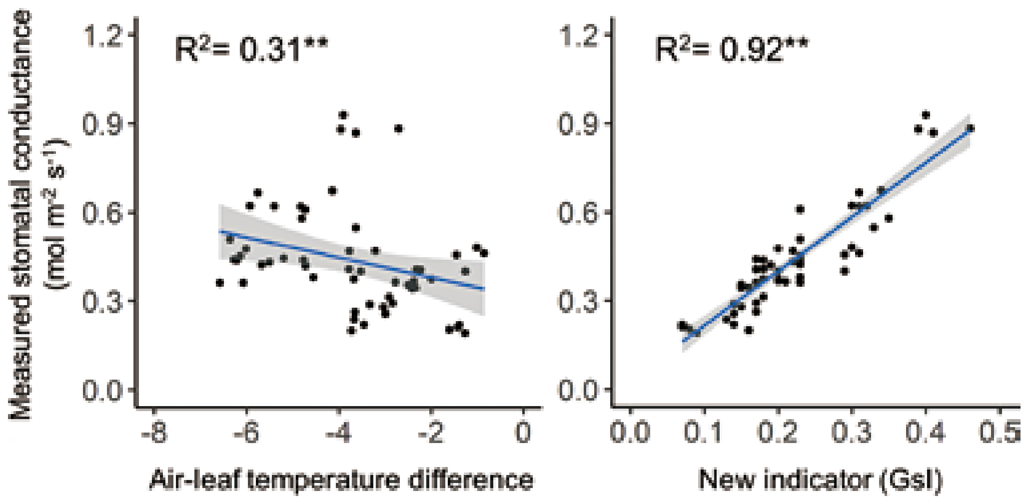

Fig. 2. Relationships between indicators based on thermal imaging and measured stomatal conductance.
Gray area represents 95% confidence interval of the regression line.

evaluating a large plant population, such as a set of genetic resources and cross-populations, for genetic analysis.

Although the relationship between GsI and measured stomatal conductance is stable for varied meteorological conditions, there are precautions for its application. First, the GsI is not suitable for plant leaves with different angles because the relationship between thermal image and actual temperature differs depending on the leaf angle. Second, GsI should not be applied to leaves having extremely low stomatal conductance such as under severe drought conditions or deeply clouded conditions. This is because the equation of GsI is premised on the occurrence of transpiration at leaf surface. Determination of stomatal conductance using GsI with the above precautions provides important physiological information related to plant responses to the environment, and will help identify superior genotypes with high adaptability to specific target environments.

(K. Iseki,
O. Olaleye [International Institute of Tropical Agriculture])

TOPIC 3

SSR marker technology package for variety identification of white Guinea Yam

White Guinea yam (*Dioscorea rotundata*), one of the most important cash crop for farmers and a major staple food for the people of West Africa, retains huge potential for alleviating widespread poverty and hunger in the region. Now, yam research is at a turning point, and recent advancements in genetics and mass propagation are expected to boost breeding efficiency and dissemination of improved varieties. On the other hand, since it is difficult to distinguish varieties based on the visible characteristics of the shoot and tuber of yam (Fig. 1), mechanical mixture between varieties grown in the same field has been a serious problem through all the steps in the breeding and propagation process, including planting, cultivation, harvesting, and storage. To overcome this problem, a simple tool to identify varieties was highly desired.

To enable variety identification of white Guinea yam, a Simple Sequence Repeat (SSR) marker system was adopted based on its various advantages such as high reproducibility, low cost, and high polymorphism. In the initial setup, 16 SSR markers that can be used to distinguish varieties and genetic resources effectively were selected from the 90 SSR markers developed in our previous study (JIRCAS Research Highlights 2015, B05) (Fig. 2). Additionally, various tools to enable successful variety identification using the developed SSR markers and maximize the benefits to users in the breeding and seed sectors were subsequently developed. For example, the developed web application "Minimum SSR Marker Finder for Guinea yam" (https://www.jircas.go.jp/en/database/yam_toolkit/finder) linked with the database contains SSR polymorphism data of over 550 varieties and lines (as of February 2020), and supports identification of the minimum set of SSR markers that can distinguish the varieties selected by each user. In addition to the conventional DNA extraction method using a young leaf sample, we developed the "Sample collection and DNA extraction methods for tuber skin" to widen the user's choice of period to conduct variety identification (Fig. 3). Also, the proposed "Sample bulking method" specially designed for large-scale propagation of yam seed tubers, enables the yam seed sector to reduce time and cost in quality control and quality assurance (Fig. 4).

These useful tools and methods were assembled as an "SSR marker technology package for variety identification of white Guinea yam" to cover all necessary steps to distinguish varieties (Fig. 5), and the website titled "Yam variety identification toolkit" (https://www.jircas.go. jp/en/database/yam_toolkit) was launched to support users in conducting variety identification

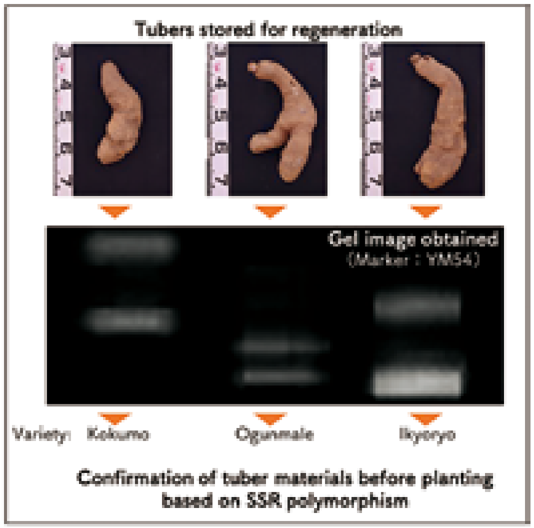

Fig. 2. Identification of varieties with similar tuber shapes using SSR markers

Fig. 1. White Guinea yam (*D. rotundata*)
Left: Shoots of multiple varieties grown in a farmer's field
Right: Tubers obtained from a single plant (DrDRS-139)

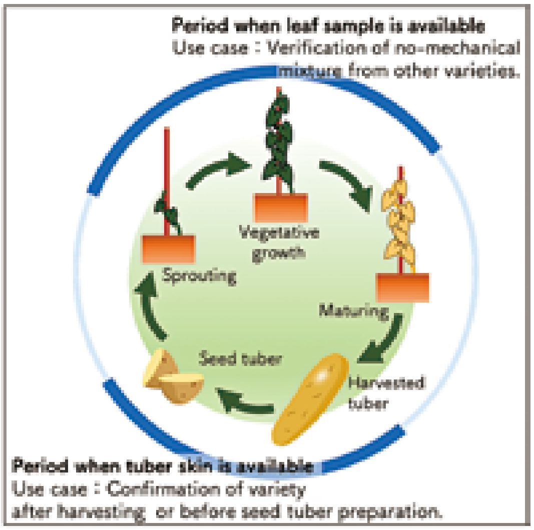

Fig. 3. Expanded period for variety identification with two types of samples

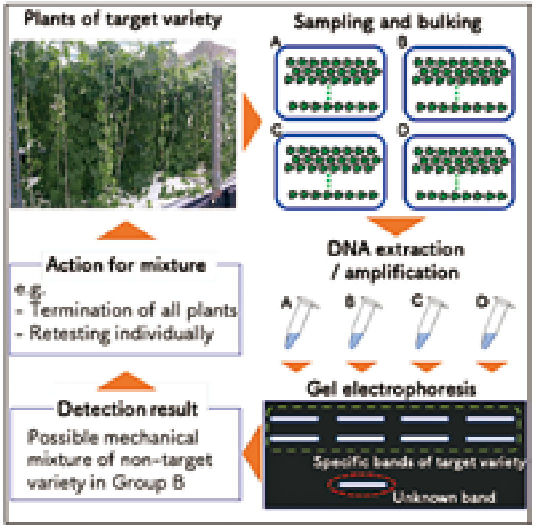

Fig. 4. Utilization of the sample bulking method to maintain purity of target variety

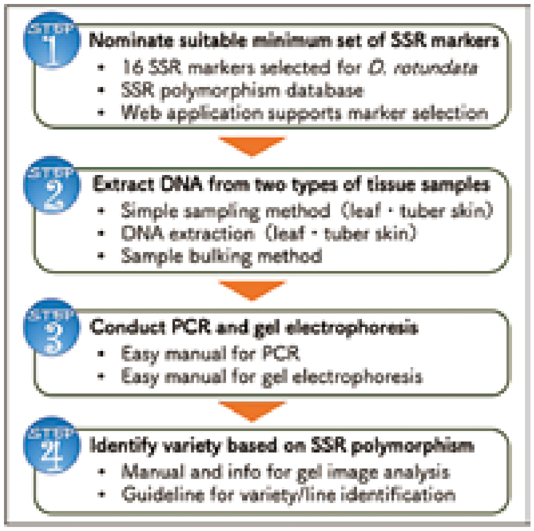

Fig. 5. SSR marker technology package for variety identification of white Guinea yam

with various guidance, tips, manuals, videos, and images. The technology package can reduce time and cost, and provide flexibility for users to ensure the uniformity of the materials before planting, prevent mechanical mixture in various stages of cultivation, and assure the quality of the products. We expect this technology package to support seed growers, extension officers and inspection officers, as well as yam researchers involved in various stages of yam improvement and dissemination. This in turn could help boost breeding efficiency and dissemination of improved varieties, and further improve food security and livelihood in West Africa.

(S. Muranaka, S.Yamanaka, M.Tamiru [Iwate Biotechnology Research Center], P. Agre [International Institute of Tropical Agriculture])

TOPIC 4

SPIKE, a quantitative trait locus for increasing the number of spikelets per panicle, enhances rice grain yield under low-yield conditions

Rice is an important food source in Asia and Africa; however, poor soil fertility and nutrient availability considerably limit rice production in these regions. In addition, the majority of local farmers lack the finances to purchase sufficient fertilizer. Therefore, it is necessary to develop genetically improved rice varieties with high nutrient-use efficiencies. Previously, a quantitative trait locus, *SPIKE*, was reported to have increased the number of spikelets per panicle in rice. Because tillering, and thus the number of panicles, is restricted under nutrient-poor soils, we expected that *SPIKE* may be useful in enhancing rice productivity under low-yield conditions.

In this study, we grew IR64 and the near-isogenic line (NIL) for *SPIKE* in the IR64 genetic background. They were grown in research plots at the International Rice Research Institute (IRRI) in the tropics across 11 seasons from 2011

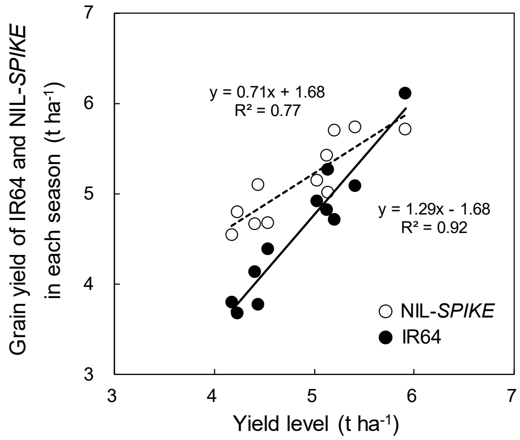

Fig. 1. Comparison of grain yield between IR64 and NIL-*SPIKE* across 11 seasons. Yield level shows mean yield between IR64 and NIL-*SPIKE* in each season.

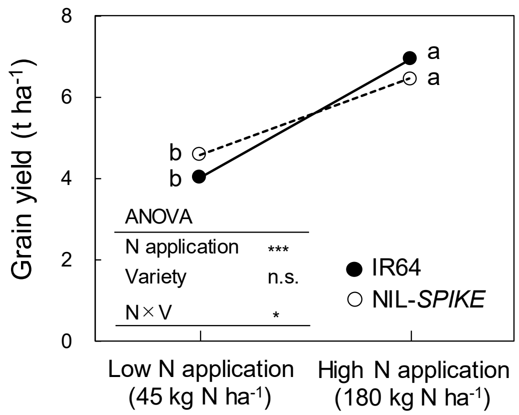

Fig. 2. Comparison of grain yield between IR64 and NIL-*SPIKE* under low- and high-N applications. *** and * show significance at 0.1% and 5% levels, respectively, while n.s. indicates not significant. Different letters show significant difference at 5% level.

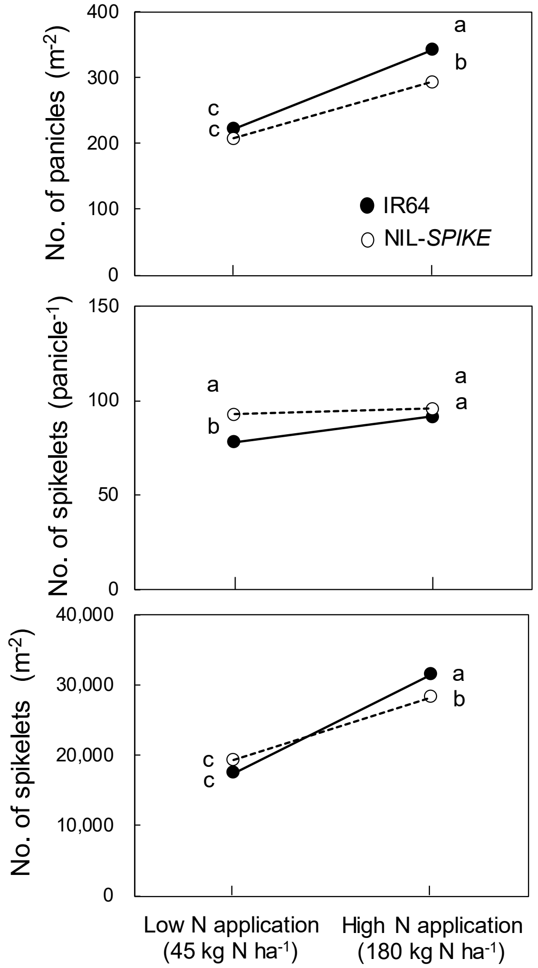

Fig. 3. Comparisons of the number of panicles m^{-2}, the number of spikelets per panicle, and the number of spikelets m^{-2} between IR64 and NIL-SPIKE under low- and high-N applications. Different letters show significant difference at 5% level.

to 2017, and in 2018 under high and low nitrogen (N) fertilizer conditions, where mean yield variation was 4.2–6.7 t ha^{-1}. In multiseasonal trials, overall yield performance of NIL-*SPIKE* was 11% superior to that of IR64. Significant variety × season interaction clarified that NIL-*SPIKE* was superior to IR64 in the lower-yield seasons (< 5 t ha^{-1}) but the difference decreased or disappeared completely in the higher-yield seasons (> 5 t ha^{-1}) (Fig. 1). A subsequent N application trial with two levels of N fertilizer (45 and 180 kg N ha^{-1}) confirmed a similar variety × N interaction for *SPIKE*; NIL-*SPIKE* tended to be superior to IR64 for grain yield under low-N application (4.3 t ha^{-1}), while the difference disappeared under high-N application (6.75 t ha^{-1}) (Fig. 2). The advantage of NIL-*SPIKE* under low-N application was due to more spikelets m^{-2} compared to IR64 but the difference disappeared under high-N application because there were fewer panicles m^{-2} in NIL-*SPIKE* compared to IR64 (Fig. 3).

The results of this study indicate that *SPIKE* is effective at increasing rice yield under low-yield conditions (< 5 t ha^{-1}), namely low-N application or low soil fertility. Therefore, *SPIKE* should be used in breeding programs aimed at regions where soil fertility is poor, or where farmers cannot purchase adequate fertilizer.

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Sugarcane and *Miscanthus* intergeneric hybrids: New sugarcane breeding materials with high photosynthetic activity in a low-temperature environment

Sugarcane (*Saccharum* spp. hybrid) is an essential crop for food and energy production in the world, hence improving its productivity is required. Sugarcane is one of several high-yielding crops with C_4 photosynthesis in tropical and sub-tropical areas; however, it is susceptible to low temperatures, and there are many production areas where low temperature is a major constraint in production. Therefore, improving its adaptability to low-temperature environments has been one of the important breeding targets in sugarcane. Among C_4 plants, *Miscanthus* spp., a sugarcane-related genus, is highly adapted to low-temperature environments because of its cold tolerance during photosynthetic activity, thereby receiving attention as a biomass crop in cold-climate regions. This study aimed to develop new sugarcane breeding materials for improving

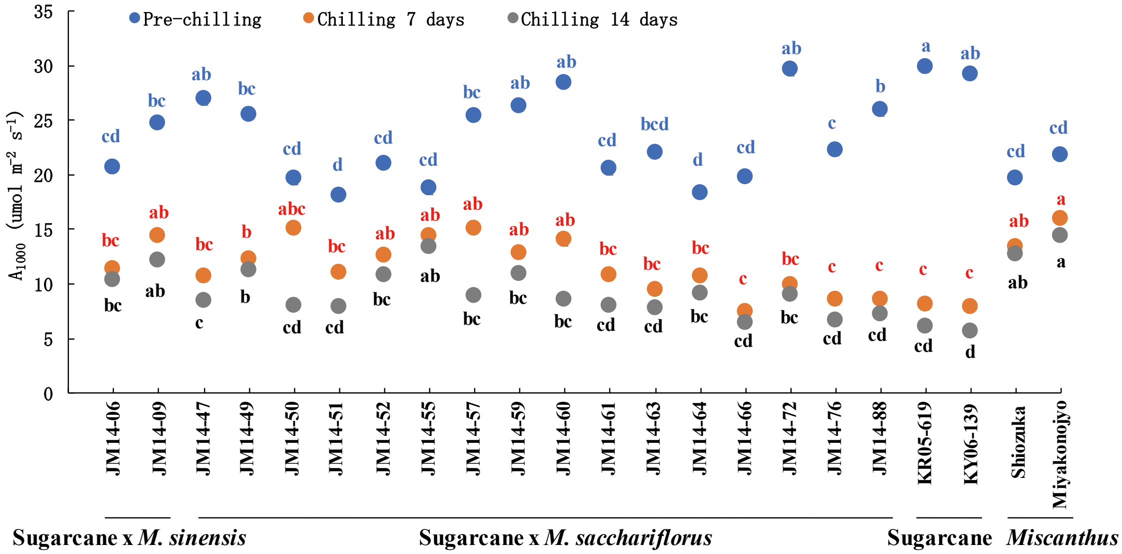

Fig. 1. Photosynthetic rates of intergeneric hybrids in the chilling treatment

The experimental materials were planted in plastic pots with three replications on October 28, 2016, and chilling treatment was started from December 22, 2016. Photosynthetic rates were measured pre-chilling (22-25°C day/13-15°C night) and after 7 and 14 days of chilling (12-13°C day/7-9°C night). A different letter indicates significant difference (p<0.05). The data show the photosynthetic rate at a photosynthetic photon flux density of 1,000 μmol m^{-2} s^{-1} (A_{1000}).

Table 1. Recovery of the photosynthetic rate after chilling treatment

Clone	A_{1500} (μmol m^{-2} s^{-1})[1)]		
	Pre-chilling[2)]	Chilling 4 days[3)]	Recovery 7 days[4)]
JM14-09	28.8 b[5)]	17.1 (59) ab	29.9 (104) a
JM14-72	33.2 a	14.8 (45) b	25.4 (77) b
JM14-88	23.4 c	13.2 (56) b	24.0 (103) b
KR05-619	28.3 b	9.3 (33) c	20.5 (72) c
KY06-139	29.3 b	9.5 (32) c	20.3 (69) c
Shiozuka	24.2 c	16.0 (66) b	24.9 (103) b
Miyakonojo	29.9 b	19.7 (66) a	28.9 (97) a

1) The photosynthetic rate at a photosynthetic photon flux density of 1,500 μmol m^{-2} s^{-1}
2) Photosynthetic rates were measured five weeks after planting (26°C/18°C day/night).
3) Photosynthetic rates were measured after 4 days of chilling treatment (12°C day/7°C night).
4) Photosynthetic rates were measured after 7 days of recovery treatment (26°C day/18°C night).
5) A different letter indicates significant difference among the treatments (p<0.05). The values in parentheses in the table indicate the ratio to the photosynthetic rate of pre-chilling.

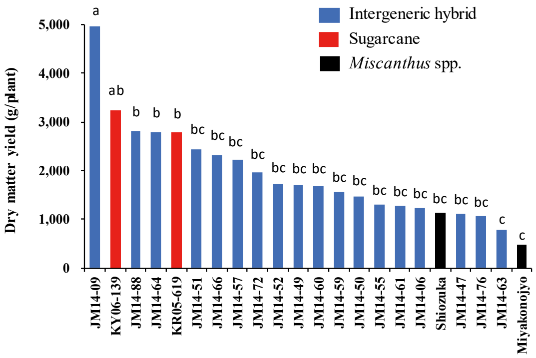

Fig. 2. Dry matter yield per year in the cold-climate region
The experiments were conducted for two years, in 2017 and 2018, at the fields in Hokkaido University (Sapporo, Japan: 43°07′N, 141°33′E). The experimental materials were planted in May and harvested in November, and the experimental plots were three replications with one plant per plot. The average temperature and precipitation in the experimental period were 17-18°C and 700-800mm, respectively. A different letter indicates significant difference (p<0.05).

cold tolerance in sugarcane by intergeneric hybridization between sugarcane and *Miscanthus* spp.

Using intergeneric crosses between sugarcane clones KY06-139 and KY05-619 as female and Shiozuka (*Miscanthus sinensis*) and Miyakonojo (*M. Saccharifulorus*) as male, we developed two hybrids between sugarcane and Shiozuka and 16 hybrids between sugarcane and Miyakonojo (Fig. 1). In the chilling stress experiment (12–13°C day/7–9°C night), the *Miscanthus* parents and some hybrids exhibited higher photosynthetic rates than their sugarcane parents after 7 days and 14 days of chilling treatment (Fig. 1). Furthermore, in the post-chilling recovery experiment, where chilling treatment (12°C day/7°C night) was applied for 4 days and then recovery treatment (26°C day/18°C night) was applied for 7 days, the *Miscanthus* parents and some hybrids showed better recovery of photosynthetic rates than the sugarcane parents (Table 1). Intergeneric hybrid JM14-09 showed higher biomass productivity than sugarcane parent KR05-619 and *Miscanthus* parent Shiozuka, based on the results of field experiments in a cold-climate region (Fig. 2).

To sum up, the intergeneric hybrids developed in this study can be utilized as new breeding materials for improving the biomass productivity and photosynthetic characteristics of sugarcane at low-temperature environments.

(Y. Terajima, S. Ando, S. Kar [Hokkaido University], T. Yamada [Hokkaido University])

TOPIC 6

Harunoogi, a high ratoon yield sugarcane cultivar developed by interspecific hybridization between sugarcane and *Saccharum spontanium*

Sugarcane (*Saccharum* spp. hybrid) is an essential crop for food and energy production, and improvement of its productivity will contribute toward promoting food sustainability and energy security around the world. Sugarcane can continue growing by low-cost cropping type ratooning, whereby the post-harvest stubbles in the fields are regrown. Improving ratoon productivity for high-latitude production areas, where low temperatures cause problems in ratooning, have been one of the most important breeding targets; however, the stagnation of genetic improvement arising from the narrow genetic diversity of cultivars and breeding materials in the world has become an issue in breeding, hence expanding genetic diversity using unused genetic resources is required. The wild sugarcane, *S. spontaneum*, is an important genetic resource for improving sugarcane ratoon yield due to its superior tillering and ratooning ability under various environments. The aim of this study therefore was to develop a sugarcane cultivar with good tillering ability and high ratoon yield for high-latitude sugarcane production areas by interspecific hybridization between sugarcane and *S. spontaneum*.

The new high ratoon yield cultivar Harunoogi was developed from a crossing between fodder sugarcane cultivar KRFo93-1 (which was developed by interspecific hybridization between sugarcane cultivar NCo310 and *S. spontaneum* Glagah Kloet and has excellent tillering ability with high ratoon yield at multiple ratooning) and the high-sugar-content sugarcane cultivar NiN24 (Fig. 1, Fig. 2). Harunoogi can produce an extraordinarily large number of stalks with sugar content comparable to that of NiF8, which is a major cultivar in high-latitude areas in Japan, even though its stalk diameter is smaller than NiF8 (Table 1). Its excellent ratooning ability enables the production of more stalks than NiF8 in

Fig. 1. Harunoogi and NiF8
Photos taken in November 2018 in Nishinoomote, Japan

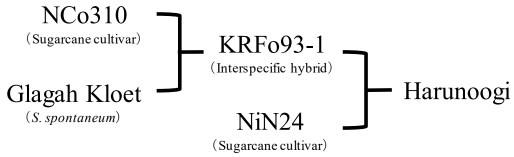

Fig. 2. The pedigree of Harunoogi

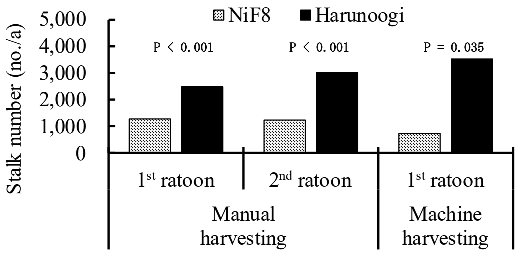

Fig. 3. Stalk number in early growth stage of the ratoon crop
The *p*-values were calculated by a generalized linear model with cultivar (fixed effect) and plot (random effect).

Table 1. The agronomic characteristics of Harunoogi

Cropping type	Cultivar	Stalk number (no./ha)	Stalk length (cm)	Stalk diameter (mm)	Single stalk weight (g)	Cane yield (t/ha)	Sugar content (%)	Sugar yield (t/ha)
New planting	Harunoogi	143,950	224	20.6	685	97.3	12.4	11.0
	NiF8	93,100	244	22.5	818	75.6	12.1	8.4
	p -value	<0.001	<0.001	<0.001	<0.001	<0.001	0.441	<0.001
1st ratoon	Harunoogi	188,667	244	19.4	619	117.2	11.8	12.7
	NiF8	110,633	238	20.5	649	71.9	12.4	8.2
	p -value	<0.001	0.272	0.016	0.337	<0.001	0.098	<0.001
2nd ratoon	Harunoogi	192,950	218	19.6	583	109.7	10.4	9.8
	NiF8	134,800	215	20.5	558	74.6	10.4	6.7
	p -value	0.003	0.733	0.116	0.492	<0.001	0.723	0.003

The experiments were conducted from 2015 to 2018 at Tanegashima Sugarcane Breeding Site, Kyushu Okinawa Agricultural Research Center (NARO) (Nishinoomote, Japan). The results in the table show the means of 4 years (2015-2018) in new planting, three years (2016-2018) in 1st ratoon, and two years (2017-2018) in 2nd ratoon. The *p*-values were calculated by a generalized linear model with cultivar (fixed effect), year, and plot (random effect).

ratoon crop, especially after machine harvesting (Fig. 3). As a result, cane yield and sugar yield in 1st and 2nd ratoon crops of Harunoogi are much higher than NiF8's (Table 1).

Harunoogi, which was jointly developed by the Japan International Research Center for Agricultural Sciences and the National Agriculture and Food Research Organization (NARO), is expected to contribute to sugarcane production in high-latitude areas in Japan. Interspecific hybridization with *S. spontaneum* will be an important strategy toward improving the tillering ability and productivity of ratoon crops in high-latitude areas where low temperature is a critical constraint in sugarcane production.

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Current status of insecticide use by farmers for controlling rice planthoppers in the northern part of Vietnam

Insecticides are widely used in Asia to control insect pests on rice such as the rice planthoppers *Nilaparvata lugens* and *Sogatella furcifera.* It has been known that these species developed resistance against several insecticide ingredients, resulting in difficulty to control. They migrate from the central and northern parts of Vietnam to Southern China and Japan every year but are unable to overwinter in the immigrated areas. Hence, insecticide use in the source areas is a key factor when considering insecticide resistance management. Here we investigated the situation of insecticide use by local rice farmers and the effect of insecticide application to the density of planthoppers in the northern part of Vietnam.

Interviews with rice farmers revealed the active ingredients used in the paddy fields. Ten groups consisting of 21 ingredients were confirmed in two villages in Nam Dinh and Vinh Phuc Provinces, with the differences noted among locations and crop seasons (Table 1). Generalized linear model analysis was performed, with locations, crop seasons, the applied number of insecticide ingredients, and the number of spiders and mirid bugs (the natural enemies of planthopppers) as explanatory variables, and the planthopper density at booting stage as response variable. The results indicated that the applied number of ingredients has a weak effect in reducing the density of planthoppers (Table 2). Pesticide application using knapsack sprayers was evaluated using water-sensitive papers (WSPs). Droplet depositions on WSPs were high at the top part of the rice plant (height above the water surface ≈ 60 cm), moderate at the middle part (40 cm) where *S. furcifera* lives, and low at the bottom part (15 cm) where *N. lugens* lives (Fig. 1). The mortality of adult female *N.*

Table 1. Insecticide ingredients used by farmers in two villages in Northern Vietnam

Group	Active ingredients	Nam Dinh		Vinh Phuc	
		Winter (38)	Summer (38)	Winter (37)	Summer (26)
Average frequency of spraying the active ingredients/field		4.48	8.83	0.29	1.88
Carbamates	BPMC	-	-	-	○
Organophosphates	Chlorpyrifos	○	-	-	○
	Chlorpyrifos-ethyl	○	○	-	○
	Quinalphos	○	○	-	-
Phenylpyrazoles	Fipronil	○	○	○	○
Pyrethroids	Cypermethrin	○	○	-	○
	Permethrin	-	○	-	○
	lambda -Cyhalothrin	○	-	-	-
	alpha -Cypermethrin	○	○	-	-
Neonicotinoids	Imidacloprid	○	○	-	-
	Nitenpyram	○	-	-	-
	Acetamiprid	-	○	-	-
	Dinotefuran	-	○	-	-
	Thiamethoxam	-	-	○	○
Avermectins	Abamectin	○	○	-	○
	Emamectin benzoate	○	○	-	○
Pyridine azomethine derivatives	Pymetrozine	○	○	○	-
Nereistoxin analogues	Thiosultap-sodium	-	○	-	-
Buprofezin	Buprofezin	○	○	-	-
Oxadiazines	Indoxacarb	○	○	-	-
Diamides	Chlorantraniliprole	-	○	○	○

Active ingredients were classified by the Insecticide Resistance Action Committee. The number in the parenthesis is the number of farmers interviewed.

Table 2. Results of generalized linear model analysis on variables affecting the density of rice planthoppers

Explanatory variables	d.f.	Estimated value	χ^2	p value
Location	1	0.63	4296.03	<0.001
Crop season	1	-0.31	662.63	<0.001
Applied number of ingredients	1	0.02	22.47	<0.001
Number of spiders	1	0.02	4534.75	<0.001
Number of mirid bugs	1	0.06	6285.56	<0.001

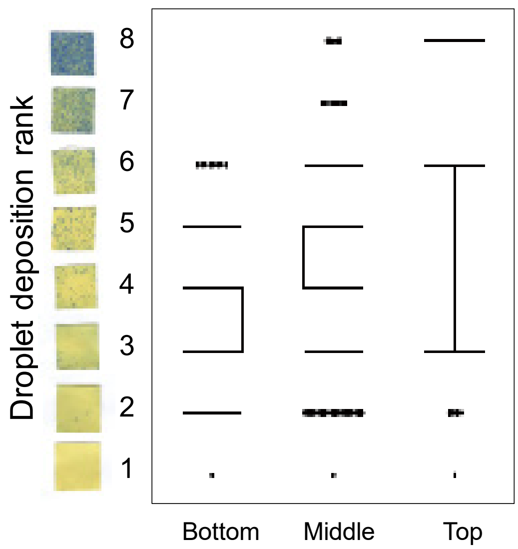

Fig. 1. Droplet deposition ranks at different heights of the rice plant

lugens was high when the droplet deposition rank was high (Fig. 2), implying that one of the factors for the weak effect of insecticide application by farmers was that insecticide droplets did not reach the targets' habitats.

The results indicated that improving the method of pesticide application, i.e., enabling

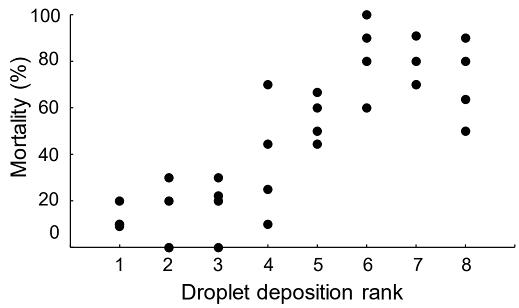

Fig. 2. Relationship between the droplet deposition rank and mortality of *N.lugens*
Dots show the mortality for each replicate. Insecticide contains 45% nitenpyram, 25% pymetrozine, and 5% imidacloprid (w/w).

the droplets to reach the planthoppers' habitat, will efficiently control rice planthopper because, in general, systemic insecticides are rarely transferred from the top to the bottom of the plant. Insecticide resistance development is probably another reason for the lower efficiency in pest control. Vietnamese planthopper population needs to be monitored for insecticide resistance.

(M. Matsukawa, Y. Kobori, C. H. Nguyen [Plant Protection Research Institute])

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 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 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 PR China. We determined cereals, as well as processed and traditional fermented foods, of which similar products appear widely in the Asian region, to be the main target foods.

A project team composed of scientists from JIRCAS and Kasetsart University in Thailand found that some amylolytic bacteria are causative agents of liquefaction in the fermented rice noodle, *Khanom chin*, and they proposed a low-cost and effective measure to prevent liquefaction by controlling the pH of the final product. The team prepared a booklet about *Khanom chin* containing these results for use in extension activities in Thailand. In addition, a collaborative effort by researchers of JIRCAS and Northwest A&F University, China, led to the development of a simple heat processing method that produces a popcorn-like gelatinized product from Tartary buckwheat, an important but not well utilized crop due to its bitterness and hard hull. Lastly, a team of economists from JIRCAS and counterpart institutes investigated the value structure and distribution system of traditional food and local crops, and they clarified the characteristics of consumer behavior.

[Asia Biomass]

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 (OPTs) and wastewater. For efficient production of biogas, bioethanol, and biodegradable materials, it is desired that OPTs accumulate more useful carbohydrates such as glucose and starch. Hence, we analyzed the relationship between soluble sugar and starch in the trunk, the storage destination of the substances produced by photosynthesis, the number of fruits and the temperature, and the rainfall amount in Penang, Malaysia. It was clarified that soluble sugar and starch accumulate in OPTs in the survey area during low temperatures and high precipitation. These findings should contribute to the stable production of palm oil as well as the utilization of soluble sugar and starch from OPTs in downstream applications.

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

Results of pond fish culture trials using indigenous species showed economic feasibility under an appropriate fish density and feeding regime. Analysis of unmanned aerial vehicle (UAV a.k.a. drone) images, meanwhile, revealed that rapid phenotyping of upland rice varieties as well as mapping of rice yield potential in rainfed paddy areas were well developed. The environmental factors relevant to the accumulation of antioxidant contents in colored upland rice varieties were partially identified. The current protein deficiency situations in mountainous rural villages where malnutrition was noted among residents, were mostly identified, and the nutritional information of aquatic animals and rice were prepared to improve nutrition. Regarding the preparation of safe, fermented fish products such as Pa daek, methodologies to reduce or eliminate histamine were efficiently disseminated to Pa daek producers in a rural village. In addition, floral disbudding efficiency for improving mango productivity was well demonstrated.

[Higher Value Forestry]

We develop technologies to improve the value of planted forests through advanced use of genetic resources and proper management of native tree species in Southeast Asia. Thinning experiments at a teak plantation in Thailand indicated that tree diameter growth is affected by the initial tree size before thinning and the basal area of competing trees around the target tree. At the teak clonal test site in Kanchanaburi, 147 clones were identified, and their genetic structure were analyzed. In teak plantations in the northern mountainous region of Laos, soil erosions were more intense on steeper slopes with poor undergrowth vegetation.

Drought tolerances were tested on four dipterocarp species. Results showed higher tolerance of species distributed in the tropical monsoon area (*Shorea roxburghii* and *Hopea odorata*) compared to species in the tropical humid area (*S. leprosula* and *Neobalanocarpus heimii*). It was found that leaf production (leaf spreading) can be explained by the effective cumulative temperature obtained by adding temperatures above a certain threshold. From genome-wide association study (GWAS) results on growth traits (diameter, tree height, branch angle) and wood density of dipterocarp species, we found that diameter growth of stem is controlled by many polygenes and that the contribution of individual genes is small. Prototypes of genomic prediction models, which could estimate phenotype from genomic information, were developed for *S. leprosula* and *S. platyclados*.

[Aquatic Production in Tropical Areas]

Development of technologies for sustainable aquatic production was conducted in Southeast Asian countries. A workshop titled "Perspectives for Research and Development on Sustainable Aquatic Production in Tropical Areas" was held in Tsukuba, Japan, to look over the current status of technical research/development of aquatic production and aquaculture industry in tropical areas, and to discuss research needs/seeds and themes/challenges that JIRCAS should address. In Malaysia, the potential causality of the reduction in blood cockle culture production and degradation of the fishing grounds was further investigated by monitoring the shell morphology and sediment oxidation-reduction potential in the sea bottom. In Myanmar, a cross-sectional environmental survey along the potential oyster habitat and appropriate oyster seedling collection sites as well as biological studies on the edible bivalves were continued. In Thailand, the co-culture system for giant tiger shrimp with seaweeds and small snails was improved to raise production above the minimum amount (0.4 kg/m^2) expected by shrimp farmers. In Laos, a demonstration training on seedling production of indigenous shrimp for local technical staff was conducted. In the Philippines, a workshop was held to wrap-up and reflect on the achievements of the Integrated Multi-Trophic Aquaculture (IMTA) studies and discuss further challenges in the IMTA system for milkfish, seaweeds, and sea cucumber.

TOPIC 1

Liquefaction of Thai fermented rice noodles can be prevented by maintaining the product in acidic condition of pH around 4

Fermented rice noodles, traditionally known as *khanom jeen* in Thailand, are produced and consumed countrywide. Similar types of products are common in Laos, Vietnam, Cambodia, Myanmar, and China. *Khanom jeen* is made from fermented rice flour containing lactate. In the noodle factories, the fermented rice flour is heated to achieve partial starch gelatinization and kneaded with water. The dough is then extruded into noodles in boiling water for about one minute, washed with water, drained using a sieve container, and sold. The fermented rice noodles have a unique and preferable flavor and texture achieved through the rice fermentation process. Normally, the products retain quality without rotting for a few days at ambient temperature. Refrigeration is not applicable to the noodles because starch retrogradation at cold temperatures ruins the unique texture. However, it occasionally suffers from severe liquefaction (Fig. 1) before the products are sold in the market. Although the direct cause has yet to be clarified, an urgent solution to the liquefaction problem is needed to reduce economic and food losses.

Liquefaction is thought to result from water release associated with digestion of the starch maintaining the noodle structure by amylolytic enzymes with pH preferences for activity. The fermented rice noodles containing 0.03% lactate is acidic with a pH of 3.7. The pH changes to 4.0, 6.0, or 7.7 after soaking in McIlvaine buffers at pH 4.0, 6.0, or 8.0 for 10 min, respectively. Moisture transudation and partial liquefaction are observed in noodles treated with buffers at pH 6.0 or 8.0 after 3 to 5 days of incubation at 37°C (Fig. 2). In contrast, such phenomena are not observed in noodles treated with buffer at pH 4.0 (Fig. 2) or in those treated with buffer containing 200 µg/mL chloramphenicol (data not shown), indicating that liquefaction of fermented rice noodles is induced, accompanied by bacterial growth in products in which the pH is heightened to 6.0 or higher. α-amylase activity is detected in noodles treated with buffers at pH 6.0 or 8.0 after 2 days or 1 day of incubation, respectively (Fig. 3A). An increase in reducing sugar is observed in accordance with α-amylase production under liquefaction-inducing conditions (Fig. 3B). It is presumably derived from oligosaccharides by starch digestion in noodles. Taken together, it is important for the producers to maintain fermented rice noodles as well as fermented rice flour in acidic condition of pH around 4 to prevent liquefaction of the products.

The producers can monitor the pH of their products by using a food-grade pH meter or with the simplified method using pH-test papers. It is also recommended that the producers check the pH of the water for washing the fermented rice noodles at the end of production. Underground water, which is generally used for the washing stage, might be alkalized due to soluble minerals.

Fig. 1. Liquefaction of fermented rice noodles

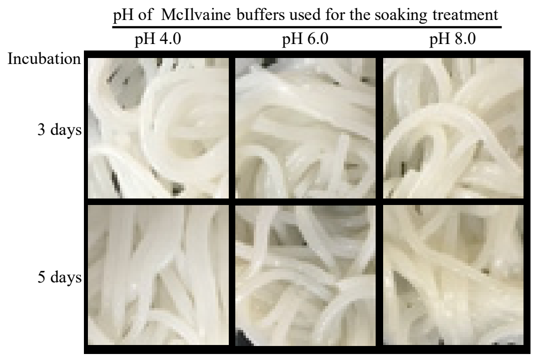

Fig. 2. Appearance of fermented rice noodles after 3 and 5 days of incubation at 37°C after soaking treatment with McIlvaine buffers at pH 4.0, 6.0, and 8.0

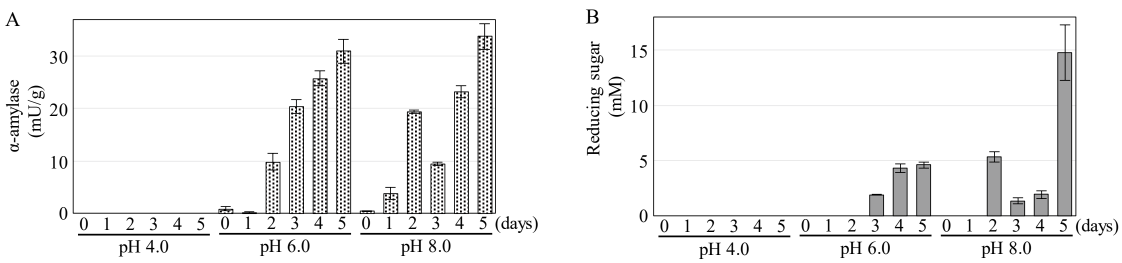

Fig. 3. Time-dependent change in α-amylase activity (A) and reducing sugar content (B) in fermented rice noodles treated with McIlvaine buffers at pH 4.0, 6.0, and 8.0

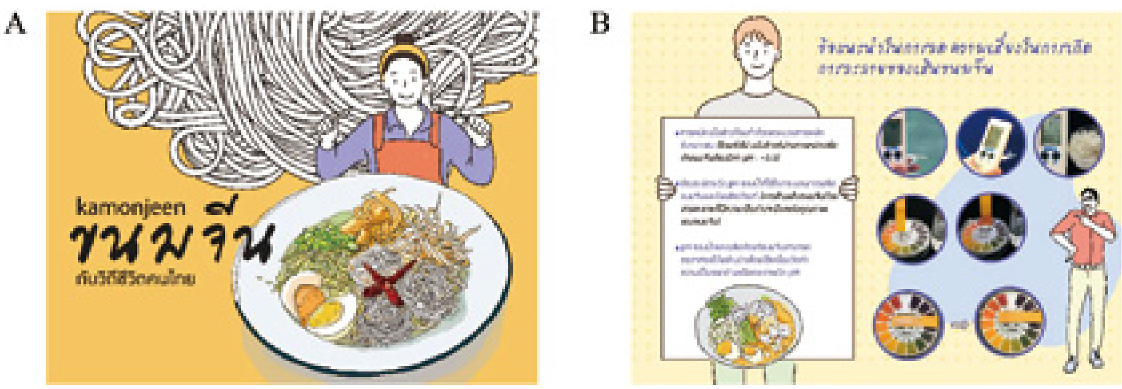

Fig. 4. Cover illustration (A) and introduction of pH monitoring methods (B) in a booklet on fermented rice noodles, written in Thai

Edible organic acids such as acetate can be used to adjust the pH of the washing water, although the usage needs to be carefully optimized in consideration of the flavor of the product. Information regarding liquefaction prevention and the manufacturing process, as well as serving ideas for fermented rice noodles, are simply summarized in a booklet in Thai (Fig. 4). It would be useful not only to the producers but also the general public, and it is expected to increase productivity, improve the food value chain, and raise awareness on this great local food tradition.

(J. Marui, T. Yoshihashi, S. Shompoosang [IFRPD, Kasetsart University], V. Surojanametakul [IFRPD, Kasetsart University])

TOPIC 2

New approach for Tartary buckwheat utilization by rapid heating treatment

Tartary buckwheat (*Fagopyrum tataricum* Gaertn.) is widely known as a functional food/medicinal source throughout the world. A relatively low-demanding crop, Tartary buckwheat can tolerate environmental stresses such as water deficiency, diseases, insects, and ultraviolet radiation, thus it is often used in organic farming systems and as an emergency crop around the world. Tartary buckwheat is anticipated to be utilized for various food products due to its high rutin content, indicating high potential in terms of functional benefits. However, its utilization is limited owing to the difficulty in dehulling its hard pericarp and the strong bitterness of its products, which in turn are attributed to quercetin formation by rutinosidase-induced rutin hydrolysis in buckwheat seed. In addition, enzyme activity in Tartary buckwheat is strong enough to hydrolyze rutin to quercetin in a very short time, comparable with that of common buckwheat. Thus, products using Tartary buckwheat as an ingredient are strongly bitter in taste even if mixed with common buckwheat, which is otherwise not bitter.

This study therefore aimed to develop an effective treatment to overcome both the limitations of dehulling and rutinosidase activity in Tartary buckwheat utilization by circulated fluidized-bed heating. Using a circulated fluidized-bed at high temperatures, the treatment enabled buckwheat to produce a popcorn-like gelatinized product (Fig. 1). Also, although rutin was mostly retained in the samples, the products did not exhibit bitterness and their functionality was conserved (Table 1). Owing to the denaturation of rutinosidase in the heat-treated products, rutin content in the model system (i.e., Tartary buckwheat mixed with common buckwheat) was retained without the formation of the bitter digested product,

Table 1. Rutin content of samples with/without the treatment (dry matter basis)

Sample name	Treatment	Rutin (mg/100g)
Tartary buckwheat (Hokkaido)	Unpopped	1,637±118.2
	Popped	1,469±49.5
Tartary buckwheat (China)	Unpopped	1,548±77.8
	Popped	1,202±72.2

Rutin was slightly decreased; however, the product did not show bitterness from the rutin-degraded product, quercetin.

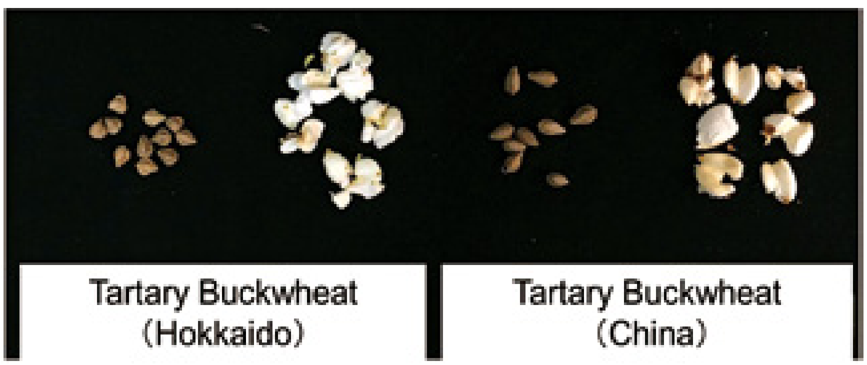

Fig. 1. Popped Tartary buckwheat using circulated fluidized-bed heating treatment
The treatment provides edible popped Tartary buckwheat in a short time.

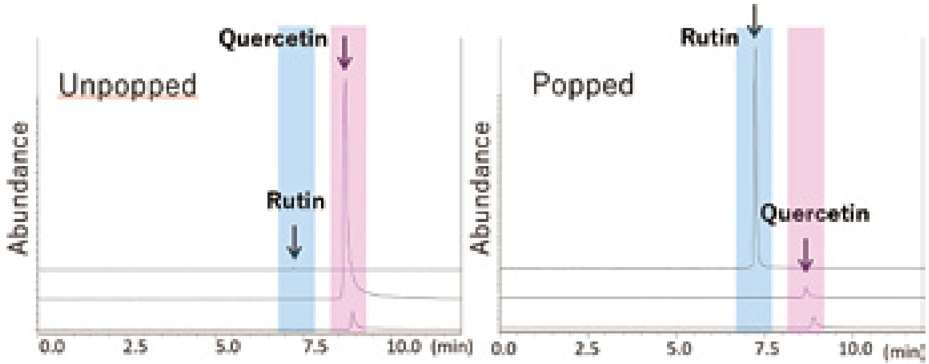

Fig. 2. Chromatograms of rutinosidase assay mixtures using crude enzymes
The assays were performed with crude enzyme from Tartary buckwheat samples with rutin, then the substrate (rutin) and product (quercetin) were quantified.

Table 2. Macronutrients in Tartary buckwheat samples (Hokkaido)

Samplename	Treatment	Protein (g/100g)	Fat (g/100g)	Ash (g/100g)	Carbohydrate (g/100g)	Fiber (g/100g)	Energy (kcal/100g)
Tartary buckwheat (Hokkaido)	Unpopped	13.7	4.1	2.3	79.9	5.7	411
	Popped	12.5	4.0	2.2	81.3	4.5	411

quercetin (Fig. 2). Nutritional analysis of pre- and post-treated products showed retention of the macronutrients even after heat treatment. The popped Tartary buckwheat could, therefore, be obtained by simple treatment, and might reveal new opportunities to utilize pre-gelatinized and rutin-rich properties by rutinosidase denaturation (Table 2).

Regarding this treatment's utilization and future prospects, its biggest advantage is that it broadens the utilization of Tartary buckwheat as a simple and low-cost functional food source. The final edible product contains high rutin without bitterness and rutinosidase activity. Furthermore, the model study showed the possibility of using the popped Tartary buckwheat as an intermediate product, providing high amounts of rutin to various foods, such as bread, steamed bun, and buckwheat noodle, as a mixture ingredient. The treatment curtails production cost by rapid heating in a circulated fluidized-bed, and it does not require high-pressure processing.

(K. Fujita, T. Yoshihashi)

TOPIC 3

Main factors that determine the amounts of soluble sugar and starch in old oil palm trunk

Palm oil occupies 40% of global vegetable oil production, with 85% of all palm oil production confined to a restricted area that is primarily within Indonesia and Malaysia. Oil palm stem contributes a large proportion of the waste, but its sap contains approximately 11% soluble sugar. Non-structural carbohydrates (NSC), including soluble sugars and starch in the stem, can be used as a substrate in bioreactors and so on. Although soluble sugar content in the sap of felled trunk was identified to be dependent on the amount of starch (JIRCAS Research Highlights 2017, C07), the mechanisms through which NSC accumulate in the stem have not yet been well documented. Oil palm cultivation is limited in the surrounding area of the equator, hence it has been considered that water stress due to high temperature and drought affects productivity of fruit bunches, which leads to the seasonality of production. Here, we investigated how environmental conditions influence NSC in stem and fruits as intermediate and final storages. These findings should contribute to the stable production of palm oil as well as the utilization of NSC from the stem in downstream applications.

The volume of fruit bunch increased from around October, reaching maximum around May the following year, then matured fruit bunches dropped. Increments in soluble sugar levels were

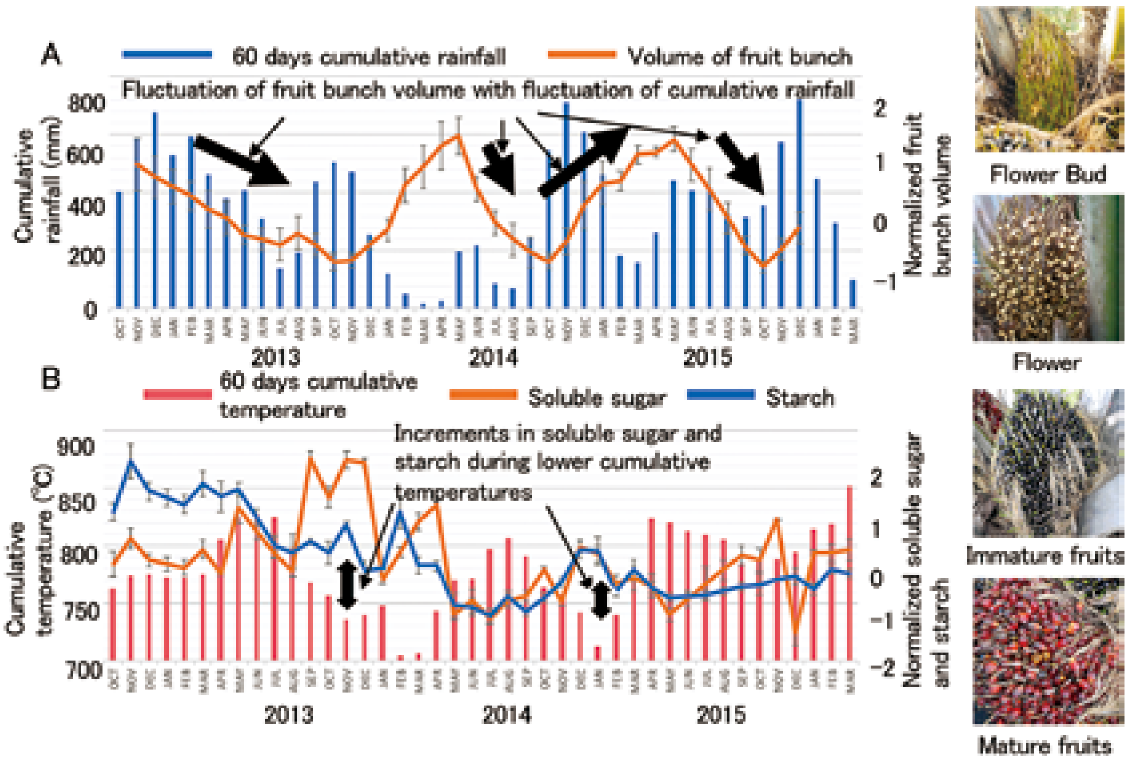

Fig 1. The volume of fruit bunch summed from all development stages, shown by photos on the right side, and 60 days cumulative rainfall (A), the amounts of soluble sugar and starch in oil palm stem and 60 days cumulative temperature during the observation period (B)

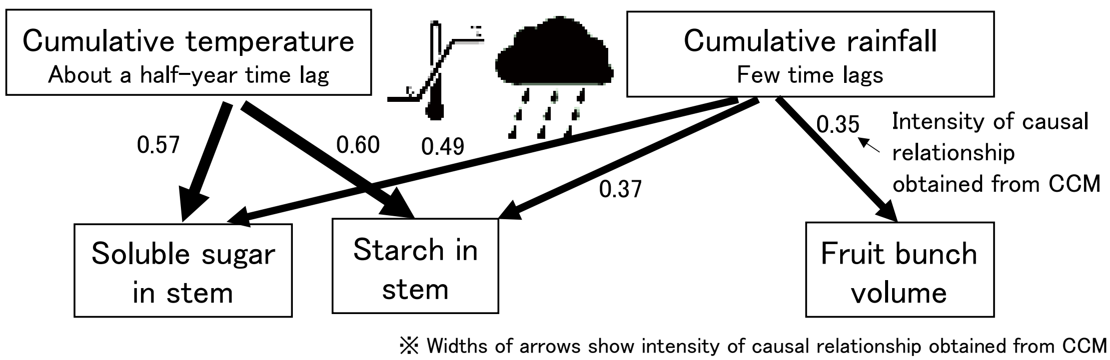

Fig. 2. Significant causal relationship from cumulative temperature and rainfall to soluble sugar, starch in oil palm stem, and volume of fruit bunch evaluated by empirical dynamic modelling

observed but increments in starch levels were not obvious during periods when there were less fruit bunches (Fig. 1). Convergent cross mapping (CCM), an analytical method in empirical dynamic modeling to identify causal relationship between time-series showing non-linear dynamic, showed a causal relationship between soluble sugar in stem and volume of fruit bunch. Furthermore, CCM showed that the 60-day cumulative temperature taken backward from the observation dates (CT) was causally and strongly related to soluble sugar and starch in stem with about a half-year time lag, but not to volume of fruit bunch. Similarly, 60-day cumulative rainfall taken backward from the observation dates (CR) was causally related to soluble sugar and starch in stem with no time lag (Fig. 2).

The above results suggest that the main factors that determine soluble sugar and starch in the stem are temperature and subsequently rainfall fluctuations. The period from October to December, when lower temperatures and higher cumulative rainfall are observed in the northern part of Malay peninsula where the study was conducted, was identified as the period with maximum stem NSC stocks. This finding can contribute to planning the timing of tree felling operations to maximize soluble sugar and starch in old oil palm stem for downstream usage in biorefineries. When the finding is applied to other regions, it is necessary to identify environmental factors indicating strong causality and its time lags.

(N. Tani, A. Kosugi, T. Arai, T. Kondo, Z. A. Abdul Hamid [Universiti Sains Malaysia (USM)], N. Joseph [USM], O. Sulaiman [USM], R. Hashim [USM], A. Satake [Kyushu University])

TOPIC 4

Bacillus aryabhattai **produces bioplastics from starch in agricultural residues**

In Southeast Asia, large amounts of agricultural residues such as cassava pulp and oil palm trunk are generated, causing various environmental problems. On the other hand, starch that remained in crop residues is considered as a useful biomass resource. In recent years, the harmful effect of petroleum-based plastics on the environment has been raised in global discussions. Polyhydroxybutyric acid (PHB), a bioplastic material, is expected to become a substitute for petroleum plastics. However, there are some challenges that prevent its widespread use. One big problem is its high production cost, half of which is due to the price of the substrate. The aim of this study, therefore, was to screen for bacteria that can produce PHB, using starch from agricultural waste, in a single step.

Eighty-four (84) strains of PHB-producing bacteria were isolated from Japanese soil, and *Bacillus aryabhattai*, the bacterium that produced the largest amount of PHB, was isolated from the screening medium. Because *B. aryabhattai* retains an amylase gene (*amyA*), starch can be degraded into glucose by the amylase secreted outside the cells, and the glucose is used as a feed resource to produce PHB and accumulate PHB granules in the cells. When the bacteria were cultured using soluble starch as a carbon source (under optimum conditions considering temperature, pH, starch concentration, etc.), the cell weight was 4.4 g/L, PHB content in cells was 46%, and PHB production was 1.9 g/L.

The above data show that the bacteria exhibit high efficiency in producing PHB from soluble starch (Fig. 1). On the other hand, *Cupriavidus necator*, which has been used industrially as a PHB-producing bacterium, cannot use starch because it has no amylase gene and cannot produce PHB even when cultured under the same conditions (Fig. 1). When *B. aryabhattai* was

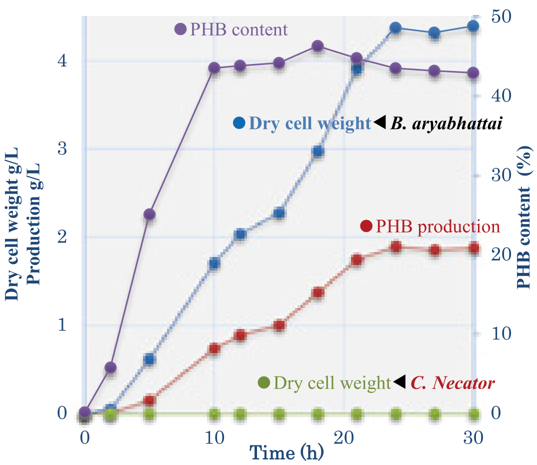

Fig. 1. PHB production from soluble starch by *B. aryabhattai*

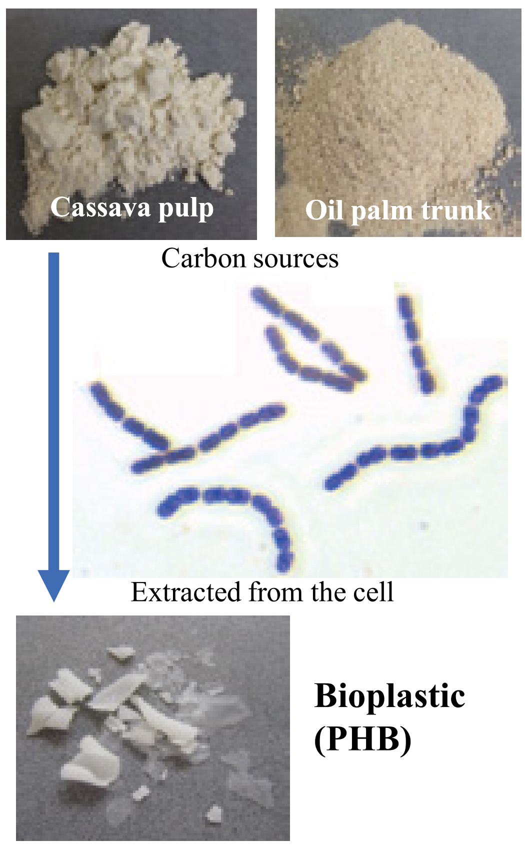

Fig. 2. PHB production from starch in agricultural waste and residues

Table 1. PHB production from unused starch in crop residues by *B. aryabhattai*

Source of starch	Starch degradation (%)	Dry cell weight (g/L)	PHB production (g/L)	PHB content (%)
Cassava pulp	96±3	1.42±0.08	0.12±0.03	8.68±1.44
Old oil palm trunk	99±1	1.95±0.05	0.33±0.06	17.07±2.83

Table 2. Physical property ratio of PHB produced from glucose and cassava pulp by *B. aryabhattai* and other bacteria

Strain	Carbonsource	Physical properties of PHB		
		Weight-average molecular weight	Number average molecular weight	Melting point (°C)
B. aryabhattai	Glucose	2.19×10^5	4.43×10^4	165
	Cassava pulp	1.61×10^5	4.28×10^4	170
Bacillus spp. 871	Glucose	5.13×10^5	Unmeasured	153
Bacillus spp. 112A	Glucose	5.21×10^5	Unmeasured	148
Saccharophagus degradans	Glucose	5.42×10^4	Unmeasured	166

cultured using cassava pulp or starch from oil palm trunk as a carbon source, the cassava pulp starch was degraded by 96% and the oil palm trunk starch by 99%. PHB production was 0.12 g/L and 0.33 g/L, respectively (Fig. 2, Table 1). The weight-average molecular weight, which indicates the physical properties of PHB, was the same as PHB produced using commercially available glucose as a carbon source (Table 2). The melting point, an indicator of heat resistance, was higher than that of PHB produced using commercially available glucose as a carbon source. From these results, the *B. aryabhattai* PHB is expected to be suitable for heat processing at high temperatures and for increasing the heat resistance of the product.

By using *B. aryabhattai*, PHB can be produced directly from starch in agricultural residues of cassava pulp and oil palm trunk without using starch-degrading enzymes, thereby reducing the cost of bioplastic production. A reduction in environmental load can be also expected.

(T. Arai, A. Kosugi, S. Sudesh [Universiti Sains Malaysia])

TOPIC 5

Efficacy of black soldier fly larvae as a protein source in aquaculture feed for the climbing perch

In Laos, demand for food fish has been increasing in recent decades, with the promotion of aquaculture playing a key role in the government's national population development strategy. However, aquaculture feed procurements have been entirely dependent on imports from neighboring countries, resulting in high costs causing limitation of broad extension of aquaculture in the country. In addition, protein content in aquaculture feeds is highly dependent on fishmeal (FM), and price fluctuations in FM largely affect the current/future price of feeds. With this background, the identification of substitutional protein sources becomes important in reducing feed costs and dependence on FM. Here, we evaluated the efficacy of black soldier fly (*Hermetia illucens*, referred to as BSF) larvae (Fig. 1a) as a protein source in aquaculture feed for the climbing perch (*Anabas testudineus*) (Fig. 1b).

The BSF larvae were cultured beforehand with feeding on fruit residues and beer draff. Three different feeds (with/without BSF larvae) were prepared as follows: feed T1 (the control feed) with the highest crude protein (CP 32.5%) using only FM as animal protein source; T2 as the lower protein feed (CP 30.0%) using FM/BSF mixed meals; and T3 as the lowest protein feed using only BSF (CP 25.0%) (Table 1).

After 123 days of culture trials using the above feeds, major growth indices (total length, body weight, survival rate, and feed conversion ratio) in fish given the feeds T2/T3 were not significantly different from those of fish given the T1, although the CP levels in the T2/T3 were lower than that

Fig. 1. Black soldier fly larvae (a) and the climbing perch (b)

Table 1. Proximate contents of the experimental feeds T1-T3 (% dry matter)

Feed	T1	T2	T3
Crude protein	32.5	30.0	25.0
Crude fat	6.7	7.6	8.9
Crude ash	11.1	9.5	7.3
Crude starch	22.8	28.0	27.7

Table 2. Growth performance of the climbing perch given the experimental feeds T1, T2 and T3

Growth index	T1	T2	T3
Total length at stocking (mm)*	46.3 ± 7.4	46.3 ± 7.4	46.3 ± 7.4
Total length at harvest (mm)**	159.9 ± 13.6	164.1 ± 11.7	160.9 ± 12.8
Body weight at stocking (g)*	2.2 ± 1.2	2.2 ± 1.2	2.2 ± 1.2
Body weight at harvest (g) **	85.1 ± 25.5	92.0 ± 22.3	83.5 ± 22.2
Survival rate (%)***	82.2 ± 2.0	81.7 ± 9.1	81.7 ± 2.9
Feed Conversion Ratio***	3.4 ± 0.2	3.2 ± 0.4	3.2 ± 0.1

Values are the mean ± standard deviation, *n = 180, **n = 60, ***n = 3

Table 3. Proximate contents of fish body reared by the feeds T1, T2 and T3 (moisture, crude protein, crude ash), and indices of protein assimilation (protein efficiency ratio, protein retention)

Contents	At stocking	At harvest		
		T1	T2	T3
Moisture	77.6 ± 0.2 (6)	63.4 ± 1.5 (18)	62.8 ± 1.0 (18)	63.1 ± 0.8 (18)
Crude protein	14.9 ± 0.3 (6)	18.1 ± 0.3 (6)	17.8 ± 0.8 (6)	17.2 ± 0.6 (6)
Crude fat	2.8 ± 0.1 (6)	12.0 ± 0.9 ^{a} (12)	12.3 ± 1.7 ^{a} (12)	14.4 ± 2.2 ^{b} (12)
Crude ash	3.8 ± 0.6 (6)	5.4 ± 1.0 ^{a} (18)	5.7 ± 0.7 ^{a} (18)	4.1 ± 0.8 ^{b} (18)
Protein assimilation indices		T1	T2	T3
Protein efficiency ratio		**0.9 ± 0.1** ^{a} **(3)**	**1.1 ± 0.1** ^{a} **(3)**	**1.3 ± 0.1** ^{b} **(3)**
Protein retention		**16.4 ± 0.7** ^{a} **(3)**	**18.8 ± 2.3** ^{a,b} **(3)**	**21.9 ± 0.8** ^{b} **(3)**

Notes:
Values are the mean ± standard deviation.
Numbers in parentheses are the number of samples.
Different capital letters indicate significant difference (Tukey's HSD test, $p < 0.05$).

in the T1 (Table 2). In addition, the protein efficiency ratio (PER) was significantly higher in fish given the feed T3 than that of fish given the T1/T2, and the protein retention (PR) was higher in fish given the T3 than that of fish given the T1 (Table 3). These results strongly indicate that the protein in BSF larvae is more assimilative for the climbing perch than that in FM.

The above results show that BSF larvae are a promising feed protein source for climbing perch aquaculture and have the potential to reduce dependency on FM, leading to feed cost reduction. Better protein assimilation of BSF larvae by the climbing perch is probably attributable to the feeding habit of the climbing perch, which is an insectivore. Therefore, the efficacy of BSF larvae on other fishes with different feeding habits should be validated separately.

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

Biological information contributing to resource conservation of the important Laotian food fish *Pa keo*

Pa keo (*Clupeichthys aesarnensis*), a small-sized clupeid fish (Fig. 1) that is widely distributed in the Indochinese Peninsula, is an important food fish over the area, including Laos. It is captured in great quantities mainly from large-scale man-made reservoirs such as the Nam Ngum Reservoir in Laos, and consumed as dried/fermented fish. In the recent decade, overexploitation/stock decline of this species as a food resource has become a matter of great concern, hence resource management is required.

Based on the above background, we attempted to investigate the population dynamics of *Pa keo* in Nam Ngum Reservoir by clarifying several biological features (e.g., the age in days and reproduction) in order to propose applicable resource management approaches for the species.

To determine the age in days by individual specimen, we analyzed the daily increments in the otolith (sagitta) (Fig. 1). On the basis of age information by individual specimen, we estimated the hatch month of each specimen and confirmed the year-round breeding of the species in the reservoir (Fig. 2). The relationship between gonadosomatic index [GSI = (weight of ovary/testis) / body weight × 100] and standard length (SL) indicated that the minimum maturation size was 28-30 mm SL for both females and males (Fig. 3), and the growth pattern was regressed by the von Bertalanffy growth curve [$Lt = 44.76 \cdot (1\text{-exp}(-0.01 \cdot t))$, $R^2 = 0.89$, n = 486] (Fig. 4a). Based on this growth model, the theoretical maximum size of *Pa keo* population in the reservoir was estimated to be ca. 45 mm SL, and ages reaching first maturation (28-30 mm SL, Fig. 3) were estimated to be over 100 days old (Fig. 4a). In the analyzed specimens (n = 486), the specimens of 30-40 mm SL were the greatest in number followed by the ones of 20-30 mm SL (Fig. 4b). Although the maximum size of the species was reportedly over 70 mm SL, a limited number of specimens were over 50 mm SL in this study (0.4% of analyzed specimens). Considering this size distribution and the theoretical maximum size observed in this study (Fig. 4), the individual maximum size in this population was considered to become smaller over time.

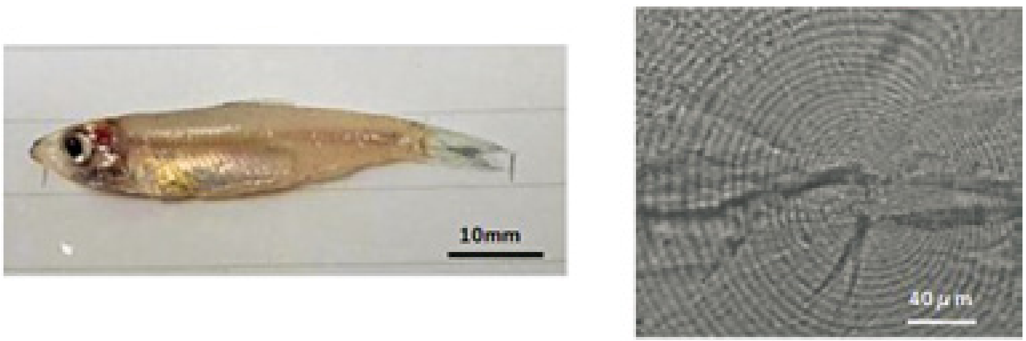

Fig. 1. Adult *Pa keo* (40 mm SL) (left) and daily increments in otolith (right)

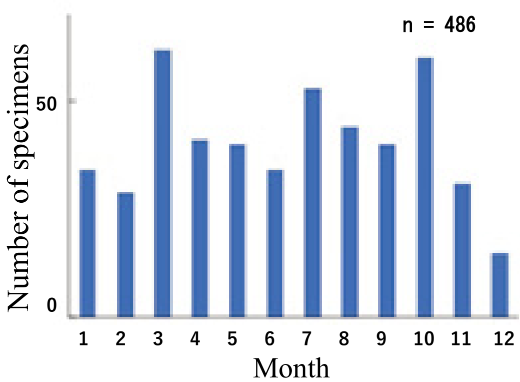

Fig. 2. Hatch month distribution

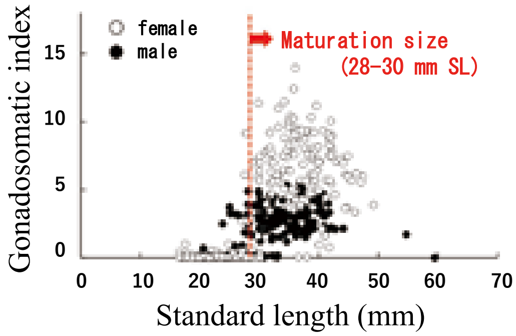

Fig. 3. Relationship between SL and GSI

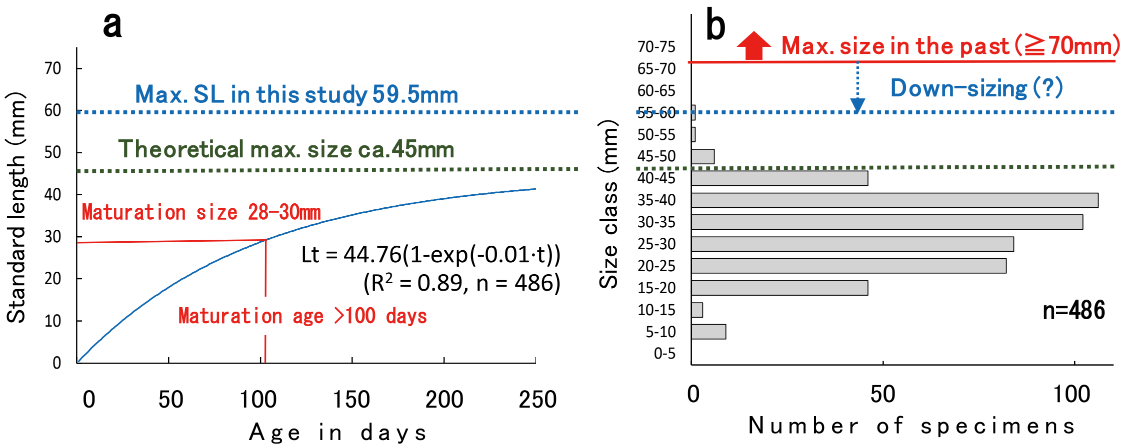

Fig. 4. Growth model of *Pa keo* population (a) and size frequency distribution (b)

This down-sizing is considered the "evolutionary down-sizing" caused by consecutive catches of larger specimens and/or over-exploitation in the population, suggesting the necessity of *Pa keo* resource management in Nam Ngum Reservoir.

Since *Pa keo* breeds year-round (Fig. 2), setting up a "non-fishing area" is considered a more efficient manner of resource conservation than setting up a "non-fishing period" from the aspect of conserving the breeding population. In addition, in order to control the increasing fishing effort (i.e., number of fishermen and fishing gears), implementation of a fishing license system and/or a fishing restriction/gear control system should be considered.

(S. Morioka, J. Marui)

TOPIC 7

Utilization of poultry by-product meal as an effective alternative to fish meal in aquaculture feed for milkfish *Chanos chanos*

In many cases, aquaculture feeds depend on fish-meal and fish-oil as their protein and fat sources, respectively. They are products of capture fisheries. The recent stagnation in capture fisheries production due to limitations on fisheries resources, has caused a steep rise in the price of fish-meal/fish-oil, and eventually aquaculture feeds, to fulfill increasing demands for aquaculture products. In the case of Philippine milkfish cage culture, feed cost covers three quarters of the total expenses. Thus, reducing feed costs is essential to improve profitability of aquaculture management. We explored possible alternative protein sources that are cheap, effective, and available on site to reduce dependency on fish-meal/fish-oil in producing fish feeds. In the Philippines, we developed low fish-meal feeds for milkfish by utilizing poultry by-products (PBP), which are wastes that are collected after removing the edible parts from poultry.

Replacing the fish-meal with PBP, the experimental feeds were formulated to contain 27% crude protein, 10% crude fat, and 31% crude starch (Table 1). Milkfish juveniles (≈50g) were fed with experimental feeds and grown to market size (≈300g). Among experimental feeds, there were no significant differences in the growth parameters such as weight gain, specific growth rate, feed conversion ratio, and survival rate of the milkfish (one-way ANOVA and Fisher's PLSD) (Fig. 2A). The plasma components (phospholipids, triacylglycerol, and total cholesterol) of the harvested fish were not significantly affected by the experimental feeds (Fig. 2B). The proximate compositions of dorsal muscle from harvested fish, such as crude protein, crude fat, ash, and moisture, were not significantly different from

Fig. 1. Harvested milkfish (*Chanos chanos*) 29.8 cm fork length

Table 1. Composition of the experimental feeds

	CTF	LPF	HPF
Poultry by-product	0%	8%	12%
Fish meal	20%	10% (−50%)	5% (−75%)
Fish oil	4.45%	4.00% (−10%)	3.78% (−15%)

The parenthesis indicates reduction rate of fish meal and fish oil.
CTF: Control feed, LPF: Low poultry by-product feed, HPF: High poultry by-product feed

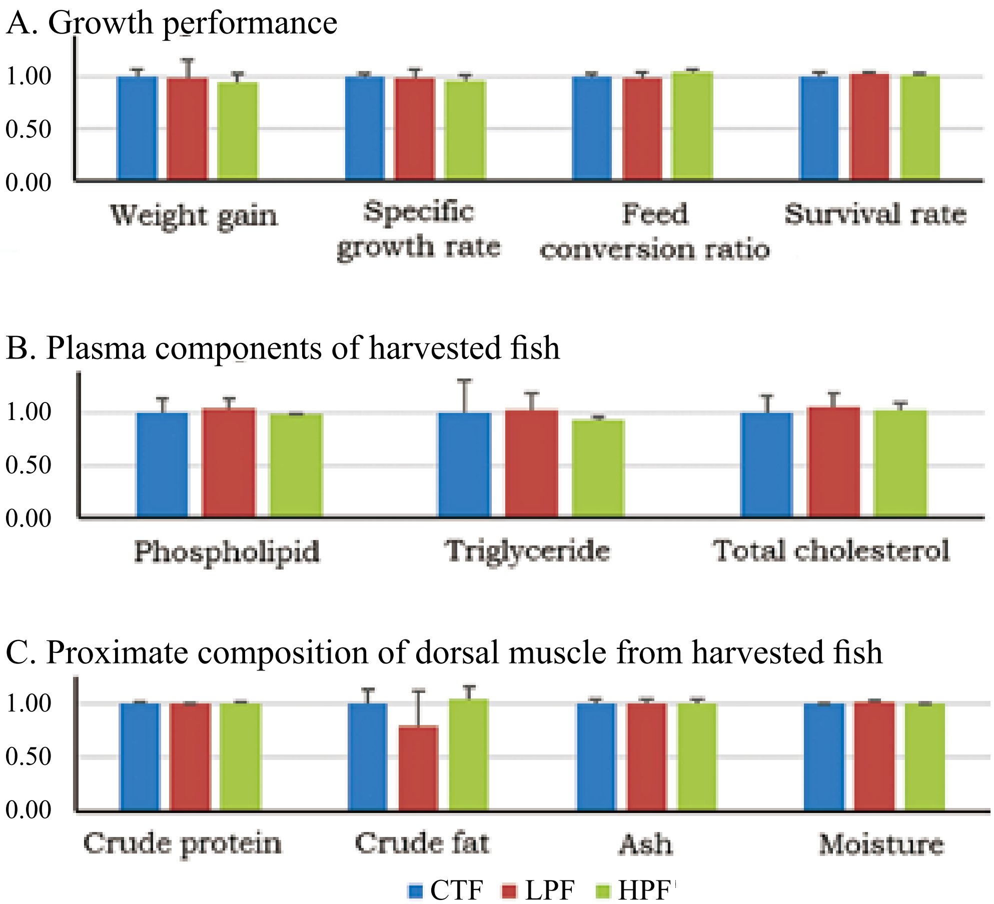

Fig. 2. Growth performance and quality of harvested milkfish fed with experimental feeds.
Relative values when each value at CTF = 1.00. Initial number of experimental fish: 1483±1, Culture period: 84 days, Average water temperature: 28.3±1.2°C
A. Growth performance, B. Plasma components of harvested fish (N=10x2 replicates),
C. Proximate composition of dorsal muscle from harvested fish (N=15x2 replicates)

each other's (Fig. 2C), and so were those of the whole body and the liver. Regarding the taste of the harvested fish, 48 participants (common people and researchers) did not recognize the differences in terms of smell, taste, and textures of the fish, and whether which of the experimental feeds were fed. These results indicate that the low fish-meal/fish-oil feeds developed using PBP have equivalent effect as commercial feeds on the growth of the juvenile milkfish and the quality of the harvested fish. As a result, we can reduce fish-meal by 75% and fish-oil by 15% if we mix 12% PBP as feed raw material for milkfish aquaculture.

We have also evaluated the versatility of the developed PBP feeds, and noted that it could be utilized effectively not only to milkfish but also to other aquaculture fishes. However, as the proximate compositions of PBP differ a lot, the compound ratio of PBP for the feeds should be adjusted accordingly.

(T. Sugita [National Research Institute of Fisheries and Environment of Inland Sea], A. B. Gavile [Aquaculture Department, Southeast Asian Fisheries Development Center (SEAFDEC/AQD), Philippines], J. G. Sumbing [SEAFDEC/AQD])

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 the FY 2019 are briefly described below. For a country-level case study in Madagascar, the estimation of micronutrient deficiency based on household survey data collected by the JIRCAS team revealed the stark reality of a rural population experiencing greater micronutrient deficiency than previously estimated based on national-level data estimates. The analyses further indicated significant seasonality in nutrition intake and diversity among rural households, highlighting the importance of designing context-specific, agriculture-nutrition interventions. The results were shared widely among international experts through publication and presentation at events including the TICAD 7 side event. In turn, an ex-ante impact assessment study was performed to evaluate the financial impact of technologies that JIRCAS typically develop. For example, in the context of the soybean sector in Brazil, a comparison of the scenario where soybean rust-resistant varieties were introduced against the scenario where only conventional varieties were grown, indicated that the adoption of new varieties could result in a significant financial gain at country-level by moderating yield loss due to damages otherwise caused by the disease, while saving expenditure on fungicides almost by half.

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 FY 2019, President Masa Iwanaga held several bilateral talks with VIPs, including the president of Niger, the director general of FAO, the president of African Development Bank, and the minister of agriculture of Madagascar, during the 7th Tokyo International Conference on African Development (TICAD 7) to exchange opinions over emerging agendas for agricultural research and potential areas of collaboration. 2019 was also the year in which Japan hosted the G20 Summit, and President Iwanaga chaired a series of events for G20 MACS (Meeting of Agricultural Chief Scientists) to set global research agendas for the coming decades. JIRCAS also collected information on emerging global agendas on agriculture, forestry and fisheries, by assigning scientists to its liaison offices in Southeast Asia (Thailand) and Africa (Kenya – temporarily suspended), as well as seconding its researchers to international research organizations such as the International Renewable Energy Agency (IRENA) and the CGIAR. The collected information through Program D activities has been regularly updated on its homepage. In March 2020. a new project called 'Pick Up' was launched to present a series of timely articles, with links to the latest news on global topics such as climate change, impacts of COVID-19 on food and nutrition security, and JIRCAS research activities. The team is currently (as of June 2020) working to launch the JIRCAS dashboard as a more effective tool to disseminate information.

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) with the aim of developing superior breeding materials; 2) the evaluation of functional components of a non-conventional yeast, 3) the comparative genetic analysis of shrimps and locusts to develop gene discovery systems, 4) the investigation of shrimp reproductive mechanisms to enhance efficiency and sustainability of seed production, and 5) the improvement of environmental adaptability of tropical fruit species, including mango and passion fruit. During FY 2019, in relation to project 1), additional resources were mobilized to support the Government of Japan's efforts to register a domestic rice variety to produce 'Awamori,' an alcoholic beverage indigenous and unique to Okinawa. All awamori made today is from indica rice imported from Thailand as local production is not sufficient to meet domestic demand. JIRCAS has identified the rice strain, YTH183, which was jointly developed by JIRCAS-IRRI, as a potential ingredient for Awamori made from domestically grown rice due to its high-yielding potential in Okinawa compared to Japanese varieties. JIRCAS has begun seed multiplication and dissemination for trials by local farmers, and has implemented experiments to collect evidence to expedite the process of registering YTH183 into a new variety.

TOPIC 1

Use of RNA interference to suppress gene expression of vitellogenesis-inhibiting hormone in the whiteleg shrimp, *Litopenaeus vannamei*

The shrimp culture industry continues to expand worldwide, and now boasts a production scale of over 5 million tons per year and market volume of nearly 30 billion U.S. dollars (FAO, 2019). In commercial shrimp hatcheries, eyestalk ablation is routinely performed because this procedure removes the source of vitellogenesis-inhibiting hormone (VIH) and allows ovarian maturation to proceed. However, it is currently viewed in the aquaculture industry that it is essential to develop a technology that could replace eyestalk ablation, with the aim of making seed production more efficient and animal-friendly. In order to develop a new maturation promoting technology that can replace eyestalk ablation, RNA interference may be used to suppress *VIH* gene expression, and thus decrease the synthesis of endogenous VIH.

In *Litopenaeus vannamei*, seven peptides (sinus gland peptides: SGP-A to -G) have been previously identified from the sinus glands in the eyestalks. Among these peptides, six peptides (A, B, C, E, F, G) have been demonstrated to possess "VIH" activity; VIH suppresses the synthesis of egg yolk protein. Against this background, we cloned full-length cDNAs from the eyestalks, and also elucidated the gene structure of these five *VIHs* (Fig. 1). Moreover, using this genetic information, we established a quantitative real-time PCR system for multiple *VIHs* in *L. vannamei*, and the expression level of each *VIH* in the eyestalk was determined in relation to molting and eyestalk ablation in separate individuals. For purposes of development of new techniques for the artificial control of ovarian

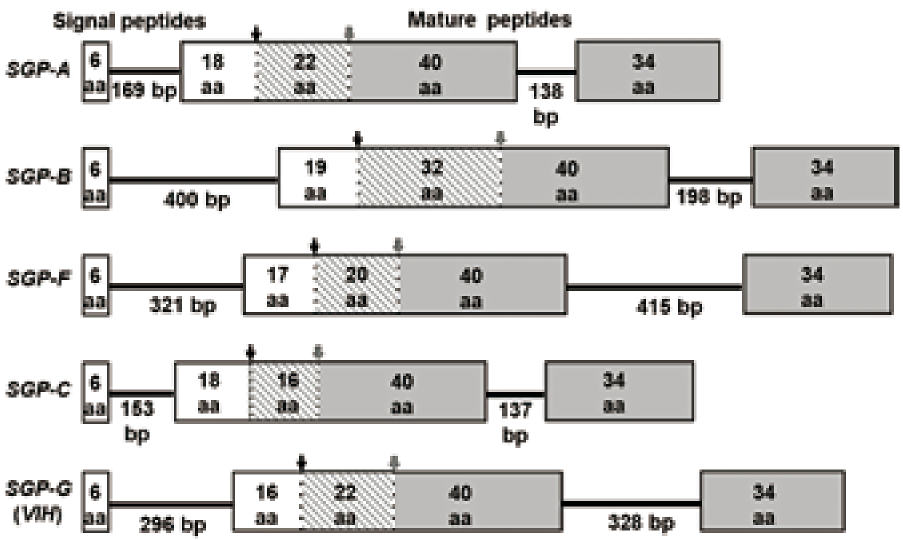

Fig. 1. Schematic diagram of gene structure for *SGPs* having vitellogenesis-inhibiting hormone activity
Exons are indicated as boxes with numbers of amino acid residues (aa), and introns are indicated as bold lines with numbers of base pairs (bp). Reproduced from Kang et al., 2018 with permission from *Fisheries Science*.

maturation, we utilized RNA interference to suppress *VIH* gene expression. Firstly, double-stranded RNA (dsRNA) for targeting the most abundant *VIH* gene in *L. vannamei* (*SGP-G*) was artificially synthesized. Next, it was injected into female adults (50 - 70 g body weight) at a final concentration of 3 µg per g body weight. As a result, *VIH* gene expression was significantly decreased both 10 and 20 days after VIH-dsRNA injection; however, there were no observed significant differences in the other groups (Fig. 2). *VIH* expression levels could be suppressed to less than 10% of original levels up to 20 days with only a single injection of VIH-dsRNA. Hence, using RNA interference, it has become possible to artificially suppress *VIH* gene expression.

Furthermore, it is possible that by simultaneously administering dsRNA complementary to not only the major *VIH* (*SGP-G*), but also to dsRNAs complementary to several other *VIH* genes, it may be possible to achieve even greater suppression of VIH action. In subsequent applications, we suggest that this technique may be applicable to other penaeid shrimp species that harbor similar amino acid sequences for VIH. We intend to continue this research in order to make possible the establishment of a new shrimp-friendly seed production technology and contribute to the sustainable development of the shrimp aquaculture industry.

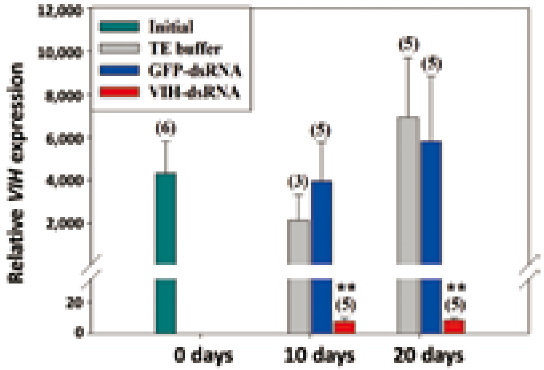

Fig. 2. Suppression of *SGP-G* gene expression following VIH-dsRNA injection
Groups are indicated as follows. Initial: non-treatment; TE buffer: shrimp injected with TE buffer as a vehicle control; GFP-dsRNA: shrimp injected with dsRNA for green fluorescent protein (GFP); and VIH-dsRNA: shrimp injected with VIH-dsRNA. Numbers in parentheses above the bars indicate the number of individuals analyzed. Reproduced from Kang et al., 2019 with permission from *Aquaculture*.

References:

FAO. 2019. *FAO yearbook. Fishery and Aquaculture Statistics 2017/FAO annuaire*. (http://www.fao.org/documents/card/en/c/ca5495t)

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(B.J. Kang, M.N. Wilder)

TOPIC 2

Genetic diversity and characteristics of mango genetic resources in Japan

Mango (*Mangifera indica* L.) is one of the major tropical fruits produced and consumed in Japan. Commercial production of mango in the country started in the 1980s mainly in the southwestern region, and substantially by monoculture of the 'Irwin' variety (occupies >90% of production in Japan). Recently, attention has been focused on mango as one of the potential crops for climate change adjustment, and as a premium fruit that can be sold at a high price in commercial markets in Japan. To promote the use of underutilized genetic resources for breeding and/or direct domestic production, assessment of genetic diversity is essential. In this study, we analyzed 120 mango genetic resources conserved at JIRCAS and Okinawa Prefectural Agricultural Research Center, covering almost all mango cultivars in Japan using 46 polymorphic simple sequence repeat (SSR) markers for cultivar identification, genetic relatedness, and genetic diversity.

The 120 mango accessions examined in this study were clearly distinguished into 83 genotypes (cultivars) excluding synonymous and identical accessions by the SSR markers. These 83 cultivars were considered to be representative mango genetic resources possessed in Japan taking their introduction background into account.

Principal coordinate analysis (PCoA), one of the multivariate analyses based on SSR data, indicated that accessions from India had a close relationship with accessions from the USA, while accessions from Thailand, Taiwan, Philippines, and Vietnam seemed to be genetically separate (Fig. 1). These groupings appear to correspond to the previously defined Indian and Southeast Asian

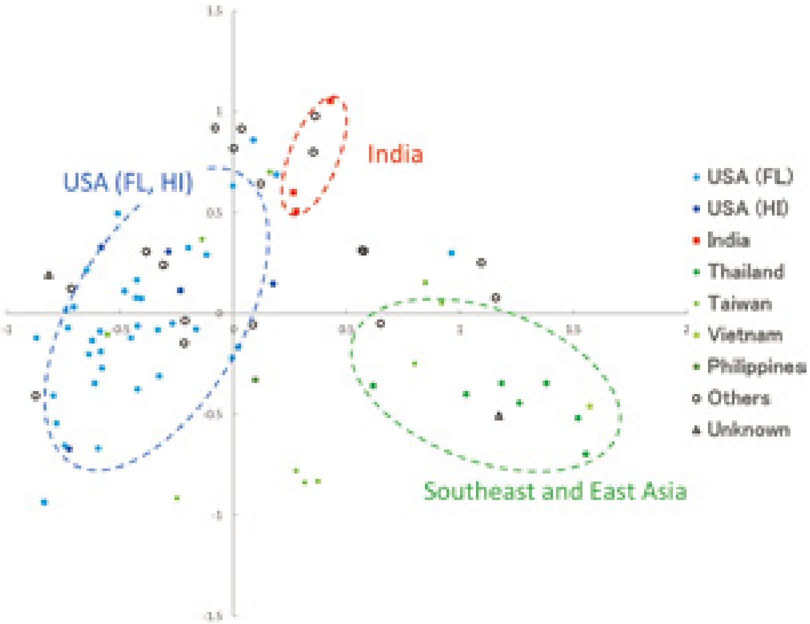

Fig. 1. A scatter plot showing the result of PCoA based on SSR marker analysis for 83 accessions of mango genetic resources in Japan
Three groups based on the origins were found (dotted circles).

Fig. 2. Mango genetic resources conserved at JIRCAS (left), a screenshot of the top page of the "JIRCAS Mango Genetic Resources Site" (center), and a linked page on the website, showing important information on mango variety characteristics (right).

types, and suggest that the Florida accessions, which originated from hybrids between those two types, are more closely related to the Indian type.

The accessions that we examined cover almost all mango cultivars in Japan, therefore their genetic information will pave the way to the use of genetic resources for breeding and/or direct domestic production in Japan. In addition, the accessions used in this study, mainly selected and established in Florida, USA, and disseminated to major production countries/areas, have been considered, reflecting the genetic diversity as representative of major cultivars in the world. Therefore, the SSR marker and genotype information in this study are possibly useful for assessing genetic diversity in other countries and areas of mango production.

Information on variety characteristics of 62 cultivars conserved with successful flowering and bearing fruits at JIRCAS-TARF (Ishigaki, Okinawa) were summarized and published on the website titled "JIRCAS Mango Genetic Resources Site" (https://www.jircas.go.jp/ja/database/mango/mango-top) (Fig. 2). This website describes the diversity of mango varieties and characteristics such as flowering period, harvesting time, and fruit quality using the data obtained during the 2010-2011 cultivation period at JIRCAS-TARF.

(S. Yamanaka, T. Ogata, H. Takagi, N. Kozai [Kagoshima University], M. Matsumura [Okinawa Prefectural Agricultural Research Center (OPARC)], Y. Onoue-Makishi [OPARC], N. Urasaki [OPARC], M. Shoda [OPARC], K. Nashima [Nihon University], F. Hosaka [Institute of Fruit Tree and Tree Science, NARO (NIFTS)]), T. Yamamoto [NARO (NIFTS)])

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 developing regions. Current programs are described in detail below. (Note: In FY 2019, some of the invitation programs scheduled for March 2020 were suspended due to the COVID-19 pandemic.)

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. Also, 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 policymaking and project design at the administrative level, thereby contributing to deeper mutual understanding and international collaboration. Twenty-one (21) visits to JIRCAS were made during FY 2019 under the Administrative Invitation Program. Invited administrators and their home institutions are listed below.

Administrative Invitations, FY 2019

No.	Name	Institution/Organization	Duration
1	Zhao Minjuan	College of Economics and Management, Northwest Agricultural & Forestry University, PR China	Aug. 19 - 24, 2019
2	Luan Guangzhong	College of Food Science and Engeneering, Northwest Agricultural & Forestry University, PR China	Aug. 19 - 24, 2019
3	Nteranya Sanginga*	International Institute of Tropical Agriculture (IITA), Nigeria	Aug. 23 - Sep. 01, 2019
4	Marco Wopereis*	World Vegetable Center, Taiwan	Aug. 25 - Sep. 02, 2019
5	Tatsuji Koizumi	Agro-food Trade and Markets Division, Trade and Agriculture Directorate, OECD, France	Aug. 30 - Sep. 08, 2019
6	Kyaw Ngwe	Department of Soil and Water Science, Yezin Agricultural University, Myanmar	Oct. 06 - 16, 2019
7	Jianmin Li*	Department of Farmland Enhancement, Ministry of Agriculture and Rural Affairs of the People's Republic of China, PR China	Oct. 16 - 20, 2019
8	Zixiong Chen*	Department of Farmland Enhancement, Ministry of Agriculture and Rural Affairs of the People's Republic of China, PR China	Oct. 16 - 20, 2019
9	Xiaoyu Xiao*	Department of Agriculture and Rural Affairs of Sichuan province in China, PR China	Oct. 16 - 20, 2019
10	Bin Zhou*	Department of Comprehensive Agricultural Development of Ningxia in China, PR China	Oct. 16 - 20, 2019
11	Changbin Yin*	Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, PR China	Oct. 16 - 24, 2019
12	Chanthakhone Boualaphanh	Rice Research Center, National Agiculture and Forestry Research Institute (NAFRI), Lao PDR	Oct. 20 - 26, 2019

Administrative Invitations, FY 2019			
No.	Name	Institution/Organization	Duration
13	Pham Xuan Hoi*	Agricultural Genetics Institute (AGI), Vietnam	Oct. 31 - Nov. 10, 2019
14	Nguyen Duy Phuong*	Molecular Pathology Department, Agricultural Genetics Institute (AGI), Vietnam	Oct. 31 - Nov. 10, 2019
15	Dang Cao Cuong*	Crops Research Institute, Thai Binh Seed Corporation, Vietnam	Oct. 31 - Nov. 10, 2019
16	Frédéric Baudron	International Maize and Wheat Improvement Center (CIMMYT), Zimbabwe	Nov. 22 - Dec. 01, 2019
17	Claudia Vieira Godoy	Brazilian Agricultural Research Corporation, Soybean (Embrapa-soja), Brazil	Nov. 23 - 30, 2019
18	Jingyuan Xia	International Plant Protection Convention, Food and Agricultural Organization of the United Nations, Italy	Nov. 24 - 28, 2019
19	Ulrich Kuhlmann	Center of Agriculture and Bioscience International (CABI), Switzerland	Nov. 24 - 30, 2019
20	Atinkut Mezgebu Wubneh	Bureau of Agriculture and Rural Development (BoARD), The Government of National State of Tigray, Ethiopia	Jan. 18 - 27, 2020
21	Md. Ismail Hossain	Agricultural Statistics Division, Bangladesh Rice Research Institute (BRRI), Bangladesh	Feb. 02 - 08, 2020

*own expense

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 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. Fifty-two (52) researchers were invited under this program during FY 2019. Invited researchers, their affiliated research organizations, and their research activities are summarized below.

Counterpart Researcher Invitations, FY2019

No.	Name	Institution/Organization	Research Theme	Duration
1	Pattsarun Cheawchanlertfa*	Enzyme Technology Laboratory, School of Bioresources and Technology, King Mongkut's University of Technology, Thonburi (KMUTT), Thailand	Characterization for halophilic anaerobic bacteria with cellulose degradation ability	Apr. 09 - Sep. 30, 2019
2	Nithya Rajan*	Department of Soil and Crop Science, Texas A&M University, USA	Intensification of research collaboration on biological nitrification inhibition of sorghum	May 12 - Jul. 31, 2019
3	Daniel Tymko Burke	National University of Ireland Galway, Ireland	Life cycle assessment (LCA) method to evaluate potential greenhouse gas (GHG) mitigation technologies	May 15 - Aug. 10, 2019
4	Jules Rafalimanantsoa	National Nutrition Office (ONN), Madagascar	Breakthrough in Nutrient Use Efficiency for Rice by Genetic Improvement and Fertility Sensing Techniques in Africa	Jun. 03 - 14, 2019
5	Harisoa Sahondra Andriamanana Razafimbelonaina	Department of Research Development (DRD), The National Center for Applied Research For Rural Development (FOFIFA), Madagascar	Breakthrough in Nutrient Use Efficiency for Rice by Genetic Improvement and Fertility Sensing Techniques in Africa	Jun. 03 - 14, 2019
6	Hobimiarantsoa Nantenaina Rakotonindrina	Laboratoire de Radioisotopes, University of Antananarivo (LRI), Madagascar	Breakthrough in Nutrient Use Efficiency for Rice by Genetic Improvement and Fertility Sensing Techniques in Africa	Jun. 30 - Jul. 27, 2019
7	Marie-Paule Mbolanirina Razafimanantsoa	Laboratoire de Radioisotopes, University of Antananarivo (LRI), Madagascar	Breakthrough in Nutrient Use Efficiency for Rice by Genetic Improvement and Fertility Sensing Techniques in Africa	Jun. 30 - Jul. 16, 2019
8	Njato Michaël 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	Aug. 06 - Sep. 14, 2019
9	Haja Bruce Andrianary	Laboratoire de Radioisotopes, University of Antananarivo (LRI), Madagascar	Breakthrough in Nutrient Use Efficiency for Rice by Genetic Improvement and Fertility Sensing Techniques in Africa	Aug. 06 - Sep. 14, 2019

Counterpart Researcher Invitations, FY2019				
No.	Name	Institution/Organization	Research Theme	Duration
10	Viviane Raharinivo	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. 06 - Sep. 14, 2019
11	Lu Qiu	College of Economics and Management, Northwest Agricultural & Forestry University, PR China	Elucidation of value in the current production and distribution of coarse cereal	Aug. 19 - 24, 2019
12	Lanlan Liu*	Chunhua Lanqiaohua Agricultural Technology Co.Ltd., PR China	Elucidation of value in the current production and distribution of coarse cereal	Aug. 19 - 24, 2019
13	Koudougou Amos	Institute of Environment and Agricultural Research, Burkina Faso	Project on establishment of the model for fertilizing cultivation promotion using Burkina Faso phosphate rock	Aug. 19 - 29, 2019
14	Sali Atanga Ndindeng	Grain quality & Post-harvest Technology, Africa Rice Center, Côte d'Ivoire	Flagship project 2, CGIAR Research Program, Rice agri-food systems (CRP RICE FP2)	Aug. 25 - Sep. 12, 2019
15	Gajender	Central Soil Salinity Research Institute (CSSRI), India	Development of sustainable resource management systems in the water-vulnerable areas of India	Sep. 01 - 14, 2019
16	Bhaskar Narjary	Central Soil Salinity Research Institute (CSSRI), India	Development of sustainable resource management systems in the water-vulnerable areas of India	Sep. 01 - 14, 2019
17	Honore Kam	Institute of Environment and Agricultural Research (INERA), Farako-Ba, Burkina Faso	Establishment of the model for fertilizing cultivation promotion using Burkina Faso phosphate rock	Sep. 05 - 22, 2019
18	Salisa Pituk	Khon Kaen Seed Research and Development Center, Development of Agriculture (DOA), Thailand	Development of an integrated pest management system for sugarcane white leaf disease based on the ecology of the vector insects	Sep. 15 - 20, 2019
19	Sangkom Aomaod	Plant Propagation Center No.10, Department of Agricultural Extension (DOAE), Thailand	Development of an integrated pest management system for sugarcane white leaf disease based on the ecology of the vector insects	Sep. 15 - 20, 2019
20	Sumontha Kumhong*	Plant Propagation Center No.10, Department of Agricultural Extension (DOAE), Thailand	Development of an integrated pest management system for sugarcane white leaf disease based on the ecology of the vector insects	Sep. 15 - 20, 2019
21	Khin May Chit Maung	Marine Science Department, Myeik University, Myanmar	Development of technologies for sustainable aquatic production in harmony with tropical ecosystems	Oct. 06 - 19, 2019
22	Swe Swe Mar	Department of Soil and Water Science, Yezin Agricultural University, Myanmar	Climate change measures in agricultural systems - Designing weather index insurance of agricultural products to extreme events	Oct. 06 - 16, 2019

Counterpart Researcher Invitations, FY2019				
No.	Name	Institution/Organization	Research Theme	Duration
23	Kyi Kyi Shwe	Department of Soil and Water Science, Yezin Agricultural University, Myanmar	Climate change measures in agricultural systems - Designing weather index insurance of agricultural products to extreme events	Oct. 06 - 16, 2019
24	Ei Thal Phyu	Marine Science Department, Myeik University, Myanmar	Development of technologies for sustainable aquatic production in harmony with tropical ecosystems	Oct. 06 - 19, 2019
25	Phonenaphet Chanthasone	Aquaculture Unit, Living Aquatic Resources Research Center (LARReC), Lao PDR	Development of technologies for sustainable aquatic production in harmony with tropical ecosystems	Oct. 06 - 19, 2019
26	Phoutsamone Phommachan	Aquaculture Unit, Living Aquatic Resources Research Center (LARReC), Lao PDR	Development of technologies for sustainable aquatic production in harmony with tropical ecosystems	Oct. 06 - 19, 2019
27	Linna Fang*	Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, PR China	Joint laboratory on agricultural development research and Development of evaluation methods of value chain for sustainable rural development rice genotypes	Oct. 16 - 24, 2019
28	Widiyatno	Faculty of Forestry, Gadjah Mada University, Indonesia	Enhancement of productivity using genetic resources in tropical rainforest and development of carbohydrate usage from unutilized biomass in Indonesia	Oct. 20 - Nov. 02, 2019
29	Yi Wang	Yunnan Agricultural University, PR China	Development of control technologies for blast races using differential varieties for rice resistance genes	Oct. 21 - Dec. 22, 2019
30	Nguyen Thi Oanh*	Agricultural Genetics Institute, Vietnam	Genetic improvement and development of breeding materials for blast resistance using a differential system	Oct. 28 - Nov. 28, 2019
31	Nguyen Thi Nhai*	Agricultural Genetics Institute, Vietnam	Genetic improvement and development of breeding materials for blast resistance using a differential system	Oct. 28 - Nov. 28, 2019
32	Nguyen Pham Hung*	Department of Science and Technology, Thai Binh Seed Corporation, Vietnam	Application of biotechnology for rice breeding especially in genome editing and marker-assisted selection	Oct. 31 - Nov. 10, 2019
33	Zhou Lin	Institute of Food and Nutrition Development, Ministry of Agriculture and Rural Affairs of the People's Republic of China, PR China	Clarification of consumer needs and choice behavior of staple grain	Nov. 11 - 16, 2019
34	Yin Yin Nwe	Cooperative Research & Extension, Palau Community College, Palau	Development of sustainable resources management system in Palau	Nov. 13 - 27, 2019

Counterpart Researcher Invitations, FY2019				
No.	Name	Institution/Organization	Research Theme	Duration
35	Wan Norhana binti MD Noordin	Innovation, Promotion and Commercialization Unit, Fisheries Research Institute Batu Maung, Malaysia	Annual Meeting on “Development of technologies for sustainable aquatic production in harmony with tropical ecosystems” and Workshop	Dec. 01 - 06, 2019
36	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” and Workshop	Dec. 01 - 06, 2019
37	Aung Naing Oo	Department of Fisheries Myanmar, Myanmar	Annual Meeting on “Development of technologies for sustainable aquatic production in harmony with tropical ecosystems”	Dec. 01 - 06, 2019
38	Nyo Nyo Tun	Marine Science Department, Myeik University, Myanmar	Annual Meeting on “Development of technologies for sustainable aquatic production in harmony with tropical ecosystems”	Dec. 01 - 06, 2019
39	Dusit Aue-Umneoy	King Mongkut’s Institute of Technology Ladkrabang, Thailand	Annual Meeting on “Development of technologies for sustainable aquatic production in harmony with tropical ecosystems” and Workshop	Dec. 01 - 06, 2019
40	Jon A. Altamirano	Farming Systems and Aquatic Ecology Section, Research Division, The Southeast Asian Fisheries Development Center / Aquaculture Department, Philippines	Annual Meeting on “Development of technologies for sustainable aquatic production in harmony with tropical ecosystems” and Workshop	Dec. 01 - 06, 2019
41	Roger Edward P. Mamauag	Technology Verification and Extension Division, The Southeast Asian Fisheries Development Center / Aquaculture Department, Philippines	Annual Meeting on “Development of technologies for sustainable aquatic production in harmony with tropical ecosystems” and Workshop	Dec. 01 - 06, 2019
42	Kaviphone Phouthavong	Living Aquatic Resources Research Center (LARReC), Lao PDR	Annual Meeting on “Development of technologies for sustainable aquatic production in harmony with tropical ecosystems” and Workshop	Dec. 01 - 06, 2019
43	Aloun Khounthongbang	Aquatic Animal Production Unit, Living Aquatic Resources Research Center (LARReC), Lao PDR	Annual Meeting on “Development of technologies for sustainable aquatic production in harmony with tropical ecosystems” and Workshop	Dec. 01 - 06, 2019
44	Anthony Adelbai Jr.	Environmental Quality Protection Board, Palau	Development of Sustainable Resources Management System in Palau	Dec. 08 - 17, 2019
45	Raweewan Chuekittisak	Khon Kaen Field Crops Research Center, Department of Agriculture, Thailand	Development of technologies for the breeding and utilization of promising high-yielding biomass crops in unstable environments	Dec. 21 - 28, 2019

Counterpart Researcher Invitations, FY2019				
No.	Name	Institution/Organization	Research Theme	Duration
46	Kazuki Saito*	Africa Rice Center, Côte d'Ivoire	Flagship Project 3 "Sustainable Farming Systems" related to the CGIAR Research Program on Rice-Based Agri-Food Systems, RICE	Jan. 05, 2020 - Jan. 04, 2023 Bouaké, Côte d'Ivoire (0.5 FTE) and Tsukuba, Japan (0.5 FTE)
47	Sabin Basi	Department of Biotechnology, Study of Ancient and New Nepal (SANN) International College, Nepal	Field evaluation of nutrient efficient advanced lines containing *Pup1* and its marker survey in Nepalese rice germplasm	Jan. 20 - Feb.07, 2020
48	Md. Abdullah Aziz	Agricultural Statistics Division, Bangladesh Rice Research Institute (BRRI), Bangladesh	Development and economic evaluation of adaptation measures to extreme weather events in Bangladesh	Feb. 02 - 08, 2020
49	Huynh Van Thao	College of Environment and Natural Resources, Can Tho University, Vietnam	Development of agricultural technologies for reducing greenhouse gas emissions from the Mekong Delta	Feb. 08 - 22, 2020
50	Huynh Cong Khanh	College of Environment and Natural Resources, Can Tho University, Vietnam	Development of agricultural technologies for reducing greenhouse gas emissions from the Mekong Delta	Feb. 08 - 22, 2020
51	Dee Arr de los Santos Paglumotan	Bacolod Office, Sugar Regulatory Administration (SRA), Philippines	Development of sustainable sugarcane cultivation system in the Philippines	Feb. 16 - Mar. 02, 2020
52	Joel Ronario	Luzon Agricultural Research and Extension Center, Sugar Regulatory Administration (SRA), Philippines	Development of sustainable sugarcane cultivation system in the Philippines	Feb. 16 - Mar. 02, 2020

*own expense

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. Fourteen (14) researchers were invited to implement their programs during FY 2019 as listed below.

Project Site Invitations, FY 2019

No.	Name	Institution/Organization	Purpose	Duration
1	Antonio Juan Gerardo Ivancovich	National University of Northwestern Province of Buenos Aires (UNNOBA), Pergamino, Argentina	Annual Meeting of the "Development of breeding materials and varieties of soybean resistant to Asian soybean rust and Cercospora leaf blight" project (in Londrina)	Sep. 09 - 13, 2019
2	Miguel Lavilla	National University of Northwestern Province of Buenos Aires (UNNOBA), Pergamino, Argentina	Annual Meeting of the "Development of breeding materials and varieties of soybean resistant to Asian soybean rust and Cercospora leaf blight" project (in Londrina)	Sep. 09 - 13, 2019
3	Adrian Dario De Lucia	Estación Experimental Agropecuaria Cerro Azul, Instituto Nacional de Tecnologia Agropecuaria (INTA-EEA Cerro Azul), Argentina	Annual Meeting of the "Development of breeding materials and varieties of soybean resistant to Asian soybean rust and Cercospora leaf blight" project (in Londrina)	Sep. 09 - 13, 2019
4	Julio César García Rodríguez	Las Huastecas Experimental Station, National Institute of Forestry, Agricultural, and Livestock Research (INIFAP), Mexico	Annual Meeting of the "Development of breeding materials and varieties of soybean resistant to Asian soybean rust and Cercospora leaf blight" project (in Londrina)	Sep. 09 - 14, 2019
5	Monica Isabel Heck	Annual Crops Department, Estación Experimental Agropecuaria-Cerro Azul, Instituto Nacional de Tecnologia Agropecuaria (INTA-EEA Cerro Azul), Argentina	Annual Meeting of the "Development of breeding materials and varieties of soybean resistant to Asian soybean rust and Cercospora leaf blight" project (in Londrina)	Sep. 10 - 13, 2019
6	Nathalia Sarahi Bobadilla Gimenez	Instituto Paraguayo de Tecnología Agraria (IPTA-CICM), Paraguay	Annual Meeting of the "Development of breeding materials and varieties of soybean resistant to Asian soybean rust and Cercospora leaf blight" project (in Londrina)	Sep. 10 - 13, 2019
7	Silvina Stewart	Instituto Nacional de Investigacion Agropecuaria (INIA) - La Estanzuela, Uruguay	Annual Meeting of the "Development of breeding materials and varieties of soybean resistant to Asian soybean rust and Cercospora leaf blight" project (in Londrina)	Sep. 10 - 13, 2019
8	Jhon Larzabal	Instituto Nacional de Investigacion Agropecuaria (INIA) - La Estanzuela, Uruguay	Annual Meeting of the "Development of breeding materials and varieties of soybean resistant to Asian soybean rust and Cercospora leaf blight" project (in Londrina)	Sep. 10 - 13, 2019

Project Site Invitations, FY 2019				
No.	Name	Institution/Organization	Purpose	Duration
9	Anìbal Morel Yurenka	Instituto de Biotecnología Agrícola (INBIO), Paraguay	Annual Meeting of the "Development of breeding materials and varieties of soybean resistant to Asian soybean rust and Cercospora leaf blight" project (in Londrina)	Sep. 10 - 18, 2019
10	Aris Hairmansis	Indonesian Center for Rice Research (ICRR), Indonesia	Joint Annual Meeting of the "Blast Research Network for Stable Rice Production" and "Environmental Stress-Tolerant Crops" project (in Nueva Ecija)	Sep. 22 - 27, 2019
11	Mohammad Ashik Iqbal Khan	Bangladesh Rice Research Institute (BRRI), Bangladesh	Joint Annual Meeting of the "Blast Research Network for Stable Rice Production" and "Environmental Stress-Tolerant Crops" project (in Nueva Ecija)	Sep. 21 - 27, 2019
12	Nguyen Thi Minh Nguyet	Molecular Biology Department, Agricultural Genetics Institute (AGI), Vietnam	Joint Annual Meeting of the "Blast Research Network for Stable Rice Production" and "Environmental Stress-Tolerant Crops" project (in Nueva Ecija)	Sep. 21 - 27, 2019
13	Gebreyohannes Girmay Woldetensai	Department of Land Resources Management and Environmental Protection, College of Dryland Agriculture and Natural Resources, Mekelle University, Ethiopia	Participation and Output Presentation at "the 7th International Symposium on Soil Organic Matters" (in Adelaide)	Oct. 02 - 09, 2019
14	Pruetthichat Punyawattoe	Plant Protection Research and Development Office, Department of Agriculture, Thailand	Research visit related to the "Feasibility study on the migration of fall armyworm in Asia and the development of management techniques" (in Yangon)	Feb. 18 - 21, 2020

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 research on topics relating to tropical agriculture for a period of one year at the Tropical Agriculture Research Front (TARF, formerly Okinawa Subtropical Station). Since October 1995, a similar program (JIRCAS Visiting Research Fellowship Program at Tsukuba) has been implemented at JIRCAS's Tsukuba premises, aiming to promote collaborative research activities that address various problems confronting countries in developing regions. In FY 2006, these fellowship programs were modified and merged into one. In FY 2019, a total of five (5) researchers were selected and invited to conduct research at JIRCAS HQ in Tsukuba but none in Okinawa (Note: For the Tsukuba-type, three of the five fellows were from the previous year while the remaining two were new invitees. No public call was issued for Okinawa-type in FY 2019).

JIRCAS Visiting Research Fellowship at Tsukuba (October 2019 - September 2020)

No.	Name	Institution/Organization	Research Theme	Duration
1	Xiang Gao	Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, PR China	Functional link between leaf NRA (nitrate reductase activity) and BNI-capacity in sorghum	Oct. 01, 2019 - Sep. 30, 2020
2	Zhumei Du	College of Grassland Science and Technology, China Agricultural University, PR China	Development of preparation techniques of fermented TMR with feed resources in Africa	Oct. 01, 2019 - Sep. 30, 2020
3	Giriraj Kumawat	ICAR-Indian Institute of Soybean Research, India	Identification and function analysis of genes controlling root development in soybean	Oct. 01, 2019 - Sep. 30, 2020
4	Luciano Nobuhiro Aoyagi	Soybean Research Center, Brazilian Agricultural Research Corporation (Embrapa Soybean), Brazil	Characterization of new soybean lines pyramided with resistance genes against Asian soybean rust disease	Oct. 01, 2019 - Sep. 30, 2020
5	Sirilak Baramee	Department of Biology, Faculty of Science, King Mongkut's Institute of Technology Ladkrabang, Thailand	Establishment of biological simultaneous enzyme production and saccharification (BSES) process using *Herbivorax saccincola* A7 and *Clostridium thermocellum*	Oct. 14, 2019 - Sep. 30, 2020

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 the capacity-building of the collaborating research institutions. In FY 2019, 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 Visiting Research Program accepts scientists with excellent research achievements and who belong to domestic and overseas research institutions or universities, to conduct overseas research on agriculture, forestry, and fisheries in tropical or subtropical regions and developing countries. In FY 2019, JIRCAS accepted one visiting researcher from Jilin University, China.

The Government of Japan also 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 postdoctoral and sabbatical fellows in national research institutes throughout Japan according to research theme and prior arrangement with host scientists, for terms of generally one month to three years. Fellowships can be undertaken in any of the ministries, and many fellows are currently working at various NRDAs affiliated with MAFF. The visiting scientists who resided at JIRCAS in FY 2019 are listed below.

Visiting Research (April 2019 to March 2020)

Name	Institution/Organization	Research Theme	Duration
Dequan Liu	College of Plant Science, Jilin University, PR China	Identification and cloning of genes controlling several important agronomic traits genes in soybean	Nov. 29, 2019 - Mar. 31, 2021

JSPS Postdoctoral Fellowship for Overseas Researchers (April 2019 to March 2020)

Name	Institution/Organization	Research Theme	Duration
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
Md Asaduzzaman Prodhan	Department of Primary Industries and Regional Development, Australia	Dissecting the genetic basis of root vigor: applications for improving rice for a changing world	May 12, 2019 - May 11, 2021

Workshops

JIRCAS-CTU Climate Change Project Workshop 2019 "Development of Agricultural Technologies for Reducing Greenhouse Gas Emissions from the Mekong Delta"

On the occasion of the 4th year of the Climate Change Measures Project, JIRCAS and Can Tho University (CTU) jointly organized and held its annual workshop at the university campus in Can Tho City, Vietnam, on September 27, 2019. The aim of the activity was to share the progress/ achievements of each research subject and discuss plans for the final stage of activities for realizing social implementation of mitigation technologies being developed under the collaborative project. There were 35 participants, including scientists from JIRCAS and project counterparts from CTU, Cuu Long Delta Rice Research Institute (CLRRI), and the Institute of Animal Sciences of South Vietnam (IASVN), as well as experts involved in the concurrent JICA Project for Building Capacity for CTU.

Dr. Nguyen Van Cong (Dean of the College of Environment and Natural Resources, CTU) gave a welcome speech, followed by Dr. Satoshi Tobita (Program Director at JIRCAS), who talked about the objectives of the workshop. Dr. Taro Izumi (Sub Project Leader at JIRCAS) then summarized the progress of the collaboration, while Dr. Nguyen Huu Chiem (Project Leader at CTU) provided updates on the state of the project in the Mekong Delta (e.g., trends in market demands with greater preference on high quality rice, African swine fever outbreaks, etc.). A series of sessions proceeded where researchers from Japan and Vietnam presented their research results and plans relevant to GHG-related issues affecting rice paddy, beef cattle, biogas digester, ICT, and life cycle assessment.

Participants were actively engaged during the discussions, and they talked about which activities are necessary to accelerate the incentivization of farmers to adopt GHG mitigation technologies. These technologies include the application of affordable methods to sterilize biogas-digester effluent and use it as paddy fertilizer and the use of ICT devices for agriculture, as well as the verification of economic benefits by the introduction of technologies and the planning of an international symposium for technology dissemination, among others. Drs. Chiem and Tobita wrapped up the workshop.

Group photo of workshop participants at the main building of the College of Environment and Natural Resources, Can Tho University

Mid-term evaluation workshop for the SATREPS project "Breakthrough in nutrient use efficiency for rice by genetic improvement and fertility sensing techniques in Africa"

The Science and Technology Research Partnership for Sustainable Development (SATREPS) project "Breakthrough in nutrient use efficiency for rice by genetic improvement and fertility sensing techniques in Africa (FY VARY Project)" organized a workshop, which also served as the mid-term evaluation of the project, at the Hotel Colbert in Antananarivo, Madagascar, on December 12, 2019. The FY VARY Project is jointly supported by the Japan Science and Technology Agency (JST) and the Japan International Cooperation Agency (JICA).

The workshop started with opening messages from the chief representative of JICA Madagascar Office and the director of Rural Mechanization Department, Ministry of Agriculture, Livestock and Fisheries, Madagascar. This was followed by Dr. Yasuhiro Tsujimoto, principal investigator of the project, who gave an overview of the project and achievements obtained so far. The outputs of the project's four research components and future research plan were presented by members of the collaboration including eight researchers from Madagascar and six from JIRCAS. The general discussion was chaired by the director of Research and Science, Ministry of Higher Education and Research, Madagascar. During the discussion, representatives from the National Center for Applied Research on Rural Development (FOFIFA), the Seed Management Committee (SOC) responsible for registering rice varieties, and agricultural materials sales companies (Agrivet and STOI) shared comments, expectations, and collaborations to deliver research results to social implementation. In addition, the representative from the French Agricultural Research Center for International Development (CIRAD) and the director of Madagascar Field Crops and Livestock Research Institute (FIFAMANOR) mentioned the possibility of research collaboration with the FY VARY Project.

The 75 participants also included those from private companies, donor institutions, and agricultural development projects. In addition, Dr. Tsujimoto was interviewed by local media, and the workshop as well as the outputs of the project were widely publicized throughout Madagascar through two TV networks, three newspaper outlets, two radio stations, and the Facebook page of the Ministry of Agriculture, Livestock and Fisheries.

The workshop facilitated sharing of research outputs obtained so far, discussion of future plans, and strengthening of collaboration among stakeholders within and outside the project for promoting social implementation of project outputs.

Group photo of workshop participants

Workshop on Improving Livestock Productivity and Animal Health in Mozambique

A knowledge-sharing activity, titled "Workshop on Improving Livestock Productivity and Animal Health in Mozambique" and organized by the Agricultural Research Institute of Mozambique (IIAM) and JIRCAS, was held at the Animal Research Directorate of IIAM in Maputo, Mozambique, on November 21and 22, 2019.

There were around 70 participants from IIAM, JIRCAS, the Mozambican Ministry of Agriculture and Food Security, universities, district extension services, family livestock farmers, and commercial livestock farmers.

The workshop was divided into five sessions — (1) Animal Health and Disease, (2) Grassland Management, (3) JIRCAS Project, (4) Reproductive Management of Livestock, and (5) Public-Private Partnership and Financial Services — with 19 presentations made altogether. Researchers from JIRCAS presented the following: (1) Outline of the sub-project "Crop-livestock integration" of the Food Security in Africa project, which is the flagship project of the Stable Agricultural Production Program, (2) Silage / total mixed ration (TMR) preparation technology using local feed resources, (3) Nutritional value and feeding technology of current feed resources in Mozambique, (4) Cultivation of multipurpose crops that can be used for crop-livestock integration, (5) Profitability and problems of dairy farming in Manhiça district, and (6) Introduction of a program (BFMmz) that can suggest improved farming plans based on a farm management model designed for assisting smallholder farmers in Mozambique. Fruitful discussions were made on the cost of silage and TMR production, the importance of improving the feed analysis system in Mozambique, and the optimization of livestock production by using the BFMmz program for livestock farmers in Mozambique.

To conclude, the current situation of animal health and livestock production in southern Mozambique became broadly understood during the workshop. However, further discussions are needed to incorporate the research achievements into Mozambique's livestock policy.

Group photo of workshop participants

Workshop of JIRCAS-NAFRI-NUOL Collaborative Projects from 2016 to 2021: Technical achievements of the projects and their applications -Potential and efficiency of underused agricultural and fishery resources in Laos-

On October 30, 2019, the workshop titled "Technical achievements of the projects and their applications -Potential and efficiency of underused agricultural and fishery resources in Laos-" was held in Vientiane, Laos. It was organized by JIRCAS and its Lao counterparts, the National Agriculture and Forestry Research Institute (NAFRI) and National University of Laos (NUOL), to share the achievements of their ongoing collaborative projects, which run from 2016 to 2021. There were approximately 80 attendees belonging to the Lao national government, the provincial governments (of Vientiane, Luang Prabang, and Savannakhet), institutes, and university.

In Laos, four projects under the Value-adding Technologies Program have been implemented, with the various studies resulting to the development of many useful technologies for paddy and upland rice cropping, aquaculture, food and nutrition, and forestry, among others. Applying these achievements toward improving agriculture and livelihood in rural areas require effective ways of providing and executing extension programs and services. The workshop's aim, therefore, was to introduce the technologies available for farmers to the local government staff who are in charge of dissemination.

Mr. Somphone Sengdara (Deputy Director of Planning and Cooperation Division, NAFRI) delivered the keynote speech, while Dr. Yukiyo Yamamoto (Program Director, JIRCAS) introduced the program outline.

The workshop had two main sessions consisting of lecture presentations by researchers and a panel discussion. Ten individual topics dealing with rice, tropical fruits, silviculture, and aquaculture were presented by researchers. The presentations were simultaneously translated between English and Lao languages to help the audience understand and encourage lively discussions.

The panel discussion, themed "Future perspectives for technical application and extension," was facilitated by Dr. Yamamoto, who categorized the project achievements based on their usage into 1) Applicable techniques for farmers, 2) Useful references for administrators, and 3) Assets for future research. The six panelists — Dr. Chanhsamone Phongoudome (Deputy Director General, NAFRI), Mr. Sengdara, and Mr. Mitsuru Kameya (Agriculture Policy Advisor, JICA), together with three JIRCAS project leaders, Drs. Shinsuke Morioka, Hiroyasu Oka, and Osamu Abe — then commented on the technologies being developed and the presentations of researchers in the previous session. They also complimented the numerous and significant achievements that have been produced and noted the results that offered promising prospects for extension. The workshop concluded with the participants agreeing on the importance of communication among researchers, administrators, and farmers.

Group photo of attendees at the JIRCAS-NAFRI-NUOL workshop

International Symposiums, Workshops, and Seminars, FY 2019			
1	Local Project Review Meeting (Water Management in Africa Project)	June 1, 2019	Mekelle, Ethiopia
	Stakeholders' Meeting (Water Management in Africa Project)	June 2, 2019	Kilte Awlaelo, Ethiopia
2	JIRCAS-NAFRI-NUOL Joint Research Annual Meeting	June 4, 2019	Vientiane, Laos
3	JIRCAS-NAFRI Steering Committee Meeting	June 5, 2019	Vientiane, Laos
4	Technical Workshop for the project titled "Establishment of fertilizing crop cultivation promotion model using Burkina Faso phosphate rock"	June 11, 2019	Ouagadougou, Burkina Faso
5	3rd Technical Coordinating Committee Meeting for the project titled "Establishment of fertilizing crop cultivation promotion model using Burkina Faso phosphate rock"	June 12, 2019	Ouagadougou, Burkina Faso
6	3rd Technical Committee Meeting for the project titled "Study on improving water efficiency in irrigation schemes in Africa (WEIRS for Rice)"	June 18, 2019	Arusha, Tanzania
7	3rd Joint Coordination Committee (JCC) meeting for the SATREPS project titled "Fertility sensing and Variety Amelioration for Rice Yield (FY VARY)"	July 12, 2019	Antananarivo, Madagascar
8	Progress Meeting for the project titled "Population dynamics of rice planthoppers and relationship with agricultural activities in Vietnam"	July 24, 2019	Hanoi, Vietnam
9	JIRCAS-SEAFDEC Joint Workshop on IMTA Research, themed "Understanding Current Challenges and Future Prospects"	August 6-8, 2019	Iloilo and Guimaras, Philippines
10	Thailand National Science and Technology Fair 2019	August 16-25, 2019	Nonthaburi, Thailand
11	International Agricultural Research Seminar titled "Power of Agriculture in Transforming Africa"	August 26, 2019	Tokyo, Japan
12	Plant Phenotyping x Engineering Ideathon	August 26-27, 2019	Tsukuba, Japan
13	The Seventh Tokyo International Conference on African Development(TICAD7)	August 26-30, 2019	Yokohama, Japan
14	TICAD7 Official Side Event: "The Power of Boosting Africa for the Future of Food and Agriculture," a symposium organized by the Ministry of Agriculture, Forestry and Fisheries (MAFF)	August 28, 2019	Yokohama, Japan
15	TICAD7 Official Side Event: Talk Session themed "African Countries x Japan Global Food Value Chain Development" at the "Japan-Africa Business Forum & Expo"	August 30, 2019	Yokohama, Japan
16	Annual Meeting for the project titled "Development of breeding materials and varieties of soybean resistant to Asian soybean rust and Cercospora leaf blight"	September 11-12, 2019	Londrina, Brazil
17	1st Joint Coordination Committee (JCC) Meeting for the SATREPS project titled "Sustainable Replantation of Oil Palm by Adding Value to Oil Palm Trunk through Scientific and Technological Innovation"	September 19, 2019	Penang, Malaysia

International Symposiums, Workshops, and Seminars, FY 2019			
18	Joint Annual Meeting for JIRCAS Research Projects "Blast Research Network for Stable Rice Production" and "Environmental Stress-Tolerant Crops"	September 24-26, 2019	Nueva Ecija, Philippines
19	JIRCAS-CTU Climate Change Project Workshop 2019	September 27, 2019	Cantho, Vietnam
20	A meeting in Thailand to assess research needs toward establishing an integrated pest management (IPM) system against fall armyworm	October 17-18, 2019	Kanchanaburi, Thailand
21	INERA-JIRCAS Collaborative Research Project Review and Planning Meeting	October 22, 2019	Ouagadougou, Burkina Faso
22	4th Technical Coordinating Committee for the project titled "Establishment of fertilizing crop cultivation promotion model using Burkina Faso phosphate rock"	October 25, 2019	Ouagadougou, Burkina Faso
23	Workshop on JIRCAS-NAFRI-NUOL Collaborative Projects from 2016 to 2021: Technical achievements of the projects and their applications -Potential and efficiency of underused agricultural and fishery resources in Laos-	October 30, 2019	Vientiane, Laos
24	Workshop on "Livestock Productivity and Animal Health" at the Agricultural Research Institute of Mozambique (IIAM)	November 21-22, 2019	Maputo, Mozambique
25	JIRCAS International Symposium, themed "International research collaboration to tackle transboundary plant pests: Contributions to Sustainable Development Goals"	November 26, 2019	Tsukuba, Japan
26	Annual Meeting for the JIRCAS project titled "Development of Technologies for Sustainable Aquatic Production in Harmony with Tropical Ecosystems"	December 3, 2019	Tsukuba, Japan
27	Workshop titled "Perspectives for Research and Development on Sustainable Aquatic Production in Tropical Areas"	December 4-5, 2019	Tsukuba, Japan
28	Mid-term evaluation workshop (5th Technical Coordination Committee meeting, TCC) for the SATREPS project titled "Breakthrough in nutrient use efficiency for rice by genetic improvement and fertility sensing techniques in Africa"	December 12, 2019	Antananarivo, Madagascar
29	FY 2019 RFD-JIRCAS Project Steering Committee Meeting	February 24, 2020	Bangkok, Thailand
30	4th Technical Committee (TC) Evaluation: "Improving Water Resource Use Efficiency in Africa"	February 27, 2020	Moshi, Tanzania
31	FY 2019 FRIM-JIRCAS Project Steering Committee Meeting	February 27, 2020	Kuala Lumpur, Malaysia

Appendix

Publishing at JIRCAS

English

1) JARQ (Japan Agricultural Research Quarterly)	
	Vol. 53 No. 3, No. 4
	Vol. 54 No. 1, No. 2
2) Annual Report 2018	
3) JIRCAS Newsletter	No. 87, No. 88
4) JIRCAS Working Report	No. 88, No. 89, No. 90

Japanese

1) Koho JIRCAS	Vol. 4, Vol. 5
2) JIRCAS News	No. 87, No. 88

Refereed Journal Articles 2019-2020

Program A

Abd El-Halim, A.A.* and Omae, H. (2019) Examination of nanoparticulate phosphate rock as both a liming agent and phosphorus source to enhance the growth of spinach in acid soil. *Soil Science and Plant Nutrition*, 65(4): 386-392, DOI: 10.1080/00380768.2019.1620082.

Abd El-Halim, A.A.* and Omae, H. (2019) Performance assessment of nanoparticulate lime to accelerate the downward movement of calcium in acid soil. *Soil Use and Management*, 35(4): 683-690, DOI: 10.1111/sum.12525.

Abd El-Halim, A.A.* and Omae, H. (2020) Performance assessment of chlorophyll meter to determine when to irrigate wheat under different soil moisture deficit conditions: A primary study. *Communications in Soil Science and Plant Analysis*, 51(7): 976-984, DOI: 10.1080/00103624.2020. 1744626.

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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 works will be conducted until 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.

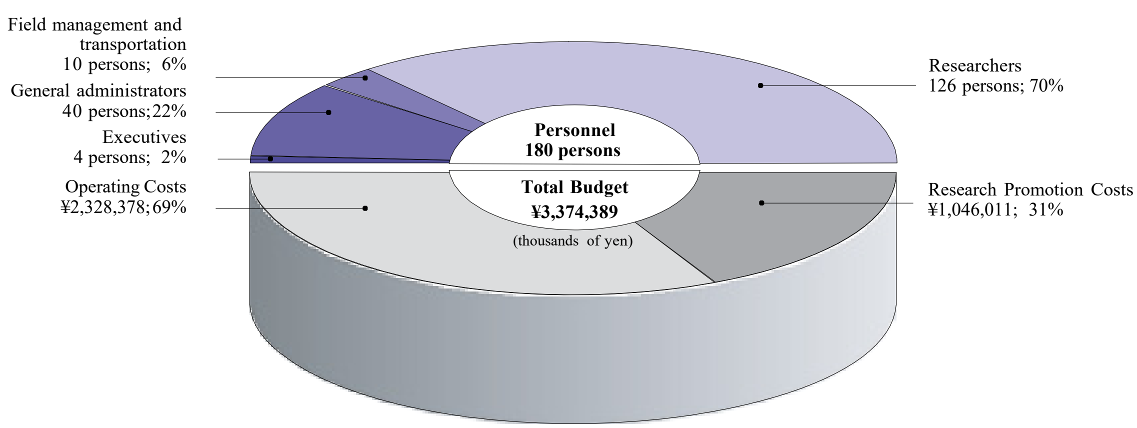
Financial Overview

Fiscal Year 2019

	thousands of yen
TOTAL BUDGET	**3,374,389**
OPERATING COSTS	**2,328,378**
Personnel (180)	2,030,966
President (1), Vice-President (1), Executive Advisor & Auditor (2)	
General administrators (40)	
Field management (10)	
Researchers (126)	
* Number of persons shown in ( )	
Administrative Costs	297,412

RESEARCH PROMOTION COSTS	**1,046,011**
Research and development	528,073
Overseas dispatches	176,330
Collection of research information	98,466
International collaborative projects	210,571
Fellowship programs	32,570

Budget FY 2019 (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 Food and Agricultural Sciences, Fukushima University
Hisayo YASUDA	Attorney-at-law, Yasuda International Law Office

JIRCAS Staff in FY 2019

President

Masa Iwanaga

Vice-President

Osamu Koyama

Auditors

Teruyoshi Kumashiro
Mari Inoue

Research Strategy Office

Miyuki Iiyama, Director

Research Coordinators
Toshimasa Masuyama, Bioenergy
Norihito Kanamori, Plant Molecular Biology

Regional Coordinator
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
Hiroshi Ikeura, Head

Research Management Section
Mie Kasuga, Head
Katsunori Kanno, Intellectual Property Expert

Communications Advisor
Baltazar Antonio

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

Research Support Office
Noriaki Nishimura, Head

Research Coordination Section
Koichi Iioka, Head
Toshiki Kikuchi, Coordination Subsection Head
Daisuke Abe, Overseas Travel and Invitation Program Subsection Head
Gen-ichiro Hanaoka, Overseas Travel and Invitation Program Subsection Officer
Kenji Iwasa, Overseas Affairs Subsection Head
Jun-ichi Irino, Overseas Affairs Subsection Specialist

Research Support Section
Takashi Kamura, Head
Koichi Fuse, Budget Subsection Head
Takayuki Yamamoto, Support Subsection Head

Information and Public Relations Office
Seishi Yamasaki, Head

Senior Researcher
Masaki Morishita, Rural Development

Public Relations Section
Kazuhiko Okada, Head

International Relations Section
Keisuke Omori, Head

Publications and Documentation Section
Akira Hirokawa, Head
Hiromi Miura, Information Security Expert
Takanori Hayashi, Information Management Expert
Shota Miyai, Information System Subsection Officer

Administration Division

Nobuyuki Inagaki, Director

General Affairs Section
Takashi Oosato, Head
Hakumi Kumagai, General Affairs Assistant Head
Jun Yatabe, Personnel Management Assistant Head
Gaku Takeda, Personnel Subsection Expert
Hitomi Ogamino, Welfare Subsection Officer
Noriko Osonoe, Personnel Subsection 1 Officer
Kumi Ehara, Personnel Subsection 2 Head

Accounting Section
Tadao Yatabe, Head
Kiyoyuki Sunaoka, Accounting and Examination Assistant Head
Takashi Ichimi, Procurement and Asset Managing Assistant Head
Ryoichi Mise, Financial Subsection Head
Shoko Yoshida, Accounting Subsection Officer
Aki Tamura, Audit Subsection Officer
Yumekazu Yano, Procurement Subsection 1 Head
Yuka Takatsuto, Procurement Subsection 2 Officer
Takehito Kato, Supplies/Equipment Subsection Officer
Tadahisa Akiyama, Facilities Subsection Head

Administration Section (Tropical Agriculture Research Front)
Kengo Uemura, Head
Hiroe Nagatomo, General Affairs Subsection Head
Masayuki Inoue, Accounting Subsection Head

Risk Management Office

Yasuyuki Nakanishi, Head

Compliance Management Section
Yuma Sukegawa, Management Subsection Officer

Safety Management Section
Masakazu Yamada, Head

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Yukari Nagatoshi, Plant Molecular Biology
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Shinsuke Yamanaka, Molecular Biology
Shinkichi Gotoh, Soil Science
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Toshihiko Takemoto, Machine Operator
Masashi Takahashi, Machine Operator
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The Japanese Fiscal Year and Miscellaneous Data

The Japanese Fiscal Year and the Annual Report 2019

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) 2019 covers the period from April 1, 2019 through March 31, 2020.

The Annual Report 2019 summarizes the full extent of JIRCAS activities that occurred during this period. The subsequent Annual Report will detail events and programs from April 1, 2020 through March 31, 2021 (FY 2020).

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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