ISSN 1341-514X

Annual Report 2021 (Apr. 2021 - Mar. 2022)

JAPAN INTERNATIONAL RESEARCH CENTER FOR AGRICULTURAL SCIENCES

JIRCAS

Japan International Research Center for Agricultural Sciences

Annual Report 2021

(April 2021-March 2022)

Japan International Research Center for Agricultural Sciences
1-1 Ohwashi, Tsukuba, Ibaraki 305-8686
JAPAN

Telephone +81-29-838-6313
Facsimile +81-29-838-6316
Homepage https://www.jircas.go.jp

Contents

JIRCAS Annual Report 2021

Research Overview

Training and Invitation Programs / Information Events

Appendix

Message from the President

President
Osamu Koyama
(FY2021-)

The first year of the Fifth Medium to Long-Term Plan

The Japan International Research Center for Agricultural Sciences (JIRCAS), including its predecessor organization, has been conducting international joint research with local research institutes and universities in the tropics and subtropics as well as in developing regions for over 50 years. It is a unique Japanese national research and development agency that contributes to the improvement of agriculture, forestry, and fisheries technologies overseas, and eventually to the development of the world's agriculture, forestry, and fisheries industries.

The situation surrounding the world’s agriculture, forestry, and fisheries has changed significantly with the times. Expectations for novel technology development in each era, such as the era of large production increase led by the Green Revolution, the era of export competition among developed countries, the era of deepening awareness of global environmental problems, and the era of volatile food prices due to the economic crisis, have also changed. In particular, in the tropics/subtropics and developing regions targeted by our Center, the need for new technologies is changing drastically due to globalization, urbanization, and rapid economic growth.

As global issues such as climate change became more apparent, the United Nations adopted a set of common goals for humankind, better known as SDGs, to overcome various issues and form a sustainable society by 2030. In order to achieve the goals, many activities are being developed. Last year, in September 2021, the United Nations Food Systems Summit was held, confirming that a series of activities related to food production, processing, transportation, and consumption will be transformed into a sustainable system. Japan also declared that it would aim to be carbon neutral by 2050, and in May 2021, it finalized its strategy for sustainable food systems called the Strategy “MeaDRI” (the name sounds like the Japanese word for “green”). It aims to both enhance productivity potentials and ensure sustainability of agriculture, forestry, fisheries, and food industries through innovation.

In parallel with the above, JIRCAS has maintained a solid and long-term corporate philosophy (JIRCAS Vision), and it has consistently endeavored to solve food and environmental problems through research and development and contributed internationally through science and technology. In March 2021, JIRCAS was instructed about the 5th Medium to Long-term Target based on the recent changes in the situation surrounding international agriculture, forestry, and fisheries research as described above, and a new five-year term was started. The new medium to long-term goal re-defines the superb mission of JIRCAS. JIRCAS is mandated to improve agriculture, forestry, and fisheries technologies around the world, including Japan, toward the realization of government policies such as “The Basic Plan for Food, Agriculture and Rural Areas,” representing Japan as a core national institute in the field of international agriculture, forestry, and fisheries research.

For the five years of the 5th term, we have set up a system that enables simple and effective business operations by arranging four business segments: Planning, Environment, Food, and Information. We are also working to improve the matrix system, a unique research promotion method of JIRCAS, in which research staff from different academic disciplines and belonging to specialized Divisions participate in multiple research projects set in the research activity segments and engage in interdisciplinary research activities that solve complex problems. In addition, we have assigned the Information and Public Relations Office directly under my supervision so it can promote institution-wide public relations and collaborative works. With this new administrative system, we have started activities to achieve our medium to long-term goals.

FY 2021 was not always smooth sailing for JIRCAS. The spread of the new coronavirus infectious disease, which had affected activities from the previous year, had not converged in Japan and overseas, thus travel restrictions and behavioural regulations remained in effect throughout the year. The activities of the research segments, where the main activity is problem-solving joint research in the field, were severely constrained. There were also political instabilities in some of the study countries. Under these circumstances, the staff of JIRCAS started and continued their research activities with much ingenuity and devoted themselves to cooperating with foreign joint research partners based on long-term relationships of trust. Thus, despite the challenges, we were able to produce outstanding research results that would lead to solving global issues such as those introduced in this report.

Furthermore, since the end of FY 2021, the international prices of energy, food, and fertilizer have continued to rise sharply, accelerated by the invasion in Ukraine, and many countries that rely on imports for food have raised concerns about or actually faced food security crises. Japan, which depends on the international market for about 60% of its food on a calorie basis, has interests and responsibilities in ensuring global food security, and international contribution through science and technology innovation is an important part of this. Under international cooperation, it is necessary to build a sustainable and resilient food system from a medium to long-term perspective. JIRCAS should and can lead the world in this field.

With a history of international joint research of more than 50 years, our strength exists in our working method where we tackle global food and environmental problems, which are sometimes in conflict with each other, with an interdisciplinary approach, and present solutions with local partners hand in hand. JIRCAS will never forget its mission as a public institution that provides global public goods, and all staff members will collaborate to create new value common to all humankind, "together for our food and planetary health." We hope that you will read this Annual Report, which introduces a part of our activities for one year, and hope that you will continue to understand, support, and cooperate with the activities of JIRCAS. We also welcome your frank advice and questions.

October 2022

Osamu Koyama, President

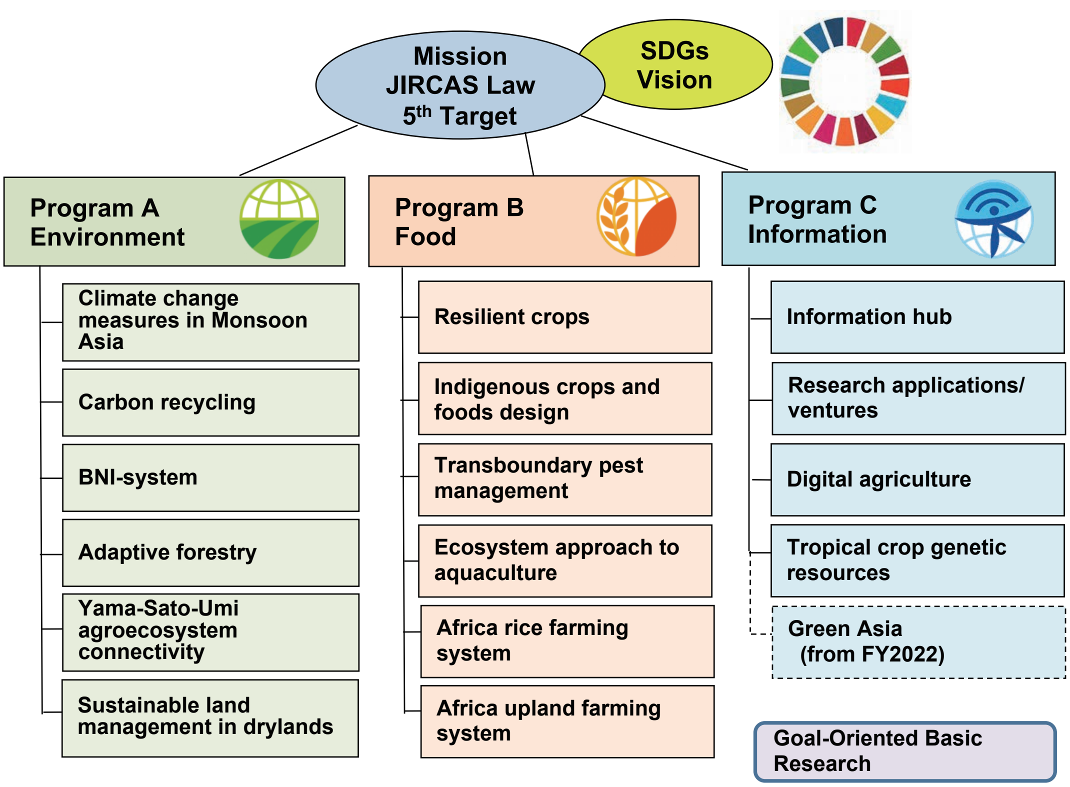


Fig. 1. Program-Project Research Framework (FY2021-2025)

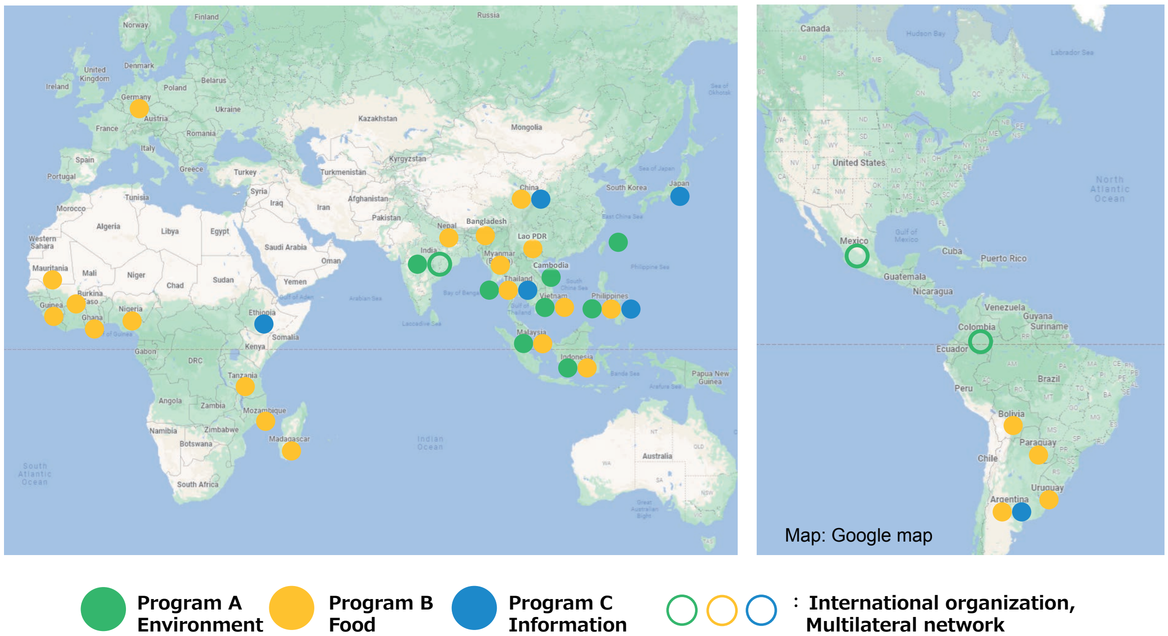


Fig. 2. Locations of activities in the 5th Medium to Long-Term Plan

Highlights from 2021

JIRCAS International Symposium 2021 Report

Of the nine "planetary boundaries," described by Rockström et al. (2009) as a "framework that defines a safe operating space for humanity with respect to the Earth system and are associated with the planet's biophysical subsystems or processes," four of them, namely, climate change, biosphere integrity, land system change, and biochemical flows (nitrogen and phosphorous cycles), have already been overstepped (Steffen et al. 2015), thus increasing awareness around the world on the urgency to minimize the anthropogenic impacts of economic activities on the environment while achieving the Sustainable Development Goals (SDGs).

The world has been moving in earnest towards the realization of a decarbonized society. In the field of agriculture, forestry, and fisheries, the United Nations Food Systems Summit was held in September 2021 to discuss the state of the food system and how it contributes to the health of Earth and humanity. When COP 26 convened in November 2021, many countries had set ambitious quantitative targets toward carbon neutrality in response to the Paris Agreement, and their commitments also encompassed the low emission targets for the food systems, which globally account for about a third of the anthropogenic greenhouse gas (GHG) emissions. These explicit commitments indicate the global community's determination to shift to the pathways in which science, technology, and innovation (STI) in the food systems should play a key role to mitigate trade-offs and to amplify synergies between economic development and environmental sustainability. These innovations must be based on scientific infrastructure to make the food systems resilient to disasters and climate shocks by reducing environmental impacts and recycling resources without compromising food and nutrition security for present and future generations given the prospects of a growing world population.

Aware of these global trends, the Ministry of Agriculture, Forestry and Fisheries of Japan formulated the Strategy MeaDRI (Measures for achievement of Decarbonization and Resilience with Innovation) on May 12, 2021, aiming to build a sustainable food system through innovations that can reduce the environmental burden, such as carbon neutrality, without affecting productivity. Strategy MeaDRI puts forward pathways in which STI can take a central role in reducing environmental footprint while enhancing productivity for food production.

In turn, it is essential to bear in mind that 'no one-size-fits-all.' The identification and customization of appropriate sets of STI to locally specific agroecological and socio-economic conditions is critical to turn trade-offs into win-win outcomes. To achieve impacts at the regional and global scales, socio-economically and technologically feasible STI options should be made available. In the case of Japan, there are huge opportunities to co-learn from experiences and lessons with countries sharing similar agroecological conditions, such as those in the Asia-Monsoon region. To do so, consensus is needed for all stakeholders, i.e., agricultural research institutions and development agencies, to jointly contribute towards a common goal of achieving productivity improvement and environmental sustainability for the countries as well as the whole Asia-Monsoon region.

These developments formed the rationale for the agenda of JIRCAS International Symposium 2021, themed "The Role of Science, Technology and Innovation in Achieving Sustainable Food Systems in the Asia Monsoon Region: A Platform for International Collaboration," and held/streamed online on the JIRCAS YouTube channel on November 17, 2021. This symposium aimed at providing a forum to discuss a platform for international collaboration contributing to the 'Strategy for Sustainable Food Systems' or Strategy MeaDRI. To do so, it had the following specific objectives. First, it reviewed recent policy developments on agriculture, forestry, and fishery sectors at country/regional level in the Asia monsoon region in the contexts of global debates on sustainable food systems transformation. Next, STI portfolios with evidence or potential to achieve both productivity improvement and environmental sustainability depending on agroecological and socio-economic contexts were identified. Finally, the roles of stakeholders for international collaboration were discussed based on respective comparative advantages.

The symposium was opened by President Osamu Koyama of JIRCAS, and followed by Director-General Toyohisa Aoyama of the Agriculture, Forestry and Fisheries Research Council Secretariat, who spoke on behalf of the Ministry of Agriculture, Forestry and Fisheries (MAFF) about the significance of the research that JIRCAS has been conducting for the past half century to improve agriculture, forestry and fisheries technologies around the world and to increase food production.

In the keynote speeches, Prof. Joachim von Braun, Chair of the Science Group of the UN Food Systems Summit, and Mr. Makoto Osawa, Former Vice-Minister for International Affairs, MAFF, spoke about the importance of science and technology innovation and dialogue between science and policy stakeholders to realize sustainable food systems that are resilient to disasters and climate change, based on global discussions.

In addition, on behalf of agricultural research and development organizations working in the Asia-Monsoon region, presentations were made by Mr. Sridhar Dharmapuri (Food and Agriculture Organization - Regional Office for Asia and the Pacific), Dr. Jon Hellin (International Rice Research Institute), Mr. Yasunari Ueda (Japan International Cooperation Agency), Dr. Yasuhito Shirato (National Agriculture and Food Research Organization), and Dr. Keiichi Hayashi (JIRCAS). In the panel session facilitated by Dr. Miyuki Iiyama (JIRCAS), the panelists explored innovations that would both improve agricultural productivity and sustainability in the Asia-Monsoon region, and discussed the ideal collaborative platform that would contribute to "Strategy MeaDRI."

The symposium was concluded by JIRCAS Vice President Yukiyo Yamamoto, who also expressed her appreciation to the speakers, panelists, and viewers in her closing remarks.

Symposium panelists

2021 (The 15th) Japan International Award for Young Agricultural Researchers (Japan Award) and Commendation Ceremony

On October 29, 2021, the Ministry of Agriculture, Forestry and Fisheries (MAFF) announced the recipients of the 15th Japan International Award for Young Agricultural Researchers (Japan Award).

Since 2007, this annual award has been organized by the Agriculture, Forestry and Fisheries Research Council (AFFRC), MAFF and supported by JIRCAS. The Japan Award is given to young agricultural researchers from overseas who have made outstanding achievements or achieved outstanding research results that will lead to future technological innovations, with the aim of further motivating young researchers to contribute to research and development on agriculture, forestry, fisheries and related industries in developing regions.

Due to the COVID-19 pandemic, the joint commendation ceremony for the 2020 (The 14th) and 2021 (The 15th) Japan Award winners was filmed in advance and streamed online on November 16, 2021 (Tuesday).

Video link to the commendation ceremony (JIRCAS YouTube channel)
https://youtu.be/l26Q4OOAkoA

The 2021 awardees and their research achievements are as follows:

Sahadev SHARMA
(39 years old, Male, Indian)
University of Malaya
Malaysia
Mangrove forest blue carbon research for effective nature-based solutions to mitigate climate change in Asia Pacific region

James Seutra KABA
(38 years old, Male, Ghanaian)
Kwame Nkrumah University of Science and Technology, Ghana
Nitrogen nutrition of cocoa (*Theobroma cacao* L.) in intercropping systems with gliricidia (*Gliricidia sepium* (Jacq.) Kunth ex Walp.)

Hala GAMAL ALI ALI EL DAOUS
(30 years old, Female, Egyptian)
Benha University, Egypt
Establishment of a novel diagnostic test for Bovine leukaemia virus infection using direct filter PCR

NEW RESEARCH COLLABORATION

JIRCAS promotes its research network with international as well as national agricultural research institutions, extension systems, universities, and the private sector, through information and personnel exchange programs. MOUs have been signed between JIRCAS and its research partners abroad and domestic to implement long-term research collaborations. In the first fiscal year of the Fifth Medium to Long-Term Plan, some of the existing MOUs were renewed and new MOUs were signed, including 31 international and 63 domestic contracts.

JIRCAS renewed a number of MOUs with leading research institutions in the Asia-Monsoon region and beyond, among them, the one with the National Agriculture and Forestry Research for Rural Development Institute (NAFRI), a major agriculture and forestry research institution in Laos. JIRCAS had an existing fixed-term MOU with NAFRI for the joint research on upland rice and has signed a new, non-fixed-term MOU for value addition through the utilization of native genetic resources (whose collection is being managed by NAFRI's Genebank) as new research activities were being planned for the Fifth Medium to Long-Term Plan.

As of March 2022, the number of active MOUs was 120. Based on the work plans elaborated in the respective MOUs, JIRCAS carried out joint research projects with 45 research institutions in 22 developing countries.

Together with domestic partners, JIRCAS implemented 86 joint research activities in total: 9 with national research and development agencies under the Ministry of Agriculture, Forestry and Fisheries, 7 with independent entities, 6 with public research institutions, 47 with universities, and 17 with private companies. Some of the private companies contributed to financing research activities implemented by JIRCAS (worth 12 million JPY).

JIRCAS also promotes collaboration with international organizations, including CGIAR, to contribute to solving global challenges. JIRCAS continued hosting one visiting scientist from AfricaRice in FY 2021.

TROPICAL AGRICULTURE RESEARCH FRONT

The Tropical Agriculture Research Front (TARF), a substation of JIRCAS, is located at the southwestern edge of Ryukyu archipelago in Ishigaki, Okinawa, Japan. Geographically, TARF is closer to Taiwan (280 km to the west) than Tokyo (2,000 km to the northeast). The climate is subtropical, with an average temperature of 24.3°C and annual rainfall of 2,107 mm. TARF's facilities include 21 hectares of experimental fields, several types of greenhouses, and lysimeters. With its geographical advantages and facilities, TARF implements basic and fundamental researches and creates improved agricultural technologies that can be applied in developing and/or island countries of the tropics/subtropics.

Research and development of agricultural production technologies

The following projects and related research activities have been implemented at TARF since FY 2021 under the Fifth Medium to Long-Term Plan: (1) Island agriculture with environmental conservation, (2) Collection, evaluation, and utilization of tropical crop genetic resources, and (3) Development of a year-round vegetable production system for the Asia-Monsoon region.

The "Yama-Sato-Umi agroecosystem connectivity" project is designed to develop and evaluate environmental conservation technologies for tropical islands through an approach emphasizing Ridge-to-Reef (Yama-Sato-Umi) agroecosystem connectivity. This project aims to establish healthy material cycles among the connected ecosystems through development of technologies to reduce environmental loads in the areas, and resource circulation targeting the Philippines and Ishigaki, Okinawa, Japan (Photo 1). For this purpose, we are conducting research under the following themes.

- Development of technologies for reducing environmental loads and circulating natural resources based at TARF
- Elucidation of soil and nutrient loads from river basins and the conditions for implementing developed technologies in tropical islands

The Optimized Subsurface Irrigation System (OPSIS) is a water-saving irrigation system developed by the National Agriculture and Food Research Organization (NARO). By installing a trapezoidal impervious sheet at the bottom of the water supply pipe, water loss due to downward infiltration is suppressed. OPSIS was installed at multiple depths in a field and outdoor lysimeter at TARF, and sugarcane cultivation was started to clarify the effects of water-saving and fertilizer application through monitoring of subsurface water and nutrients. Applying biochar to soil is a prospective technology both for carbon sequestration and for less-leaching fertilizer-derived nitrate nitrogen. We have conducted an indoor pipe experiment to clarify the effect of biochar application on nitrogen load reduction at multiple depths. The results showed that the peak of nitrate-nitrogen leaching may differ depending on the application depth. To search for alternative resources of chemical fertilizers, the effects of applying filter cake, bagasse ash, and compost generated in sugarcane cultivation systems are being tested both at field- and pot-level, with the aim of improving soil physical properties.

The "Tropical crop genetic resources" project is designed to strategically develop and promote research on tropical crops based on domestic and international issues and research needs for each crop, taking advantage of such diverse and abundant tropical crop genetic resources and geographical location in TARF. Furthermore, by sharing and providing this information and technology, we aim to strengthen collaboration that will lead to the formation of networks with domestic and overseas research institutions for the advancement of tropical crop genetic resource utilization. For this purpose, we are conducting research under the following themes across several crops such as rice, sugarcane, and tropical fruits.

- Information and networking of genetic resources
- Evaluation of genetic resources and development tools
- Utilization of genetic resources for new breeding materials and cultivation technologies
- Domestic research collaboration through utilization of genetic resources

To improve major rice varieties in tropical countries, genetic study and development of breeding materials have been conducted. One of our main objectives is to enhance rice productivity under various unfavorable conditions such as less fertile soil. We are also developing breeding materials resistant to rice blast disease to reduce application of pesticides. Newly developed breeding lines introducing field resistance genes by DNA marker selection are effective against panicle blast. Within the framework of the collaborative rice blast research network, developed breeding materials are shared with national agricultural research institutes in Bangladesh, Philippines, Vietnam, Indonesia and so on. We also apply genome editing technologies, enabling us to introduce mutation in genes accurately improving rice varieties as well.

Sugarcane research at TARF enables the establishment of essential information and technologies for the effective use of sugarcane-related genetic resources in breeding to improve sugarcane's productivity and adaptability to adverse environments and reduce its environmental load. We are focusing on wild sugarcane (*Saccharum spontaneum*) and *Erianthus* collected in Japan and Thailand as important genetic resources, and are developing databases listing their essential traits and selecting breeding materials as well. Furthermore, we are planning to develop breeding technologies by using genome information and evaluation techniques for acid and drought tolerance and resistance to white leaf disease. We are also aiming to develop new breeding materials and varieties by using the genetic resources to promote sugar and fiber utilization in the sugarcane industry in Japan and Southeast Asian countries including Thailand.

Tropical fruit research for utilization of genetic resources has been conducted to contribute to the promotion of tropical fruit production and sharing of information through research networking in Japan and main production areas in Southeast Asia. Tropical fruits are gaining attention as alternative crops that can be grown to cope with climate change in Japan. Also, the introduction of diverse tropical fruit species will contribute to the diversification of food and nutrient sources. In this project, we focus mainly on mango and passion fruit research, with the aim of achieving effective flowering and fruit setting for stable production through evaluation of genetic resources and development of new breeding materials and cultural technologies. Regarding the practical implementation of such knowledge in passion fruit production, a virus-free propagation technique has been developed for the viral disease, which has been spreading in recent years.

Several integrated research activities focusing on a plant factory are being conducted at TARF. A new 5-year JIRCAS subproject titled "Social implementation of the Asian monsoon plant factory system" was launched in 2021. Moreover, three independent research studies are being conducted in collaboration with private companies to boost tomato cultivation in summer, improve the shipping quality of tomato fruits, and increase strawberry production in subtropical regions. Another activity is a cross-sectoral collaboration among the private sector, NARO, and JIRCAS, supported by project grants from the Bio-oriented Technology Research Advancement Institution (BRAIN) Research Program on Development of Innovative Technology, to develop a strawberry cultivation system that is adapted to tropical/subtropical regions (Photo 2). Through all the research activities mentioned above, we aim to develop technologies for stable year-round production of tomatoes and strawberries in tropical/subtropical regions.

Contribution to domestic agriculture

TARF contributes to domestic agriculture through the following activities:

1) Generation advancement

Early generations of rice population consisting of 60 accessions from NARO breeding stations all over Japan are grown twice a year.

2) Conservation of genetic resources

Through the NARO Genebank project, TARF, as a sub-bank for tropical and subtropical crop genetic resources, maintains 534 accessions of sugarcane and its relatives, 62 of *Erianthus*, 150 of tropical fruit trees, and 125 of pineapple vegetatively in fields and greenhouses.

3) Development of varieties for Nansei Islands

TARF-JIRCAS contributes to domestic sugarcane breeding by taking advantage of the optimum environmental conditions for sugarcane crossing in Ishigaki Island. Promising clones showing vigorous ratooning ability and root growth were selected from the backcrossing populations of intergeneric hybrids between sugarcane and *Erianthus*, and provided to the domestic sugarcane breeding programs of NARO and the Okinawa Prefectural Agricultural Research Center.

Photo 1. An international meeting on "Balancing Agricultural Production and Environmental Conservation on Tropical Islands" (February 14, 2022 at TARF)

Photo 2. Achievement Briefing Meeting on Asian Monsoon Plant Factory System (AMPFS) Follow-up Activities (December 9, 2021 at TARF)

Academic Prizes and Awards

Project Leader Tsujimoto receives the 18th Japanese Society of Crop Science Best Paper Award

Dr. Yasuhiro Tsujimoto, Project Leader and Senior Researcher of the Crop, Livestock and Environment Division, received the 18th Japanese Society of Crop Science Best Paper Award for the paper titled “Challenges and opportunities for improving N use efficiency for rice production in sub-Saharan Africa.”

This award is given to members of the Crop Science Society of Japan (CSSJ) who are authors of outstanding papers published in the journal *Plant Production Science*. In this paper, they reviewed the problems of low fertilizer input and poor nutrient soil conditions in rice production in Africa, and their improvement measures using the current situation of fertilizer input and utilization efficiency in Madagascar as an example.

The award ceremony was held online at the 251st CSSJ Meeting on March 28–29, 2021.

Link to the award-winning paper:
Yasuhiro Tsujimoto, Tovohery Rakotoson, Atsuko Tanaka & Kazuki Saito (2019). Challenges and opportunities for improving N use efficiency for rice production in sub-Saharan Africa.
https://doi.org/10.1080/1343943X.2019.1617638

Project Leader Yasuhiro Tsujimoto

Dr. Kawai receives the 25th Kira Award of the Japanese Society of Tropical Ecology

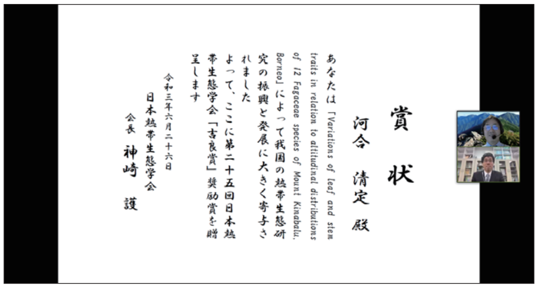
Dr. Kiyosada Kawai of the Forestry Division was awarded the 25th Kira Award of the Japanese Society of Tropical Ecology. The award was given for his research titled “Variations of leaf and stem traits in relation to altitudinal distributions of 12 Fagaceae species of Mount Kinabalu, Borneo.”

The Kira Award is given to a member of the Japanese Society of Tropical Ecology who has made a significant contribution to the promotion and development of tropical ecology research. The award was presented on June 26, 2021.

Dr. Kawai has been studying the function and adaptive significance of leaf and stem characteristics (morphological traits) in temperate and tropical tree species. In the research for which he received the award, he clarified that species with thicker leaves and higher dry weight per leaf area are distributed at higher altitudes and in a wider range of altitudes in the beech family, which is a major component of tropical montane forests in Borneo. It has been known that the species found in tropical montane forests vary greatly depending on altitude, and these results reveal part of the mechanism. The results of this study are expected to contribute to the prediction of the appropriate planting environment for forestry tree species and the evaluation of the impact of temperature increase due to climate change.

Dr. Kawai’s achievement was recognized for its clarification of the importance of leaf shape in environmental adaptation in tropical montane forests, where research has lagged behind, and for providing basic knowledge for environmentally adaptive forestry.

The 25th Kira Award of the Japanese Society of Tropical Ecology
https://www.jaste.website/gakkai
Link to the award-winning paper:
https://doi.org/10.3759/tropics.MS19-14


賞状
河合 清定 殿
あなたは「Variations of leaf and stem traits in relation to altitudinal distributions of 12 Fagaceae species of Mount Kinabalu, Borneo」によって我国の熱帯生態研究の振興と発展に大きく寄与されました
よって、ここに第二十五回日本熱帯生態学会「吉良賞」奨励賞を贈呈します
令和三年六月二十六日
日本熱帯生態学会
会長 神崎 護

Dr. Kawai’s award certificate

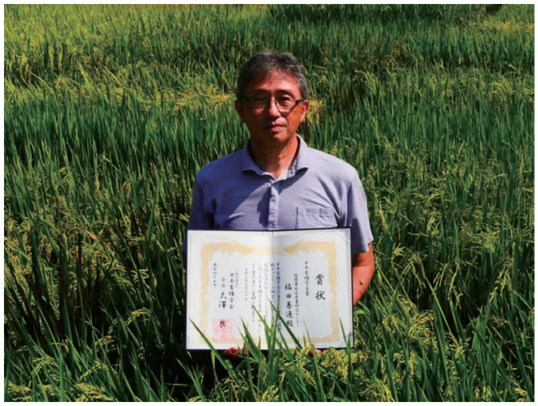
Dr. Fukuta receives the Japanese Society of Breeding Award for dissemination of the rice blast resistance differential system

Dr. Yoshimichi Fukuta, a former senior researcher in the Biological Resources and Post-harvest Division and the Tropical Agriculture Research Front (TARF) and proponent of the international network research for the development of rice blast control technology at JIRCAS, received the 2020 Japanese Society of Breeding Award on March 20, 2021.

The award was in recognition of Dr. Fukuta’s extensive research on the dissemination and utilization of a differential system for rice blast resistance, wherein he developed a system that can evaluate the pathogenicity of rice blast fungus strains and the resistance of rice cultivars in tropical developing regions in Asia and Africa. Dr. Fukuta has also clarified the global distribution of rice blast fungus races and resistance variation in rice cultivars. This has made it possible for countries such as Indonesia, Vietnam, Philippines, and Bangladesh to develop blast control technologies and improve rice cultivars using their own differential systems. For sustainable and stable rice production in the future, it can be said that a foundation has been established for research on the development of pest control technologies based on the differential system, including evaluation of the pathogenicity of resistance genes and fungal systems, breeding of resistant rice cultivars, and clarification of the dynamics of fungal races.

Dr. Fukuta gave the commemorative lecture at the 139th Meeting of the Japanese Society of Breeding held online on March 20, 2021. Due to the continuing coronavirus pandemic, the awarding ceremony scheduled on the autumn meeting of JSB in Hirosaki University was cancelled, and the award certificate and medal were sent to Dr. Fukuta.

Japanese Society of Breeding Homepage (in Japanese)
https://www.nacos.com/jsb/07/07prize_2020.html



Dr. Yoshimichi Fukuta

Dr. Nishigaki bags Best Poster Presentation Award at the Annual Meeting 2021 of the Japanese Society of Soil Science and Plant Nutrition

Dr. Tomohiro Nishigaki, Researcher in the Crop, Livestock and Environment Division, received the award for excellence in poster presentation at the Annual Meeting 2021 of the Japanese Society of Soil Science and Plant Nutrition (JSSSPN) held online on September 14-16, 2021. The winning poster was titled "Cultivation of *Stylosanthes guianensis* can enhance phosphorus dynamics and following rice production in the central highlands of Madagascar."

In his award-winning research, Dr. Nishigaki showed that the forage legume *Stylosanthes guianensis* (stylo) has superior phosphorus absorption capacity compared to rice, maize, and soybean in a phosphorus-deficient farmer's field in Madagascar. Furthermore, rice yield in the following year was higher in the plot where stylo was grown than in the plot where rice or maize was grown in the previous year. The results of this study showed that the cultivation of stylo can enhance nutrient cycling and rice productivity in agricultural fields where phosphorus deficiency is a problem, and can contribute to the adoption of fertilizer management by local farmers who have little access to expensive chemical fertilizers.

JSSSPN Best Poster awarded to Dr. Nishigaki

Former JIRCAS Director receives the 2020 Best Paper of Soil Science and Plant Nutrition (SSPN Award)

Dr. Kazunobu Toriyama, former Director of the Crop, Livestock and Environment Division, and his colleagues have been awarded the 2020 Best Paper of Soil Science and Plant Nutrition (SSPN Award) and received the certificate at the award ceremony at the Annual Meeting of the Japanese Society of Soil Science and Plant Nutrition held online on September 15, 2021.

The award-winning paper entitled "Contribution of fallow weed incorporation to nitrogen supplying capacity of paddy soil under organic farming" was supported by the Japan Society for the Promotion of Science Grant-in-Aid for Scientific Research Grant Number (B) 26310304 (PI: Prof. Kazuhiko Kobayashi, University of Tokyo).

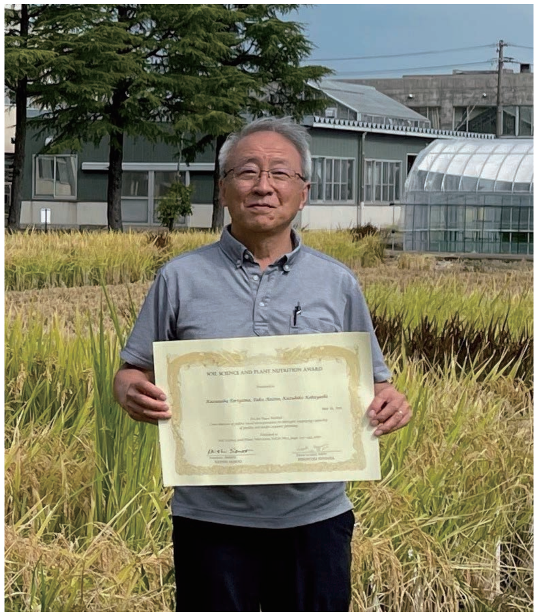
In the paper, fallow weeds were labelled with nitrogen (N) isotope (^{15}N) to track the behavior of N after soil incorporation and to understand the phenomenon that fallow weed incorporation enhances soil N supplying capacity of paddy soil under organic rice farming. Since then, organic farmers in Tochigi Prefecture have been plowing in grass weeds (mainly *Alopecurus aequalis*) during the fallow season for nearly 20 years, and have maintained an average paddy yield of 4.4 t ha^{-1}. The research was conducted to clarify this sustainable rice cultivation practice.

Specifically, the cultivation tests showed that 17% of the N absorbed by rice becomes weed-derived through continuous weed incorporation for several years or more, and that sustainable rice production is possible by increasing and maintaining soil N supply capacity through weed-derived N. In conventional organic rice cultivation, leguminous green manure has been attracting attention from the aspect of aerial N fixation, but it tends to cause excessive N supply, and its control has been an issue. The grass weed plowing during the fallow season, which is the subject of this study, absorbs 30-40 kg N ha^{-1} of the mineralized soil N during the fallow season in early spring and returns the entire amount to the soil, which not only reduces N loss from fallow fields but also supplies comparatively stable amount of N, thus an adequate N supplying technique for organic rice farming.

Incidentally, in May 2021, the Ministry of Agriculture, Forestry and Fisheries (MAFF) formulated the "Strategy for Green Food Systems, MeaDRI" to achieve both productivity improvement and sustainability of the food, agriculture, forestry, and fisheries industries through innovation in order to build a sustainable food system. One of the goals of the strategy is to increase the ratio of organic farming to total cultivated land to 25% (1 million hectares) by 2050.

The results of this study, which revealed the contribution of fallow weeds to nitrogen supply in paddy field soils under organic farming, not only received high academic acclaim, but will also contribute to the establishment of a sustainable food system through the promotion of organic farming in Japan and overseas.

Toriyama K, Amino T, and Kobayashi K (2020). Contribution of fallow weed incorporation to nitrogen supplying capacity of paddy soil under organic farming. *Soil Science and Plant Nutrition*, 66: 133-143.



Former Director Kazunobu Toriyama

Alopecurus aequalis

Project Leader Tsujimoto and collaborators receive the ACSAC10 Best Presentation Award

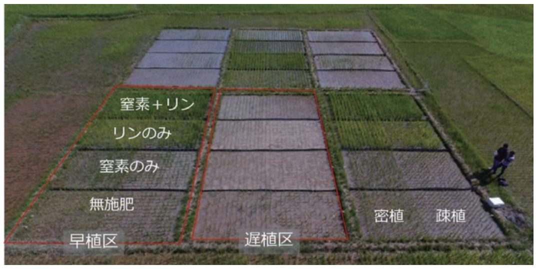
The research results of Project Leader Dr. Yasuhiro Tsujimoto (Crop, Livestock and Environment Division) and collaborators, presented by Dr. Bruce Haja Andrianary of the University of Antananarivo, Madagascar, received the Best Presentation Award at the 10th Asian Crop Science Association Conference (ACSAC10) which was held online on September 8-10, 2021. The presentation titled "The Effect of Nitrogen and Phosphorus Applications on Rice Yield can be Changed by Farmers' Management Practices —Transplanting Dates and Densities" focused on the interaction between the effect of phosphorus fertilization and climatic conditions in rice cultivation.

The results of the award-winning research provided field evidence that the effect of P application differs depending on the climatic growing conditions. The repeated on-farm trials in the central highlands of Madagascar identified that phosphorus deficiency delayed the heading dates of rice by 6 to 24 days. The prolonged growth duration increased the risk of cold stress at reproductive to ripening stages because temperature declines at the end of the rainy season. Then the effect of P application was much greater when avoiding cold stress by shortening the growth duration.

It is well known that phosphorus deficiency delays the development of rice and other plants, but its effects on crop productivity through changes in climatic conditions during the growth period have not been shown. The results obtained in this study are expected to lead to more effective use of phosphorus fertilizers, which are concerned about environmental impact and resource depletion, and may lead to improved phosphorus fertilization efficiency and rice yield.

In addition, on May 12, 2021, the Ministry of Agriculture, Forestry and Fisheries (MAFF) launched the "Strategy for Sustainable Food Systems, MeaDRI" which aims to achieve both improved productivity and sustainability of food, agriculture, forestry and fisheries through innovation. Within this strategy, MAFF also aims to reduce the use of chemical fertilizers, and the results of this project are expected to contribute to the international development of this strategy.

Part of the results of this research is available in the September 2021 issue of the *Field Crops Research* journal.
https://doi.org/10.1016/j.fcr.2021.108256



In this study, the effects of different transplanting dates, planting densities, and fertilization methods on rice productivity were repeatedly tested in farmers' fields in Madagascar.

Dr. Andrianary (third from right) completed his dissertation including the results of this research and was awarded the PhD degree from the University of Antananarivo (Project Leader Tsujimoto is second from right).

Project Leader Fujita among Most Highly Cited Researchers in 2021 Clarivate Listing

In November 2021, Dr. Yasunari Fujita, Project Leader in the Bioresources and Post-harvest Division of JIRCAS, has been selected by Clarivate Analytics of the USA as a Highly Cited Researcher in the field of Plant and Animal Sciences for the eighth consecutive year.

Each year, Clarivate, a company providing analytics of scientific and academic research, identifies the world's most influential researchers who have published multiple papers frequently by their peers in the past decade. The year 2021 saw the selection of approximately 6,700 researchers from around the world across 21 research fields and multiple disciplines.

Project Leader Fujita aims to lead the development of resilient crops through molecular biological research related to stress tolerance of plants, and has been cited in various research papers on environmental stress.

Project Leader Fujita (right) with President Koyama (left)

References

Clarivate Analytics Web of Science
https://clarivate.com/webofsciencegroup
Highly Cited Researchers 2021
https://clarivate.com/wp-content/uploads/dlm_uploads/2021/11/Executive_Summary_Highly_Cited_Researchers_2021.pdf

Project Leader Tsujimoto receives the 20th Japan Prize in Agricultural Sciences, Achievement Award for Young Scientists

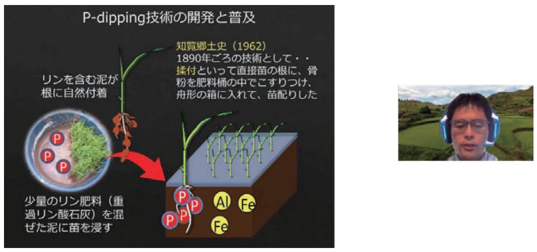
Dr. Yasuhiro Tsujimoto, Project Leader in the Crop, Livestock and Environment Division of JIRCAS, has been awarded the 20th Japan Prize in Agricultural Sciences, Achievement Award for Young Scientists, for his research on the development and dissemination of effective rice fertilization technology suitable for cultivation environments in Africa. The Foundation of Agricultural Sciences of Japan gives the award to young researchers who have made outstanding contributions to the advancement of agriculture.

Project Leader Tsujimoto is currently pursuing research on improving crop productivity in Africa, constantly visiting, making observations, and doing experiments at the production sites. In the process, he devised a fertilization technique in which a small amount of phosphorus fertilizer is added to the roots of rice seedlings before transplanting. This technology is already being used in Madagascar, and was highly evaluated as an achievement that can contribute to improving rice productivity in Africa, where the amount of fertilizer input is low and soil phosphorus deficiency and various environmental stresses are problems.

The award ceremony was held on November 26, 2021 at the Yayoi Auditorium, University of Tokyo. Project Leader Tsujimoto was on a business trip to Madagascar, so he participated in the awarding ceremony and gave the commemorative lecture online.

List of 2021 Awardees
http://www.nougaku.jp/award/award1.2021.html

PL Tsujimoto participating in the awarding ceremony online from Madagascar



PL Tsujimoto giving the commemorative lecture

Auditor Isoda (Part-time) receives the 17th JICA President Award

Auditor Hiroko Isoda (part-time) received the 17th Japan International Cooperation Agency (JICA) President Award at the commendation ceremony held at the JICA Headquarters in Chiyoda-ku, Tokyo on December 9, 2021.

The JICA President Award is presented each year to individuals and organizations in recognition of their achievements and significant contributions to human resources and socio-economic development in developing countries through international cooperation projects. This year, the JICA President Award was presented to 42 individuals and organizations.

Auditor Isoda is currently Professor at the Alliance for Research on the Mediterranean and North Africa (ARENA), Faculty of Life and Environmental Sciences, University of Tsukuba. She was awarded for her longtime contribution to the JICA projects in the North African region. Congratulations to Auditor Isoda!

※ JICA Website: The 17th JICA President Award Commendation
https://www.jica.go.jp/english/news/press/2021/20211206_en_21.html

Dr. Matsumoto receives the Iwate Prefecture Governor's Award

On December 22, 2021, Dr. Yukio Matsumoto, Researcher in the Fisheries Division, received the best paper award for research on Sanriku coast by Iwate Prefecture for his research on "Fenton reaction as a possible stimulus to induce spawning in Ezo abalone *Haliotis discus hannai* during stormy weather."

Synchronous spawning is an important behavior which increases fertilization success of invertebrates with external fertilization. In this study, it was observed that Ezo abalone released eggs after rainwater reached the sea bottom due to the passage of a low-pressure system. The hydroxyl radicals produced by the chemical reaction between hydrogen peroxide and iron (II) ions (Fenton reaction) in the rainwater may induce egg releasing behavior of Ezo abalone. In addition, it was confirmed that the Fenton reaction in the aquarium can induce the spawning of abalone easily and with high probability.

This method may be applied to the egg collection of donkey's ear abalone (*Haliotis asinina*) and other marine invertebrates (sea cucumbers, bivalves etc.), which are important aquaculture species in Southeast Asia.

In order to accumulate research personnel and revitalize marine and fisheries research along the Sanriku coast of Iwate Prefecture, the prefectural government has been implementing the "Paper award for research on Sanriku coast by Iwate Prefecture" since 2009, inviting and commending young researchers for their research papers based on the Sanriku area. Dr. Matsumoto's research was recognized for scientifically clarifying basic knowledge on abalone spawning during storms.

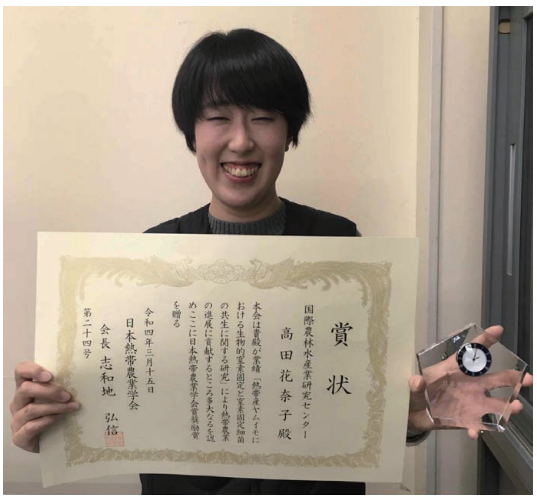
Dr. Matsumoto (front row, left) with the Iwate Vice-Governor (front row, center)

Research Fellow Takada receives the JSTA Promotional Award for Achievement in Tropical Agriculture

Dr. Kanako Takada, a research fellow in the Crop, Livestock and Environment Division, received the 2022 Promotional Award for Achievement in Tropical Agriculture from the Japanese Society for Tropical Agriculture (JSTA) for her research on biological nitrogen fixation and symbiosis of nitrogen-fixing bacteria in tropical yams. The awards ceremony and lecture were held on March 15, 2022.

This prize is awarded to JSTA members who have made outstanding research achievements that contribute to the advancement of tropical agriculture and are expected to make further progress in the future.

The award-winning research focused on biological nitrogen fixation by symbiosis with microorganisms in yam, which is produced as a staple food crop in tropical and subtropical regions such as West Africa. The study revealed symbiotic relationships of yam with various bacteria, including nitrogen-fixing bacteria, and that these bacteria are able to fix nitrogen from the atmosphere and promote the growth of yam. The research results have been recognized for elucidating the unique nitrogen absorption mechanism of yams, and for demonstrating new findings that symbiotic microorganisms contribute to the growth and nutrient absorption of yams.



Dr. Kanako Takada

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 Fifth Medium to Long-Term Goals in FY 2021, including that JIRCAS will focus on research areas that address growing expectations for the development of technologies in the agriculture, forestry, and fisheries sectors to achieve the Sustainable Development Goals (SDGs). Based on the Fifth Medium to Long-Term Goals, JIRCAS drafted and began to implement a detailed five-year plan, the Fifth Medium to Long-Term Plan (FY 2021 - FY 2025).

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 2021 as follows:

1) Research activities for each Research Project were reported in January 2022.
2) Summary reports of research activities for each Research Program were prepared. In addition, summary reports of the management of research and development activities were also prepared. These reports were collectively evaluated by the President, Vice-President, Auditor, and Program Directors at the in-house evaluation meeting held in mid-February 2022.
3) A meeting to promote research cooperation in international agriculture, forestry and fisheries was held in late February 2022. The research activities of JIRCAS were reported to government officials from MAFF and specialists from other research institutes under MAFF, and there was an exchange of ideas on how to promote cooperation with JIRCAS.
4) The JIRCAS External Evaluation Committee performed a comprehensive evaluation of all JIRCAS activities, which also include administrative operations, in a meeting held in March 2022.

The members of the evaluation committee are listed in the Appendix. The results of the in-house evaluation and a summary of all activities were submitted to MAFF in June 2022.

5. Medium to Long-Term Plan

JIRCAS implements three 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 2021 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 Fifth Medium to Long-Term Plan (FY 2021 - FY 2025)

Program	Projects
A (Environment)	6
B (Food)	6
C (Information)	4

Fifth Medium to Long-Term Plan (FY 2021 - FY 2025)

Program A

Development of agricultural technologies for climate change, resource recycling and environmental conservation

Projects:

1. Development of comprehensive agricultural technologies for climate change mitigation and adaptation in Monsoon Asia
2. Development of carbon recycling technologies to address global issues caused by agricultural waste
3. Development of planet-friendly agricultural production systems using biological nitrification inhibition (BNI) technology
4. Evaluation of genetic resources for strengthening productivity and adaptability of tropical forests
5. Development and evaluation of environmental conservation technologies for tropical islands through an approach emphasizing Yama-Sato-Umi (Ridge-to-reef agroecosystem) connectivity
6. Development of sustainable land management technologies under extreme weather conditions in drylands

Program B

Technology development towards building a new food system with improved productivity, sustainability and resilience

Projects:

1. Development of resilient crops and production technologies
2. Design of crop breeding and food processing of indigenous resources to create new and diversified demands
3. Development of environment-friendly management systems against transboundary plant pests based on ecological characteristics
4. Development and dissemination of sustainable aquaculture technologies in the tropical area based on the eco-system approach
5. Development of sustainable rice cultivation and food production systems in Africa
6. Technology development towards supporting farmers' decision-making to boost sustainable upland farming system in Africa

Program C

Strengthening function as an international hub for providing strategic information on agriculture, forestry and fisheries, and mobilizing new research partnerships

Projects:

1. Strategic information hub for international agricultural research
2. Practical application of global research results and establishment of a model platform for promoting private-sector research collaboration and creating new business ventures
3. Towards the development of digital agriculture technologies in Sub-Saharan Africa
4. Advancement of tropical crop genetic resources utilization through the development of database, technologies and research networking

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 120 MOUs and JRAs remained in force at the end of FY 2021.

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.

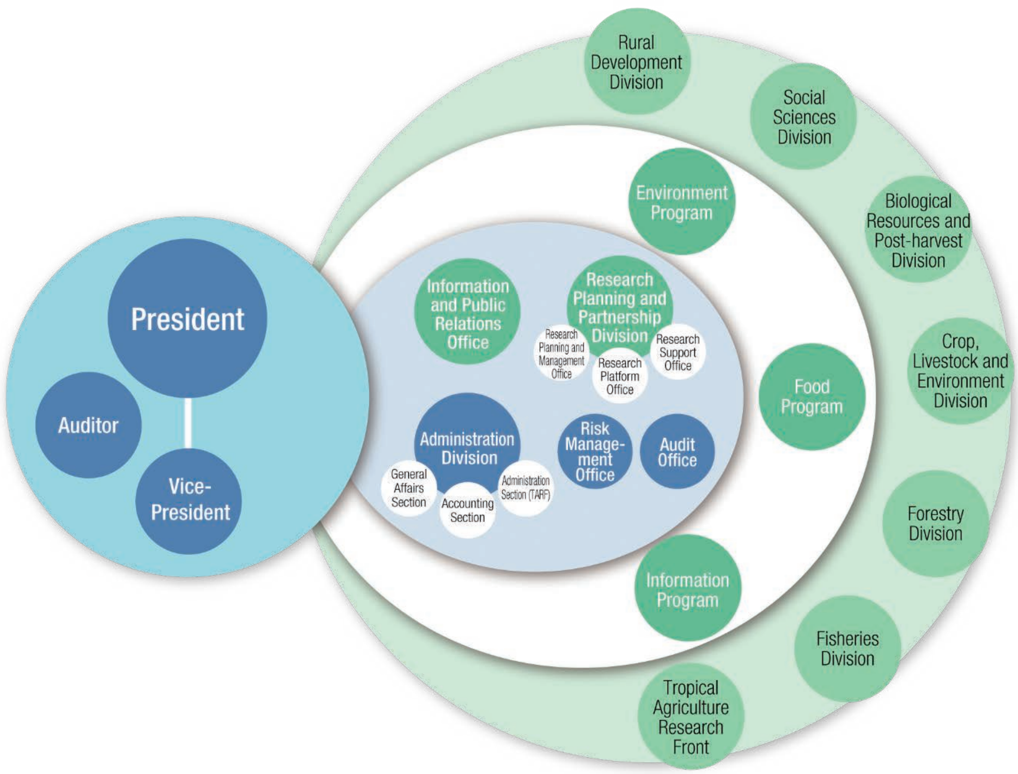
7. Organization of JIRCAS

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

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

The directors of divisions 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

"Development of agricultural technologies for climate change, resource recycling and environmental conservation"

A significant rise in greenhouse gas (GHG) emissions through crop cultivation, livestock production, and extractive forest resource use has amplified the burden on people's lives and the environment. The 'Environment Program' aims to ensure sustainability in the agriculture, forestry, and fisheries sectors and establish appropriate resource management by maximizing resource use efficiency, especially in developing countries and regions that are vulnerable to the adverse impacts of climate change.

[Climate change measures in Monsoon Asia]

For this project, we selected a study site in Cambodia for multiple drainage in a large paddy area and proceeded with the preparation for field observations, including soil greenhouse gas emissions. We revealed that multiple drainage can increase rice yield as well as reduce soil methane emission, compared to continuous flooding as noted from paddy fields in An Giang Province, Vietnam. We tested the connectivity of ICT devices in Vietnam and started ICT operations in the paddy fields. A visualization tool that estimates the utility of irrigated reservoirs was developed. We found that multiple drainage can cancel out the enhancement of soil methane emission by biogas effluent application in a paddy field. Our studies suggest that the water requirement of ratoon rice is larger in the early growth stage and smaller in the late growth stage compared to transplanted rice. We conducted preliminary cultivation experiments for rice yield increase by multiple drainage in Japan and analyzed the optimum environmental and agronomic conditions to achieve it. Using satellite data archived over the past 40 years, the diffusion of irrigation systems was monitored in the Ayeyarwady Delta in Myanmar. As a result, an increase in cultivation area was observed due to an increase in the cropping intensity. However, a decreasing trend in vegetation activity due to salt damage was observed in the coastal regions.

We analyzed the physicochemical properties of soils collected from various environments and land uses in Negros Island, Philippines, and revealed that soil carbon content in the tropical humid region is not influenced by the amount of clay but strongly by its quality. We also confirmed that some soils have a high carbon storage potential.

We have clarified that the most common system of cattle manure management in Southern Vietnam is sun-drying. We measured the GHG emission by chamber-based approach to estimate the country-specific emission factor value for the category. We established a highly precise estimation equation for enteric methane emission with a large dataset that covers the Southeast Asian countries. Enteric methane emission data were gathered from the Global Research Alliance - Livestock Research Group (GRA-LRG) representatives of Southeast Asian countries. We incubated *Pichia kudriavzevii* C3-9 with cassava pulp without specific information about the produced region and found that the amount of cell wall proteins and β-glucan decreased compared to incubation with the standard culture medium, indicating that incubation with cassava pulp alters the cell wall composition of the yeast and exposes the chitin, the inner cell wall component.

The results of long-term experiment conducted in Thailand during the previous medium to long-term plan were compiled and presented to the Department of Agriculture, Ministry of Agriculture and Cooperatives of Thailand, and a discussion was initiated on concrete efforts toward strengthening the Nationally Determined Contribution (NDC) of Thailand on GHG emission reduction.

[Carbon recycling]

The establishment of technologies and social systems that promote agricultural waste recycling will help address issues related to the treatment and disposal of farm waste. This project will develop a microbial saccharification-gasification bioreactor to generate biogas and hydrogen from agricultural waste with high efficiency at a larger scale. We have successfully developed a new saccharification technology for brewers' spent grain (BSG). Facultative anaerobic microorganism *Paenibacillus macerans* strain I-6 was isolated and has shown high degradation ability for BSG. Based on strain I-6, a biogas production system from BSG has been developed. This technology will contribute to reducing GHG emissions in food factories through recycling of the agricultural waste.

[BNI-system]

Field testing of biological nitrification inhibition (BNI)-enabled wheat (BNI-Munal and BNI-Roelfs F2007) was conducted at the Hachimandai Experimental Field in Tsukuba for confirmation of the BNI effect introduced from *Leymus racemosus*. After coordinating with Indian research institutes, JICA, and JST on the SATREPS project, experimental sites for BNI-enabled wheat were selected in five Indian states (Punjab, Haryana, Delhi, Madhya Pradesh, and Bihar).

Zeanone and HDMBOA were found as major hydrophobic BNI compounds in maize, as well as HMBOA and HDMBOA-β-glucoside, which are converted to HDMBOA in the soil to exhibit BNI. It was explained that 45% and 69% of BNI in maize was due to the hydrophobic and the hydrophilic compounds, respectively.

We compared quantities of gene and expression of the ammonia monooxygenase gene (amoA) in nitrifying bacteria and archaea using soil DNA and RNA. Quantification of nitrifying bacteria and archaea using developed protocols was conducted by tube cultivation trials of each of the two high- and low-sorgoleone lines.

The turnover time of *Brachiaria* roots to establish a DNDC (Denitrification-decomposition) model for the *Brachiaria*-maize rotation system was measured at the Tropical Agriculture Research Front (TARF) with a minirhizotron imaging system accompanied by N_2O emission and soil chemical analysis. The BNI effect on post-*Brachiaria* maize production was conducted up to the fourth crop after *Brachiaria* pasture.

BNI compounds were incubated together with the soil from the Hachimandai Experimental Field in the presence of ammonium ions to verify the nitrate formation and behavior of BNI compounds. MBOA showed a different dose-response curve from those of usual BNI compounds; however, MBOA and zeanone showed significant nitrification inhibition in the soil, and were degraded gradually by soil microorganisms.

Ex-ante impact analysis of GHG reductions by BNI-enabled wheat was conducted based on life cycle assessment (LCA). A preliminary and post-dry season survey was conducted in Maharashtra State, which is the main sorghum production area in India, and areas with soil pH of 4–7 were selected for the survey as suitable sites for BNI-enabled sorghum ex-ante analysis.

The BNI International Consortium website system was renewed to facilitate updating by item. The 4th BNI International Consortium Meeting, which had been planned for March 2022, was postponed to November 2022 due to the difficulty of holding the meeting because of border measures and regulations against COVID-19. Worldwide recognition of BNI research was promoted through national and international media.

[Adaptive forestry]

Tropical forests are rich in diversity and have trees with a variety of excellent properties for timber but there are challenges to the sustainable use of such resources. This project aims to clarify the characteristics, functions, and adaptability to environmental changes of the indigenous genetic resources of tropical forests in Southeast Asia and other regions, and to develop silviculture technologies to enhance forest productivity and environmental adaptability to climate change based on the results. In this project, we clarified the following eight subjects. 1) The sapwood density and the degree of native embolism were negatively correlated during the dry season across nine drought-deciduous tree species in a seasonal tropical forest in northeastern Thailand, suggesting that sapwood density can be used as an index of drought tolerance of tropical trees. 2) In our common garden experiment, the height growths of *Shorea leprosula* were significantly different among populations. In *S. leprosula*, the excision of expanding leaves caused a significant reduction of shoot elongation, indicating that young expanding leaves positively regulate shoot elongation. This result suggests that observation of leaf expansion would help to understand the timing of shoot elongation and to identify environmental factors regulating shoot elongation in *S. leprosula*. 3) Genome sequencing of *S. leprosula* revealed that a whole-genome duplication occurred around 70 million years ago in the common ancestor of dipterocarps after the split from Malvaceae such as cacao. Drought-responsive genes were enriched in the retained duplicated genes of the dipterocarp genomes compared to other genes. The information on the dipterocarp genomes and drought-responsive genes will help to select drought-tolerant dipterocarps adapted to future climates for planting. 4) Aiming at the technical development of genomic selection, a progeny trial of *Shorea macrophylla* in Gadjah Mada University was adopted for developing methods of genomic prediction model. Among 290 individuals in the progeny trial, Single Nucleotide Polymorphisms (SNPs) at 14,923 loci were identified and five SNPs of these were significantly associated with tree height. In addition, using convolutional neural network (CNN), a genomic prediction model that predicts tree height and other phenotypic traits was improved. 5) Analysis of existing data on tropical forest trees revealed that leaf hardness depends on thickness and existence of bundle sheath extension, regardless of tree species, and that all dipterocarp species, which are important timber tree species, correspond to this leaf type. 6) To develop a growth model for planted timber tree species, we analyzed the data on *Shorea parvifolia* after 23 years of planting, using a plantation of local tree species such as dipterocarp established by JICA about 30 years ago in Chikus, Perak, Malaysia. As a result, we clarified that diameter growth increased with the width of planting line, whereas the survival rate decreased significantly with the width. 7) A portable automated chamber system was designed to monitor soil CO_2 and CH_4 flux at the same time in several forests and plantations in Malaysia and Indonesia. In addition, the preliminary survey on soil microbial dynamics and GHG balance in a forested site in Hokkaido revealed that global warming brought about the decrease in the amount of anaerobic soil methanogen (methane producer) due to soil aridification and subsequent increase in the amount of CH_4 uptake in soil. 8) Online discussions were conducted among main counterpart institutions, such as the Forest Research Institute Malaysia, the Royal Forest Department in Thailand, and the Faculty of Forestry, Gadjah Mada University in Indonesia, to apply the outcomes of collaborative researches on genetic diversity and select suitable planting sites for conservation of genetic diversity and forest restoration of tropical genetic resources while considering the environments for adaptation. Dipterocarp, teak, rosewood, and falcataria species were selected as target species for the project.

[Yama-Sato-Umi agroecosystem connectivity]

Bagasse, a sugar processing residue, was used as mushroom beds and tree sapling medium. The availability of the material was confirmed in field tests. An underground irrigation system, OPSIS (optimized subsurface irrigation system), was installed at TARF and soil moisture observation has been started to clarify the moisture characteristics at different installation depths. A pipe experiment was conducted at different biochar application depths, and we confirmed that biochar application mitigated nitrate leaching. Experiments to develop deep planting technology in sugarcane cultivation were started at TARF in Japan and in Negros and Luzon islands in the Philippines, and the soil moisture contents at different planting depths were found to be different. Indoor lysimeter tests showed that *Erianthus* and an intergeneric F_1 hybrid of sugarcane and *Erianthus*, exhibited greater dry matter partitioning to roots and lower nitrate nitrogen leaching compared to those of sugarcane. We found that some isolated microalgae can grow high in neutralized sugarcane mill wastewater. Field surveys were conducted to determine the distribution and seasonal changes of three target seaweed species in Ishigaki Island. A periodic water quality monitoring was conducted for the major rivers in Ishigaki Island to evaluate the relationship between the river water quality and its catchment characteristics. An analysis using a machine learning method revealed that the concentrations of nutrients (nitrogen, phosphorus, and silica) in river water were strongly dependent on the catchment properties (e.g., land use, surface geology). For example, areal coverages of sugarcane fields and livestock barns were among the most important in nitrogen concentration, indicative of the significant contributions of agricultural and livestock productions in the watershed. Activities to prevent red soil runoff from farmland are assumed to become established in Okinawa Prefecture based on information from local organizations that support farmers' activities. The nitrogen footprint—a tool which estimates the amount of nitrogen released into the environment from the food production system—was applied to Ishigaki Island to identify agricultural products and production processes that have higher environmental impacts.

[Sustainable land management in drylands]

To achieve sustainable agriculture and food security in drylands, it is crucial to develop a sustainable land management (SLM) strategy consisting of both soil conservation/restoration techniques and a drought-resilient cropping system.

In Burkina Faso, four-year field experiments at the INERA Saria Station showed that the "Fallow Band System" increased sorghum yield by 1.5 times compared with control. With regard to the combined technology of stone line and grass strip of *Andropogon*, the payback period and future benefits were clarified. In order to increase the size and durability of "Soil Block" in line with local needs, the mixing ratio of soil and organic matter was evaluated at TARF and it was shown that the soil/organic matter ratio of 6:4 was the most suitable with less collapse and deformation. In the socio-economic survey aimed at developing an effective dissemination method for soil conservation technologies, we established a survey system, selected the survey site, and collected socio-economic information in the site. We also obtained information on farmers' awareness of soil deterioration and their evaluation of the "Fallow Band System." To modify the questionnaires for baseline survey, we pretested the prototype.

To understand crop responses to different soil types under three climate zones in the Sudan savanna, experimental fields were installed in farmers' villages located in North and South Burkina Faso. Field locations were determined through a soil survey conducted by line transects to detect the representative soils of this region. Preliminary field trials using major upland crops elucidated that the most adaptable crop species are different for each of the patterns of drought stress that occurred in response to the soil types. Tolerance evaluation for drought and excess water stresses were performed for cowpea genetic resources at the International Institute of Tropical Agriculture (IITA), Nigeria. Several accessions were identified as potential gene sources for stress tolerance. Soybean genetic resources were applied for the screening of varieties with good emergence from hard crusted soil. A rapid screening method was developed using artificially developed mimic soil crust which makes it possible to evaluate seed emergence under uniform condition. Potential varieties of crust tolerance were identified for seed multiplication to test in field trials. To detect the occurrence of historical drought, a simulation model that estimates changes in soil water content was developed. A cowpea yield simulation model was also developed to evaluate the effect of historical droughts on grain production.

In India, the installation depth of a sub-surface irrigation tube (20cm), the construction interval of Cut-soiler (2m), and soil analysis items were determined. The setting up of lysimeter and field experimental plots was started from the end of November, and the soil sampling point was determined. A supplementary test was conducted at TARF to examine the installation depth of a water drop tube, and it was confirmed that if the depth is 20 cm, water can be saved without a large reduction in yield. As a result of analyzing groundwater data in India, it was confirmed that groundwater level dropped by about 3 m in the rainy season, and we found that there is a possibility of excessive water intake not commensurate with rainfall, causing upconing (i.e., a rise in the freshwater-saltwater interface beneath a pumping well). To obtain a highly accurate conversion formula ($EC_{1:2}$ to EC_e) useful for evaluating salt affected soil, we started soil sampling and analysis from the end of January. To evaluate the applicability and dissemination potential of the developed technology, candidates for the farmer survey were selected from the groundwater irrigation area, and a survey system was established. In addition, the survey form was prepared for preliminary survey in the next fiscal year.

TOPIC 1

Multiple drainage can cancel out the enhancement of methane emission by biogas effluent application in a rice paddy

Household biogas production from livestock manure and its domestic use in cooking and heating is popular in Vietnam. However, the discharge of untreated biogas effluent (also known as methane fermentation digestate) containing plant nutrients, including nitrogen, into rivers causes local environmental problems such as water pollution. To address this issue, the biogas effluent was used as organic fertilizer for rice, the locally dominant crop, and was found to be effective (2019 Research Highlights article entitled "Variable-timing, fixed-rate application of cattle biogas effluent as fertilizer for rice using a leaf color chart"). However, because biogas effluent also contains labile organic carbon, which is a substrate for microbial production of methane (CH_4), a potent greenhouse gas (GHG), its application to a paddy field may enhance CH_4 emission from the flooded soil. Here we hypothesized that combining multiple drainage with biogas effluent application can cancel out the CH_4 enhancement, and tested this by observing a farmer's paddy field with triple rice cropping in the Mekong Delta, Vietnam.

Chemical properties, including organic matter content, of the biogas effluent produced from cattle manure varied among rice seasons, and the application of cattle biogas effluent increased

CH_4 emission by 19% on average as compared to synthetic fertilizer application (Fig. 1). We tested two multiple drainage practices: alternate wetting and drying (AWD), which is a water-depth-dependent irrigation method; and midseason drainage followed by intermittent irrigation (MiDi), which is a day-number-dependent irrigation method. Although the lowland location made it difficult to naturally drain flooded surface water, both AWD and MiDi reduced CH_4 emission in proportion to the increase in the number of drained days between crop establishment and final drainage in each rice season (Fig. 2). As a result, the proposed combination practices reduced CH_4 emission by 11–13% and nitrous oxide (N_2O), another potent GHG, emission by 35–54% without loss of grain and straw yields as compared to the conventional practice with synthetic fertilizer application and continuous flooding (Fig. 3). The Global Warming Potential (GWP), carbon dioxide (CO_2)-equivalent of combined CH_4 and N_2O emissions, and grain-yield-scaled GWP were also reduced by the proposed combination practices.

The results indicate that the proposed combination practice (i.e., multiple drainage with biogas effluent application) can be applied to the rice-producing areas using livestock biogas effluent as organic fertilizer. It is likely that multiple drainage can further reduce CH_4 emission in case of a field location under better drainage conditions.

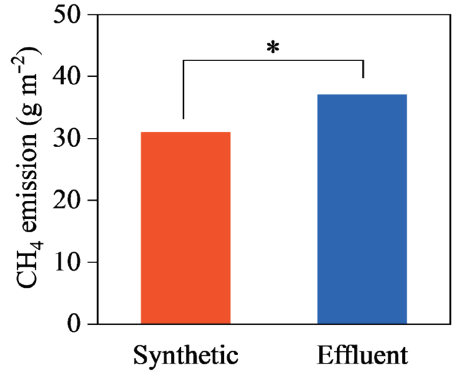


Fig. 1. CH_4 emissions from synthetic fertilizer application and biogas effluent application
Statistically significant difference at $p < 0.05$ by ANOVA

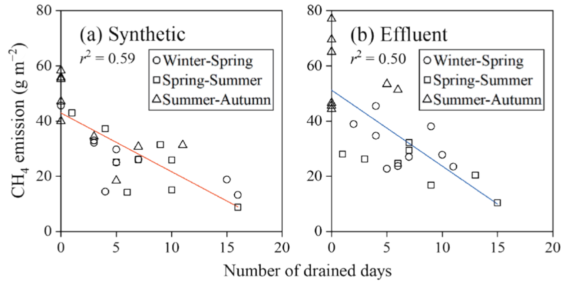


Fig. 2. Relationships between CH_4 emission and the number of drained days between crop establishment and final drainage in each rice season for (a) synthetic fertilizer application and (b) biogas effluent application

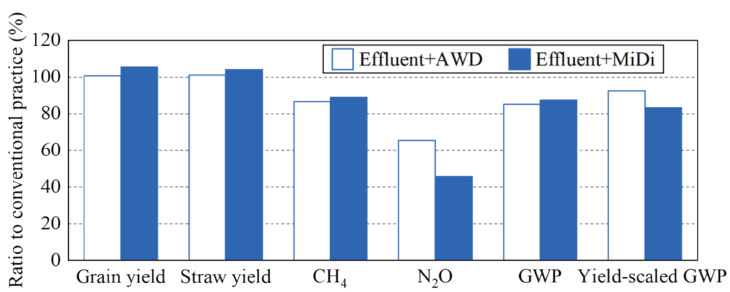


Fig. 3. Comparisons between the proposed combination practices, biogas effluent application with AWD or MiDi, and the conventional practice with synthetic fertilizer application and continuous flooding

Reference

Minamikawa K et al. (2021) *Agriculture, Ecosystems and Environment* 319: 107568

Figures reprinted/modified with permission.

(K. Minamikawa, K. Uno, K.C. Huynh [Can Tho University, Vietnam (CTU)], N.S. Tran [CTU], C.H. Nguyen [CTU])

TOPIC 2

Water requirement of ratoon rice is larger in the early growth stage and smaller in the late growth stage compared to transplanted rice

Actual crop evapotranspiration (ET) and crop coefficients (Kc values) are necessary for ratoon rice crop irrigation planning, but these data have been hardly reported. Kc is usually determined experimentally, using ET values measured by lysimeters and eddy covariance. However, especially in developing countries, determining Kc remains difficult because ET observation systems are expensive. The focus of this study, therefore, was to evaluate the ET and Kc of ratoon cropping in a tropical region of Myanmar using a simplified method.

Our method combined the manual observation of water depth in concrete paddy tanks (1.62 m L × 0.84 m W × 0.4 m D on the inside of tank) and the ET model estimation using Bayesian parameter inference with meteorological data. The difference in daily pond water depth (mm day^{-1}) above the soil surface in a tank with and without planting rice are defined as daily ET and evaporation (E), respectively. When it rains, the daily pond water depth cannot be measured because the water balance in the tank is unknown. The missing ET and E values could be interpolated with modeled values by statistical modeling to determine the Kc values (Fig. 1).

The ratios of ET and E of ratoon crop to main crop (59% and 55% for the rainy season and 74% and 82% for the cool and dry season) were almost equivalent for both seasons (Fig. 2). Thus, the difference in the ET between main crop and ratoon was mainly attributed to the difference in climate conditions in each cropping period. The R^2 of the transplanted rice was higher than that of the ratoon in number of tillers with the accumulated temperature. The transplanted rice reached the maximum tillering period at about 1,500°C accumulated temperature. On the other hand, the ratoon had vigorous tillering with large variations in the initial growth stage (Fig. 3). Consequently, the Kc regression curves for transplanted rice and ratoon crops were considerably different because of the difference in tillering traits (Fig. 4). The results suggest that irrigation scheduling of ratoon rice cropping should take into account higher crop water requirements in the initial growth stage and less water consumption in the late growth stage than transplanted rice cropping.

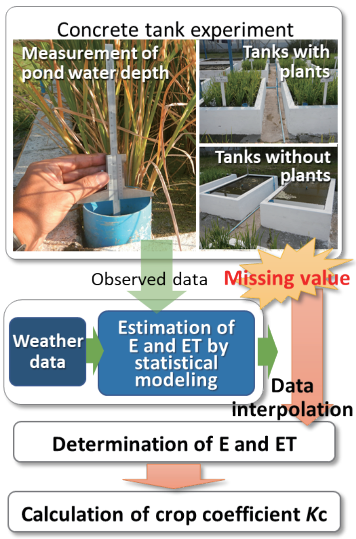


Fig. 1. Calculation procedure for crop coefficient Kc
Weather data indicate the net radiation, air temperature, humidity, and wind speed.

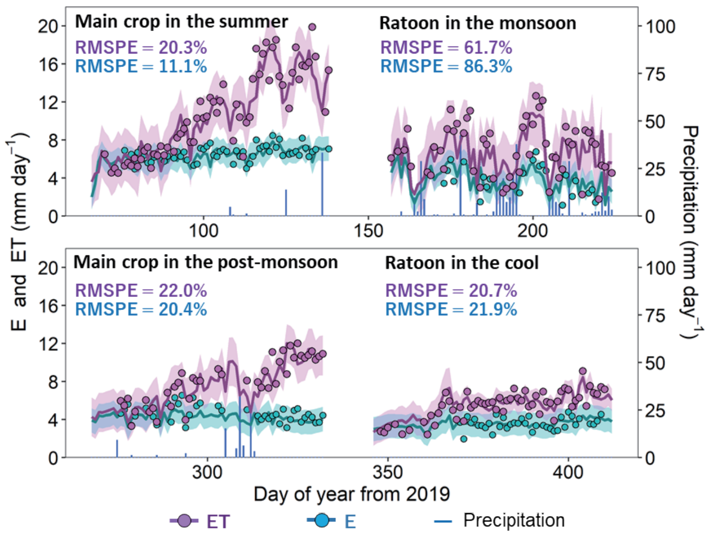


Fig. 2. Observed and estimated E and ET in ratoon double rice cropping in different seasons
The periods of the first and second double cropping are February 2019 to August 2019 and September 2019 to April 2020, respectively. The model estimates are described with lines and bands corresponding to the means and 95% credible intervals. RMSPE, root mean squared percentage error.

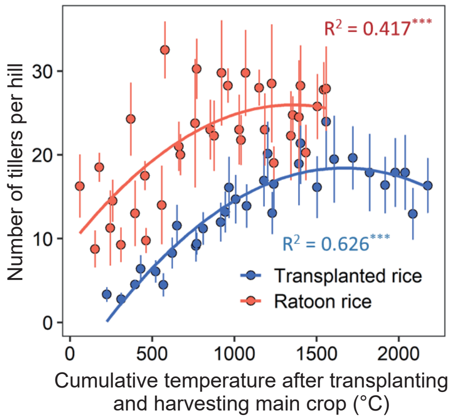


Fig. 3. Comparison of the cumulative temperature and number of tillers per hill described with non-linear bands and dots with bars
The error bars, the standard errors (n = 4~8); R^2, determination coefficient; ***, 0.001% significance level.

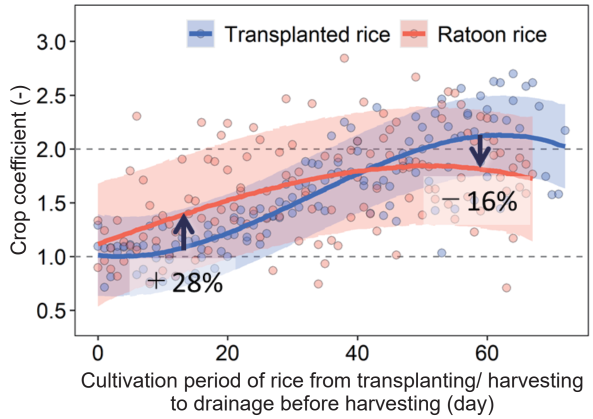


Fig. 4. Kc regression curves for transplanted and ratoon rice described with lines and bands corresponding to the means and 95% credible intervals (transplanted rice: *n* = 138, ratoon: *n* = 135)
Values with percent in the figure is the increase-decrease rate in the Kc of ratoon rice with transplanted rice.

Reference

Shiraki S et al. (2021) *Agronomy* 11(8):1573. https://doi.org/10.3390/agronomy11081573
Figures reprinted/modified with permission.

*(S. Shiraki,
Thin Mar Cho [Department of Agricultural Research (DAR), Myanmar])*

TOPIC 3

Effect of conventionally decomposed oil palm trunks on the soil environment

Oil palm fruit is harvested 3 years after planting until the harvest yield declines at around 25 years, and oil palms need to be replanted at an interval of 25–30 years to maintain oil productivity. Oil palm trunks (OPTs) are logged for replantation and the fiber residues are disposed of into the palm plantation area. The fiber residues are expected to increase soil fertility through recycling of carbon and minerals via fiber decomposition. However, the unregulated disposal of OPT can have detrimental effects on soil functioning and plant growth. To understand the effect of OPT fiber on the soil environment, this study compared corn, tomato, and bean plant growth and nutrient availability in soil mixed with OPT fiber and other comparable soil amendments using cellulose powder.

(A) Soil+OPT fiber (1:20), (B) soil+cellulose powder (1:20), and (C) unamended soil as a negative control plot were prepared and tested. The effect of amendment with OPT fiber on plant growth was compared in a pot experiment. In the period after 25 days after sowing, the low chlorophyll contents were consistent with the symptoms of nutritional disorders such as yellowish leaves and stunting of height. Furthermore, OPT fiber treatments caused a reduction in heights and SPAD values (chlorophyll content), with a maximum reduction of 54.9% of the height and 58.8% of SPAD compared with plants grown in the control soil. The dry weight of biomass was reduced by 53.3% for the OPT fiber treatment when compared with the control (Fig. 1). The plants grown with OPT fiber were deficient in total nitrogen and magnesium when compared with those without fiber amendment, which suggested that nitrogen and minerals in the soil might be taken up by the changing microflora because of the OPT fibers' presence (Table 1). To confirm the differences in the soil microflora, metagenomics analysis was performed on untreated soil and soil from each lignocellulose treatment. The microflora of soils mixed with OPT fiber and cellulose revealed substantial increases in bacteria such as families *Cytophagaceae and Oscillospiraceae*, and two major fungal genera, *Trichoderma* and *Trichocladium*, that are involved in lignocellulose degradation. OPT fiber resulted in

Table 1. Plant analysis results of plants grown in unamended soil and soil supplemented with oil plant trunk (OPT) fiber

Elements	Corn		Tomato		Beans	
	Unamended	OPT fiber	Unamended	OPT fiber	Unamended	OPT fiber
Potassium (P)	0.09%	0.07%	0.11%	0.18%	0.08%	0.09%
Magnesium (Mg)	0.25%	0.17%	1.18%	0.70%	0.60%	0.53%
Phosphorus (K)	3.16%	2.91%	3.49%	3.75%	1.32%	1.42%
Total nitrogen (N)	2.09%	0.73%	3.36%	1.56%	1.58%	0.68%
Inorganic nitrogen	0.24%	0.01%	0.22%	0.01%	0.02%	0.01%

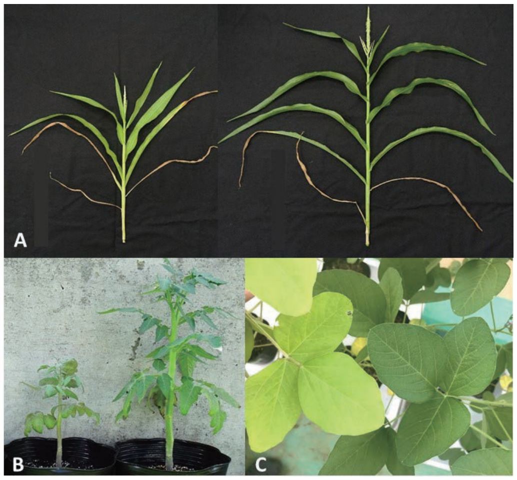


Fig. 1. Growth trend of plants
A: corn, B: tomato, C: beans. Left: soil mixed with OPT fiber (OPT fiber), right: soil not mixed with OPT fiber (unamended soil).

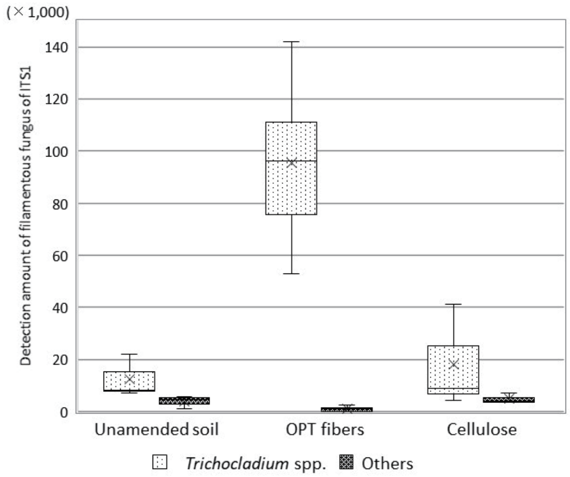


Fig. 2. Microbial relative abundance of sequences from unamended soil, OPT fibers, and cellulose
The ITS region sequence amount of *Trichocladium* spp. and other filamentous fungi generated by metagenome is shown. As a control, the soil mixed with cellulose (manufactured by Sigma-Aldrich) is shown.

a drastic increase in the ratios and amounts of *Trichocladium* in the soil when compared with those of cellulose treatments (Fig. 2).

These results indicate that unregulated disposal of OPT fiber into plantation areas could result in nutrient loss from soil by increasing the abundance of microorganisms involved in lignocellulose decomposition. To protect palm plantation productivity, co-composting of these biomass products or re-using OPT for other products is necessary.

Reference

Uke A et al. (2021) *Journal of Environmental Management*, 295:113050

Figures and table reprinted/modified with permission.

A. Uke, A. Kosugi,
J.-A. Chuah [Universiti Sains Malaysia, USM],
K. Sudesh [USM],
N. Z. H. A. Z. Abidin [Malaysian Palm Oil Board, MPOB], Z. Hashim [MPOB])

TOPIC 4

BNI-enabled wheat is nitrogen-efficient and maintains productivity

The amount of nitrogen fertilizer used in modern agriculture is enormous, amounting to about 120 million tons worldwide. However, most of it (about 70%) is not absorbed by crops and is leached out from farmland, making farmland a source of pollution to the aquatic environment and emission of nitrous oxide (N_2O), a global warming gas with a greenhouse effect up to 298 times greater than that of carbon dioxide. The release of excess nitrogen into the environment is related to nitrification in the soil. Nitrification is a microbial oxidation reaction from ammonia-form nitrogen (NH_4^+-N) to nitrate-form nitrogen (NO_3^--N), which is an important pathway in the nitrogen cycle of the earth. NH_4^+ is retained in the soil and does not migrate much, while NO_3^- is weakly bound to the soil and is highly mobile, so it easily leaches out of the farmland. Nitrification in agricultural soils is highly active due to a large amount of industrially fixed nitrogen fertilizer applied, so the conversion to NO_3^-, which cannot be retained by the soil, and its leaching into the hydrosphere proceed rapidly, and N_2O is released into the atmosphere during the process (Fig. 1 left).

Therefore, if the nitrification rate of agricultural soil can be suppressed, it could be an effective means of solving the problem. Biological Nitrification Inhibition (BNI) is the process by which crops themselves secrete substances that inhibit nitrification. BNI technology that utilizes BNI can both maintain and increase crop yields with less nitrogen fertilizer input and reduce environmental impact. By inhibiting nitrification, crops have more opportunities to absorb nitrogen, which allows reducing NO_3^- leaching and N_2O release. The introduction or enhancement of BNI capacity through breeding can be expected to both reduce agricultural greenhouse gas emissions and nitrogen fertilizer application.

We have been investigating the BNI potential of wheat, a major cereal covering the largest area among food crops, and developed BNI-enabled wheat by introducing superior BNI capacity from *Leymus racemosus* into high-yielding wheat varieties through chromosome engineering tools. Substitution of *Leymus racemosus* chromosome N short-arm with wheat chromosome 3B introduced BNI capacity, and the resulting line was further back-crossed with high-yielding varieties. (Fig. 2) The BNI-enabled variety, "BNI-Munal," showed around 2–5 times higher BNI capacity than the parental variety, "Munal." This high-yielding background "BNI-Munal" showed suppression of nitrifying microorganisms in rhizosphere soil, resulting in the lowering of soil nitrification rate and N_2O emission (Fig. 3); therefore, the environmental load by agriculture caused by nitrogen fertilizer can be reduced. "BNI-Munal" also showed efficient use of NH_4^+ in terms of nitrogen assimilation and soil organic nitrogen. "BNI-Munal" showed a significantly higher yield than Munal, and a 60% reduction in nitrogen application (from 250 to 100 kgN/ha) did not show a difference in yield between

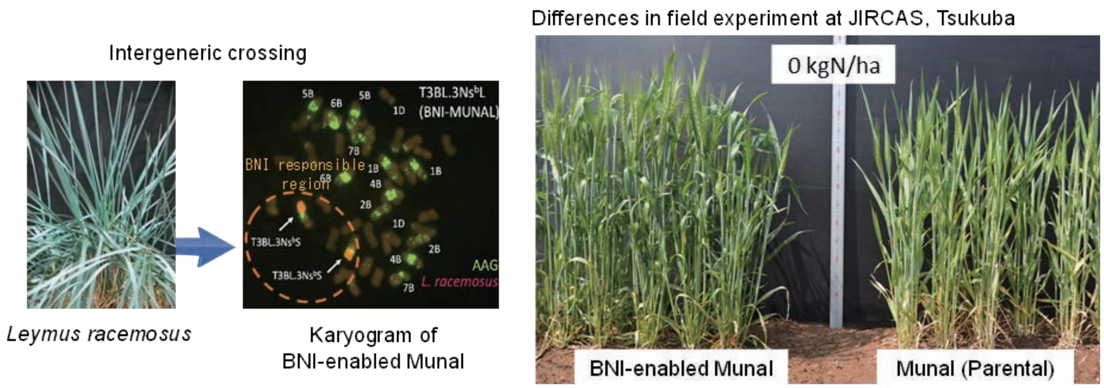


Fig. 1. BNI-enabled wheat with *Leymus racemosus* N chromosome (ex. BNI-Munal)

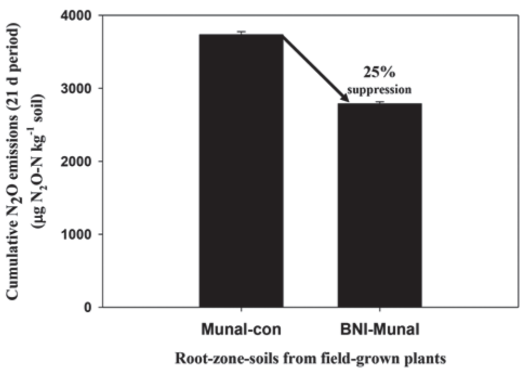


Fig. 2. N_2O emission from BNI-enabled Munal
N_2O emission was suppressed by 25%.

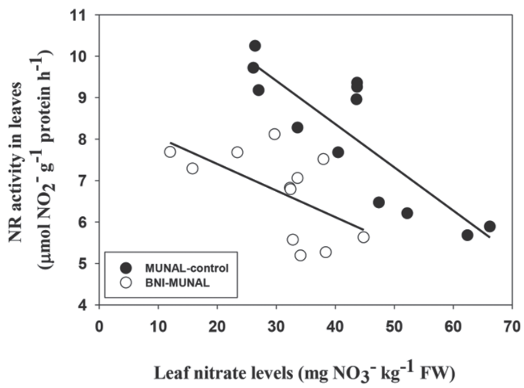


Fig. 3. Changes in nitrogen assimilation
BNI-enabled wheat prefers ammonium.

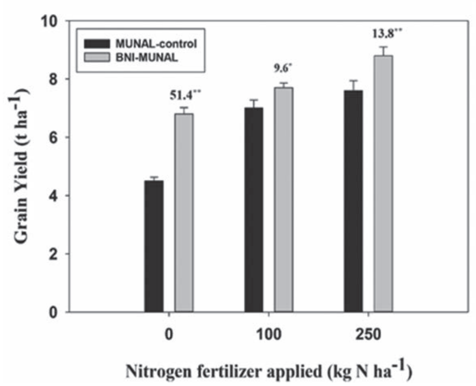


Fig. 4. Grain yield under different nitrogen application levels
No significant difference in yields between Munal-control at 250 kg/ha and BNI-enabled Munal at 100 kg/ha.

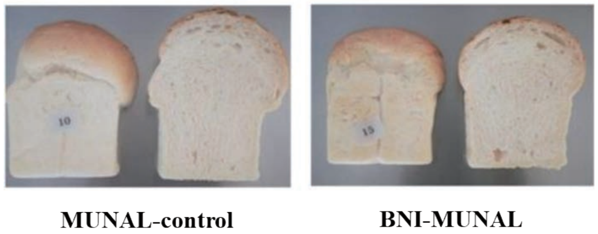


Fig. 5. Bread making quality of BNI-enabled wheat
BNI-enabled Munal can be processed into bread as well as Munal-control.

BNI-enabled and parental variety, hence the grain protein content (and bread-making quality) also did not change (Fig. 3). Further improvement in BNI capacity can be made by reducing the N chromosome short-arm and elucidating the mode of action, which is ongoing.

Reference

Subbarao et al. (2021) *PNAS* 118: e2106595118. https://doi.org.10.1073/pnas.2106595118
Figures reprinted/modified with permission.

(G. V. Subbarao, M. Kishii, T. Yoshihashi, S. Tobita [Nihon Univ.], M. Iwanaga and 9 others)

TOPIC 5

Discovery of biological nitrification inhibitors in maize roots

Nitrogen (N) fertilizer is an essential component for growing most crop plants. However, almost half of the applied N fertilizer is lost from soil as nitrate (NO_3^-, a water pollutant) and as nitrous oxide (N_2O, a greenhouse gas) by two microbial metabolic processes: nitrification and denitrification, respectively. To control agronomic N losses, biological nitrification inhibition (BNI) is a promising strategy. BNI is an ecological phenomenon by which certain plants release bioactive natural products that can suppress nitrifying soil microbes. Our objective in this research is the identification of hydrophobic BNI compounds released from maize roots.

In the search for BNI compounds from the surface extract of maize roots, a new, highly active BNI compound was discovered, together with another highly active compound. In addition, two BNI-active compounds were identified from the root extract of maize (Fig. 1). The compound with the strongest BNI activity (the ability to suppress nitrification by nitrifying bacteria) was named "zeanone" because it

Table 1. Quantity of BNI compounds in maize roots

Compound	Root surface (220 mg)	Root inside DCM extract (395 mg)	Root inside MeOH extract (10 g)	Root (10.615 g)
Zeanone	0.1 mg	0.05 mg	–	0.15 mg (19% of total BNI activity)
HDMBOA	110 mg	132 mg	–	242 mg (20% of total BNI activity)
HMBOA	–	–	3.0 mg	3.0 mg (2% of total BNI activity)
HDMBOA-β-glc	–	–	20 mg	20 mg (4% of total BNI activity)

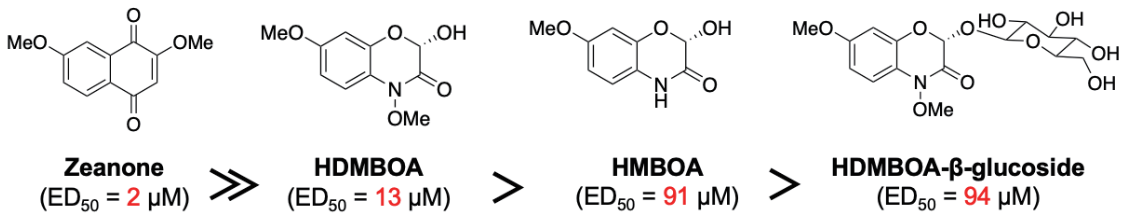


Fig. 1. Structure and BNI activity of BNI compounds

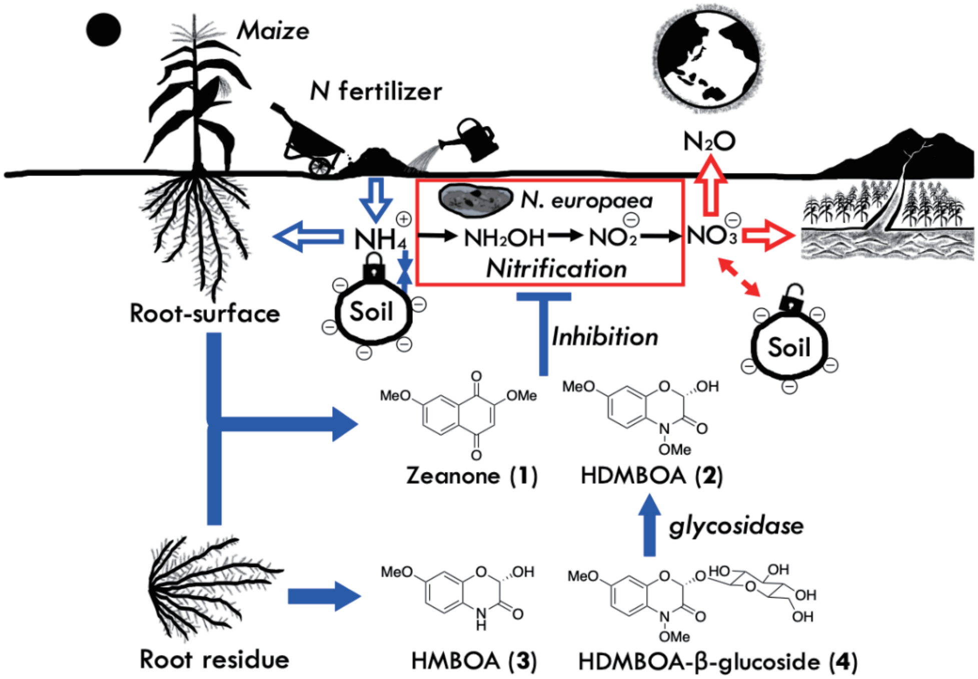


Fig. 2. Proposed BNI mechanism in maize

was the first BNI compound to be discovered in nature. The four compounds, including the newly discovered zeanone, were found to have an activity equivalent to 45% of the total BNI activity of maize roots (Table 1). Based on the obtained results, a BNI mechanism in maize is proposed (Fig. 2).

The results of this research are expected to open the way for the construction of eco-friendly agricultural production systems that utilize the BNI-producing ability (BNI capacity) of maize.

Reference

Otaka J et al. (2021) *Biol Fertil Soils* 58: 251–264. https://doi.org/10.1007/s00374-021-01577-x

Figures and table reprinted/modified with permission.

(J. Otaka, T. Yoshihashi, G. V. Subbarao, H. Ono [National Agriculture and Food Research Organization])

Reduction in nitrogen fertilizer-induced greenhouse gas emissions by BNI-enabled wheat

Since the beginning of the "Green Revolution," nitrogen (N) fertilizer consumption worldwide has increased ninefold. Soil nitrifier activity and nitrification have been increased by high fertilization rates, resulting in declining agronomic N-use efficiency (NUE) and an increase in environmental problems. The agronomic NUE for cereals is reported to be 30–50%. The remaining N is partially lost to the environment, exacerbating groundwater pollution by nitrate and climate change by nitrous oxide (N_2O) emissions from farmlands.

To increase NUE and to reduce the detrimental effects of reactive N on the environment, JIRCAS has focused on the release of root exudates from plants, a mechanism known as "Biological Nitrification Inhibition (BNI)." In collaboration with the International Center for Maize and Wheat Improvement (CIMMYT), JIRCAS has developed BNI-enabled wheat with a 30% nitrification inhibition rate. Aiming to reach carbon neutrality by 2050, the research team is currently developing BNI-enabled elite wheat varieties with a 40% reduction in nitrification.

Thus far, the potential impacts of deploying BNI-enabled elite wheat in wheat production systems have yet to be evaluated. The present study aims to evaluate the potential changes in fertilizer application rates, life cycle greenhouse gas (LC-GHG) emissions (Fig. 1), and NUE at the farm level. Moreover, it aims to evaluate the potential changes in worldwide nitrogen fertilizer-induced GHG emissions across wheat-harvested areas.

The study showed that BNI-enabled wheat with a 30% reduction in nitrification could reduce LC-GHG emissions by 12.3% and N fertilization by 11.7%, and improve NUE by 12.5% at the farm level by 2030 (Fig. 2, 30%). Furthermore, BNI-enabled wheat with a 40% reduction in nitrification could reduce LC-GHG emissions by 15.9% and N fertilization by 15.0%, and improve NUE by 16.7% by 2050 (Fig. 2, 40%). In addition, N fertilizer-induced GHG emissions could be reduced by 9.5% across wheat-harvested areas worldwide by 2050 if BNI-enabled wheat with a 40% reduction in nitrification is introduced only to areas suitable for BNI wheat (Fig. 3).

JIRCAS, together with CIMMYT, has presented estimates on the development of BNI-enabled wheat, which can reduce fertilizer use and GHG emissions, and will promote the use of BNI-enabled wheat in wheat-producing countries to achieve both high productivity and reduced environmental load from agriculture.

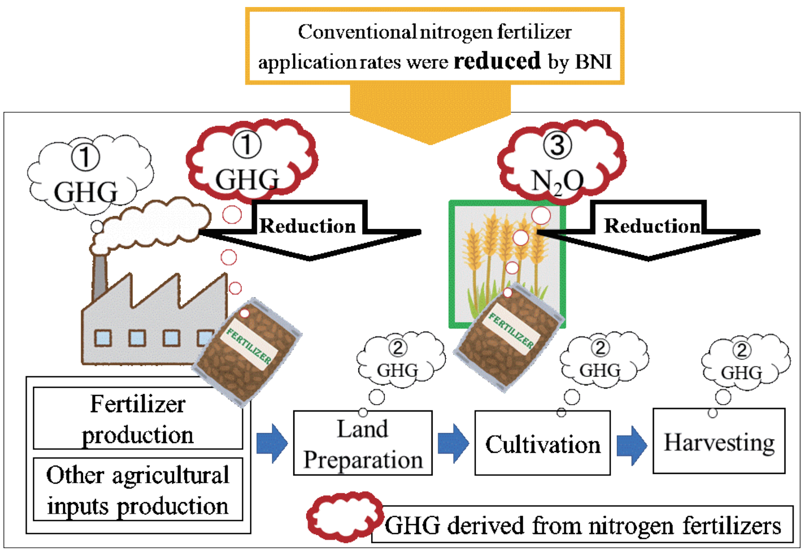


Fig. 1. Life Cycle Greenhouse Gas (GHG) emissions when nitrogen fertilizer-induced GHG emissions are reduced by BNI-enabled wheat

① GHG emissions from production of agricultural inputs such as fertilizer; ② GHG emissions from fuel consumption when machinery is used for land preparation, cultivation, and harvesting; ③ N_2O emissions from nitrogen fertilization applied in a field; and the sum of ①, ② and ③ is called "Life cycle greenhouse gas emissions." Nitrogen fertilizer-induced GHG emissions (GHG emissions from nitrogen fertilizer production and N_2O emissions from nitrogen fertilization, marked in red in Fig. 1) are reduced when nitrogen fertilizer application is reduced by BNI-enabled wheat.

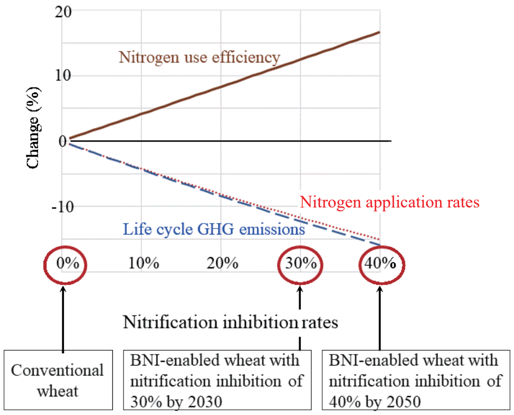


Fig. 2. **Changes in life cycle GHG emissions, nitrogen fertilizer application rates, nitrogen-use efficiency, and nitrification inhibition rates caused by introduction of BNI-enabled wheat**

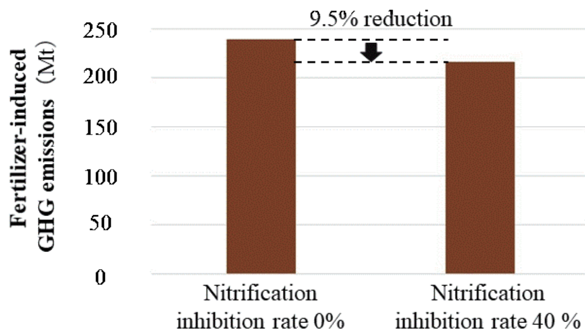


Fig. 3. **Reduction in nitrogen fertilizer-induced GHG emissions when BNI-enabled wheat is introduced only to the area suitable for BNI-enabled wheat**

Reference

Leon A et al. (2021) *Environmental Science and Pollution Research* 29, 7153–7169. https://doi.org/10.1007/s11356-021-16132-2

Figures reprinted/modified with permission.

(A. Leon, G.V. Subbarao, N. Matsumoto, M. Kishii, G. Kruseman [International Maize and Wheat Improvement Center])

TOPIC 7

Relationship between leaf and stem growths of a tropical timber tree, *Shorea leprosula*, in the family Dipterocarpaceae

Dipterocarpaceae is an important timber family in Southeast Asia. Dipterocarp species flower at irregular intervals from three to ten years, hindering the collection of seeds and provision of good planting materials. Furthermore, there is an urgent need to understand the effects of climate change on the production of these timber species. Because stem elongation is a basis for seedling growth and timber production, it is important to elucidate how stem elongation is regulated in dipterocarps to solve these problems. However, the regulation of stem elongation is still not clear yet in dipterocarps.

To reveal it, we studied the regulation of stem elongation by focusing on the relationship between stem elongation and leaf growth. Through weekly observations of *S. leprosula* branches, we found that the branches have two clear growth phases, the active growth and the growth-arrested phases (Fig. 1). Although it has been discussed that branches of dipterocarps grow continuously or intermittently, this result indicates intermittent branch growths in *S. leprosula*. During the active growth phase, stems and young leaves coordinately grew (Fig. 1). Young leaves rapidly grew and were unfolded when stems showed clear elongations. Furthermore, internodes became significantly shorter if a young growing leaf was removed from the internodes (Fig. 2), suggesting that growing leaves positively regulate internode elongation.

Our previous study showed that small changes in ambient temperature regulate the timing of leaf growth in dipterocarps (Research Highlights 2020, C07). Thus, the observed regulation of stem growth by leaves would suggest that temperature changes also affect the timing of stem growth in *S. leprosula*. Considering the effect of temperature on stem growth in dipterocarps, our results will contribute to a stable supply of planting materials by controlling the growth of dipterocarp seedlings using multiple nurseries in different temperature conditions. Besides, we will be able to use the relationship between temperature and stem growth observed in this study when evaluating the effects of global warming on sustainable timber

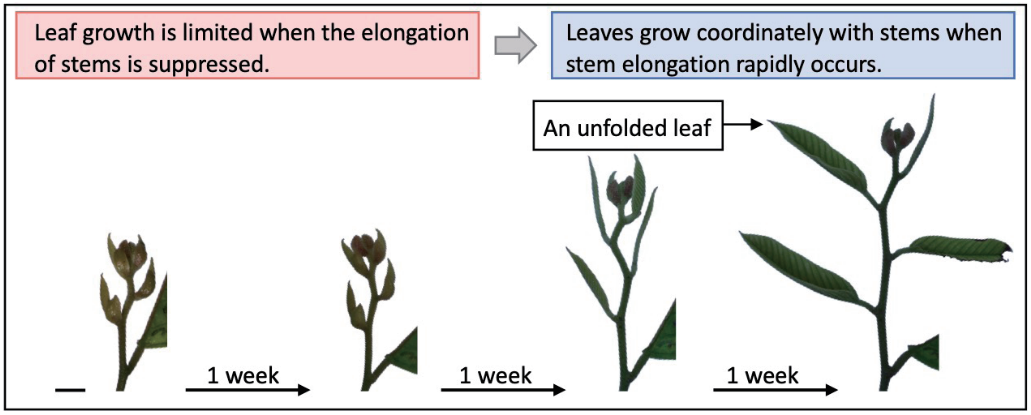


Fig. 1. The leaf and stem growths on an intermittently growing *Shorea leprosula* branch
The figure shows the result of weekly observation of an *S. leprosula* branch. As shown in the two pictures on the left, *S. leprosula* branches show a growth-arrested phase for several weeks. However, during an active growth phase as shown in the two pictures on the right, the rapid growth of branches is observed. Due to the active growth and growth-arrested phases, *S. leprosula* branches grow intermittently. Leaves and stems coordinately grow on *S. leprosula* branches. Young leaves rapidly grow and are unfolded when stems show clear elongations. Scale bar indicates 1 cm.

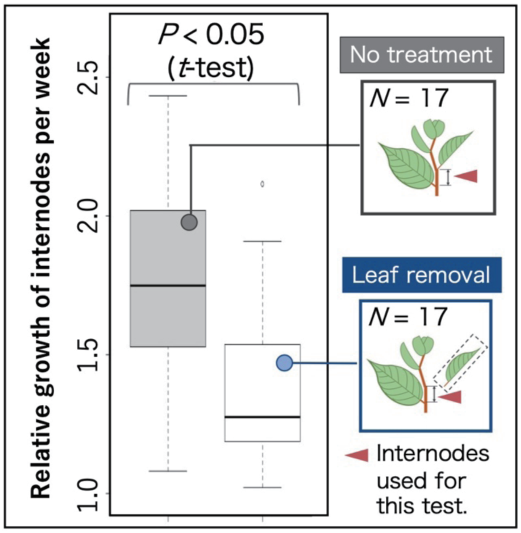


Fig. 2. The effect of growing leaves on the internode growths of *Shorea leprosula*
The relative growths of the internodes whose growing leaves were experimentally removed (right) were significantly smaller than those of the control (left). The red arrowhead indicates the position of internodes measured to test the changes in growth rate. N represents the number of branches used for the experiment.

production of dipterocarps. Furthermore, because the removal of young growing leaves suppresses stem growth, damages on growing leaves could negatively affect the stem growth in dipterocarps. If climate change increases the damage on young leaves by insect attacks and droughts, these damages will have negative impacts on seedling growth and timber production of dipterocarps. Further studies are required to evaluate more precisely these negative effects on dipterocarp forestry.

Reference

Kobayashi M J et al. (2021) *JARQ* 55(3):273–283
Figures reprinted/modified with permission.

(M.J. Kobayashi, N. Tani, K.K.S. Ng [Forest Research Institute Malaysia (FRIM)], S.L. Lee [FRIM], N. Muhammad [FRIM])

TOPIC 8

Teak growth doubles in the Lao Mountains depending on the control of stand density and topographic conditions

Teak plantations are being promoted in the mountainous areas of Lao PDR including in Luang Prabang Province. However, teak growth varies greatly depending on the conditions of the planting site. Clarification of the factors related to the growth of planted teak and establishment of a suitable land determination method will be the basis of effective land use in mountainous areas.

In this study, the growth history of teak trees was estimated from annual rings for each of the three canopy trees felled from 27 plots of teak plantations aged 20 and over in the southwestern part of Luang Prabang Province. A total of 81 teak trees were felled and cut into round slices at regular intervals to create a disk, and the annual rings were read. Based on the analysis of annual rings, we estimated the diameter growth and tree height growth process of each teak tree with the age and analyzed the relationship between tree growth and topographic conditions as well as stand density.

The diameter growth (Fig. 1, left) and tree height growth (Fig. 1, right) of planted teak differ by about twice.

The diameter growth and tree height growth of teak individuals are significantly affected by the shape and gradient of the slope to be planted (Fig. 2). For the fast growth of teak, the gradient of slope should be gentle, with the concave part considered better than the convex part and the lower part deemed better than the upper part of the slope.

In the study area, the actual stand density of planted teak was about 500 to 1,600 trees/ha at the stand age of 20 years and over. In that range,

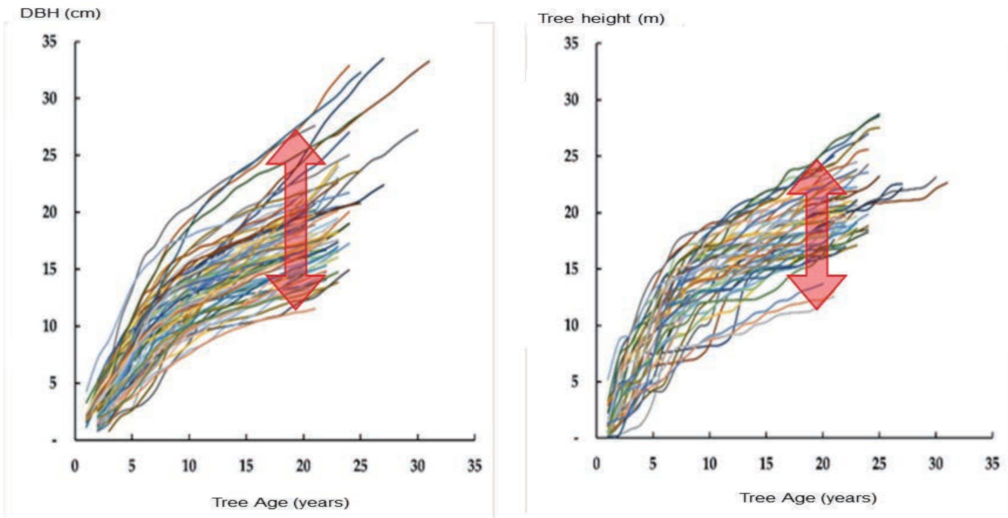


Fig. 1. Diameter growth (left) and height growth (right) of planted teak
Note: Growth history was estimated from annual rings for each of the three canopy trees felled from 27 plots of teak plantations.

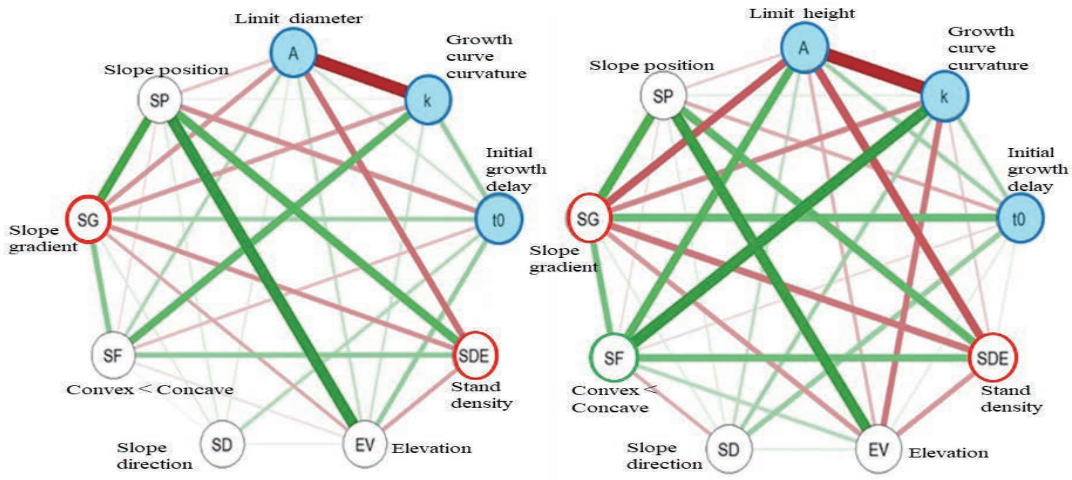


Fig. 2. Partial correlation network between DBH–age growth curve parameters and topographic conditions (left) and height–age growth curve parameters and topographic conditions (right)
Note: The green and red lines indicate positive and negative correlations, respectively. The line thickness indicates the strength of the Spearman's partial rank correlation. The letters in blue circles indicate variables of tree growth parameters A, k, t_0 in Mitscherlich growth function; $Y=A(1-\exp(-k(t_i-t_0)))$. Other circles indicate stand density (SDE) and topographic conditions such as elevation (EV), slope gradient (SG), slope direction (SD; N<E<S<W), slope form (SF; convex<concave) and slope position (SP). The factors in green circle ○ and red circle ○ have significant positive and negative relationships with growth at the 1% level.

the lower the tree density, the better the diameter growth and tree height growth.

This teak suitability determination method can be disseminated to farmers by technical instructors because the index used can be obtained by simple measuring instruments or visual measurement at the site. Substituting the output of the prediction formulas for diameter growth and tree height growth into the volume estimation formula leads to the prediction of teak yield. This result is expected to be applied to areas with similar climate, meteorology, geology, and soil conditions (for example, northern Thailand) with some correction.

Reference

Vongkhamho et al. (2022) *Forests* 13, 118. https://doi.org/10.3390/ f13010118

Figures reprinted/modified with permission.

(A. Imaya [Forestry and Forest Products Research Institute],
S. Vongkhamho [Forestry Research Center, NAFRI, Lao PDR],
C. Takenaka [University of Nagoya],
K. Yamamoto [University of Nagoya],
H. Yamamoto [University of Nagoya])

TOPIC 9

Calculation of rice farmers' premiums for index-based flood insurance

There is concern that climate change will induce extreme events such as severe droughts, high tides, and bigger cyclones. Thus, the development of non-life insurances products targeting crops is desired in the Ayeyarwady region in Myanmar, where cyclone Nargis caused severe damage in 2008. The development of weather index insurance is progressing because it does not require actual surveys of damaged areas, and farmers do not abandon cultivated areas impacted by a disaster. However, it is difficult for farmers to understand what crop insurance is and to calculate the insurance money needed to maintain farming operations. Therefore, this research aimed to provide a method to calculate the optimum insurance money for farmers.

An insurance money function is derived by solving a utility maximization problem, taking into account the receipt of insurance money and premium payments for a risk averse farmer. The insurance money and the premium are found by substituting the average numbers of the 320-farm data (Table 1). These are shown to correspond to the farm price of rice and risk aversion rate of the farmer. If the relative risk aversion rate is zero, plus, and minus, the farmers are risk neutral, risk averter, and risk lover, respectively. If the farm price of rice goes up from 280 to 320 Kyat per kg, the annual premium that an average farmer with an average cropping area of 5.6 ha willingly pays will increase from 10,000 to 120,000 Kyat (Fig. 1). If the relative risk aversion rate rises from 0.1 to 0.9, the required insurance money will increase from 30,000 to 800,000 Kyat per average farmer (Fig. 2). If total rainfall from May to October is 3,700 mm which is the regional average; if the relative risk aversion rate is 0.68 which is the average number in Ethiopia in a previous research; and if the farm price of rice is 306 Kyat per kg which is the regional average, the premium will be 58,000 Kyat, i.e., around 42.6 USD per average farm. This calculated premium is equivalent to 3% of the average farm income.

Weather index insurance premiums can be calculated in response to changes in rainfall, relative risk aversion rate, farm price of rice, and input prices such as fertilizer price. The target disaster is flood. Flood disaster area rate during a period and marginal disaster area rate, which shows the rate of increase in disaster damage for 1 mm increase in rainfall, are required for application of the method to other regions.

Table 1. Data for calculation of insurance money and premium (n=320)

Variable	Unit	Number
Flood damage area rate	%	0.929
Marginal damage area rate	%	0.00065
Rainfall (May-Oct. total)	mm	3,700
Threshold of rainfall	mm	3,500
Farm price of rice	Kyat/kg	306
Price of fertilizer	Kyat/kg	630
Wage rate	000Kyat/(man day)	2.5
Capital user price	000Kyat/tractor	1,007
Land rent	000Kyat/acre	2,500
Fertilizer application	kg	1,128
Labor input	man day	392.1
Capital input	Harvest fee 000Kyat	607.8
Land input	acre	13.77
Fertilizer cost share	dimensionless	0.165 (modified to.0.232)
Labor cost share	dimensionless	0.274 (modified to 0.386)
Capital cost share	dimensionless	0.167 (modified to 0.235)
Land rent share	dimensionless	0.104 (modified to 0.146)
Total of cost share	dimensionless	0.710 (modified to 1.000)
Relative risk aversion	dimensionless	0.68
Margin of non-life insurance company	%	0.1

Note: 1 US Dollar = 1,360 Kyat, 108.8 JPY, in 2016 (survey period average), Relative risk aversion data is from a previous research in another country.

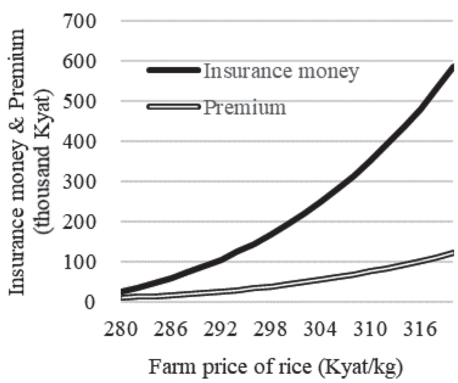


Fig. 1. Price of rice and premium
If the farm price of rice goes up, the demand for insurance will increase.
Note: Total rainfall from May to October is 3,700 mm, relative risk aversion is 0.68.

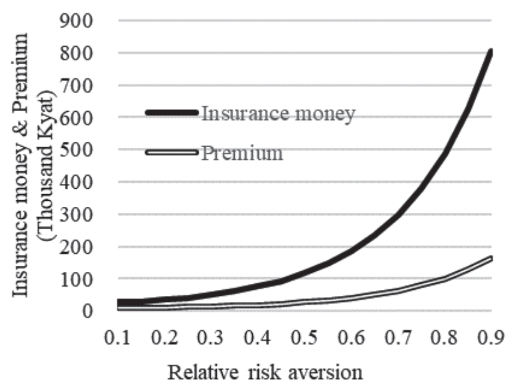


Fig. 2. Risk aversion rate and premium
If the risk aversion rate is close to 1.0, the required insurance money will increase significantly.
Note: Total rainfall from May to October is 3,700 mm, price of rice is 306 Kyat/kg.

Reference

Furuya J et al. (2021) *Paddy and Water Environment* 19: 319–330. https://doi.org/10.1007/s10333-021-00859-2

Figures and table reprinted/modified with permission.

*(J. Furuya, A. Hirano,
S.S. Mar [Yezin Agricultural University],
T. Sakurai [University of Tokyo])*

African phosphorus fertilizer from indigenous low-grade phosphate rock could replace imported phosphorus fertilizer in rain-fed rice cultivation

In tropical semi-arid regions including Burkina Faso, soils with low phosphorus (P) availability are widely distributed, limiting rainfed rice production. Fertilizer application rates by local farmers are limited mainly due to the high price of imported P fertilizers. A vast amount of phosphate rock deposits are found in Africa. However, most of them have been rarely utilized because of the high impurity and low solubility. If local P fertilizer can be manufactured from this unused resource, it is expected to reduce fertilizer prices and increase fertilizer application rate. Japan International Research Center for Agricultural Science (JIRCAS) has succeeded in increasing the solubility of low-grade African phosphate rock by applying two major methods: partial acidulation and calcination. Imported superphosphate (SSP) mostly consists of water-soluble P (Table 1). On the other hand, partially acidulated phosphate rock (PAPR) consists of water-soluble P and ammonium citrate-soluble P, and calcinated phosphate rock (CPR) of ammonium citrate-soluble P and citric acid-soluble P (Table 1). The solubility is in the order of water-soluble P > ammonium citrate-soluble P > citric acid-soluble P. A field experiment was conducted on the river bottom, which is the main area for rainfed rice cultivation, and on the riverside slope where rainfed rice cultivation can be expanded (Fig. 1, upper panel) to identify the effect of African P fertilizer on rice grain yield.

Rice grain yield is significantly increased by SSP application at all sites on the river bottom and riverside slope (Fig. 1, middle panel), suggesting that P is a limiting factor in rice cultivation. In the river bottom, both partially acidulated and calcined phosphate rock show comparable performance with SSP (Fig. 1, lower panel). Therefore, both can replace imported P fertilizer. In the lower and middle parts of the riverside slope, partially acidulated phosphate rock is as effective as SSP, while calcined phosphate rock is not (Fig. 1, lower panel). Both water-soluble and ammonium citrate-soluble P contributed to grain yield in the river bottom with a high ground-water level, and only water-soluble P contributed to grain yield on the riverside slope with a low ground-water level (Table 2). Therefore, the differences in fertilization effect can be explained by the differences in P composition in fertilizer (Table 1).

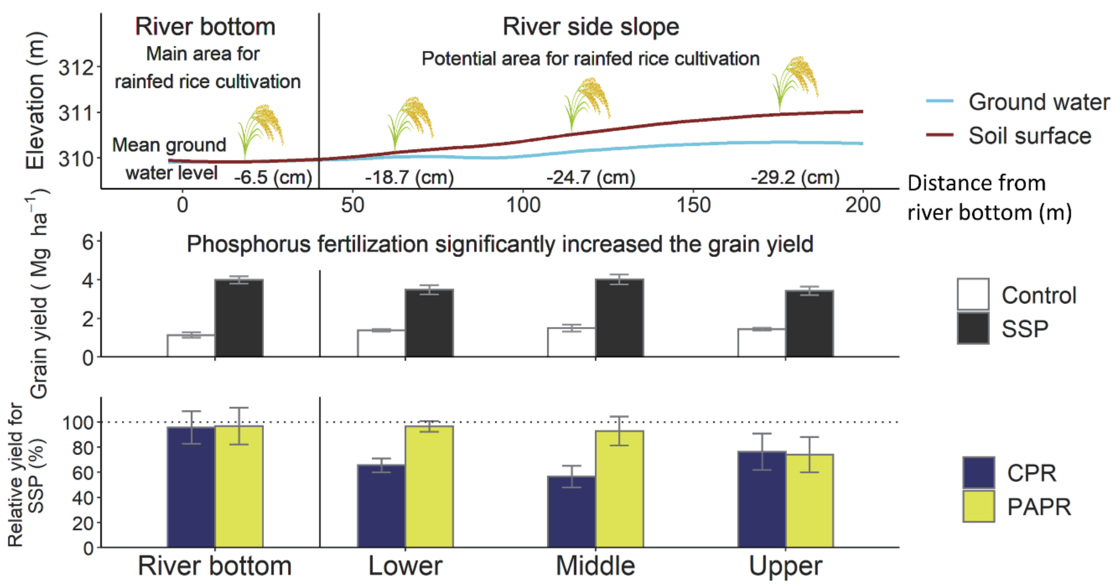


Fig. 1. Outline of the field experiment and fertilization effect of African phosphorus fertilizer from low-grade phosphate rock
Error bar: standard error

Partially acidulated and calcined phosphate rock fertilizers from African low-grade phosphate rock can be widely used in rain-fed rice cultivation in tropical semi-arid regions. Information on effective P fraction in rainfed rice cultivation will be useful for developing the locally adopted P fertilizer.

Table 1. Phosphorus composition of fertilizers

Types of phosphorus fertilizers	Water-soluble phosphorus	Phosphorus composition High ← Solubility ← Low Ammonium citrate-soluble phosphorus	Citric acid-soluble phosphorus
Single superphosphate (Imported phosphorus fertilizer)	◎	×	×
Partially acidulated phosphate rock	○	○	×
Calcinated phosphate rock	×	○	◎

◎:> 50%, ○:25–50%, ×: < 25%

Table 2. Contribution of phosphorus fraction to the yield

Phosphorus composition	River bottom	Riverside slope		
		Lower	Middle	Upper
Water-soluble phosphorus	◎	◎	◎	◎
Ammonium citrate-soluble phosphorus	◎	○	△	×
Citric acid-soluble phosphorus	×	×	×	×

◎: contributes at 1% level, ○: contributes at 5% level, △: contributes at 10% level

Reference

Iwasaki S et al. 2021. *Soil Science and Plant Nutrition*, 67 (4), 460–470. https://doi.org/10.1080/00380768.2021.1932584

Figure and tables reprinted/modified with permission.

(S. Iwasaki, K. Ikazaki, S. Nakamura, F. Nagumo, M. Fukuda [National Agriculture and Food Research Organization], K. Ouattara [Institute of the Environment and Agricultural Research, Burkina Faso])

Program B
Food

“Technology development towards building a new food system with improved productivity, sustainability and resilience”

Economic disparities within developing regions are widening and needs are diversifying, including responses to increasingly complex food and nutrition issues. In the agriculture and fisheries sectors, solving food and nutritional deficiencies is still an important issue. At the same time, there are growing expectations for new initiatives, such as qualitative improvement of nutrition, higher value-added products, and transformation to a new food system utilizing ICT and IoT. In order to contribute to the stable production of food and improved nutrition to meet new needs in developing regions such as Asia and Africa while also taking domestic benefits into consideration, the ‘Food Program’ aims to develop crops and food processing technologies by utilizing various characteristics of indigenous crops and advanced methods such as ICT and IoT. To maintain and strengthen the food production base, we are also working on control technologies for transboundary pests and diseases that are expanding beyond national borders, and revitalizing the fisheries industry through appropriate management of aquaculture and fishing grounds. Furthermore, for the African region, which is facing serious food and nutrition problems, we are contributing to rice production and the Coalition for African Rice Development (CARD), and developing technologies to improve agricultural productivity, sustainability, and resilience, including field crops and livestock production. To achieve our goals, we conduct the following six research projects.

[Resilient crops]

For the development of resilient crops and production technologies, we focused on the following research in FY 2021. We conducted an integrated analysis of phenotypic and genotypic data from approximately 160 quinoa lines under multiple environments to select candidate lines of useful breeding material to enhance the resilience of Bolivian quinoa (SATREPS Bolivia). We have established a high salt stress evaluation cultivation system for quinoa and identified applicable lines and positions for the viral vector method in quinoa. We have developed a set of partial chromosome fragment substitution lines containing chromosome fragments of DJ123, a native Indian variety with high phosphorus utilization efficiency, in the genetic background of the major Indian variety IR64. We found that the GS3 allele, which governs the yield-grain length and grain weight of Akita 63, promoting thousand-grain weight and grain length, increases nitrogen use efficiency for grain yield by 18%. In addition, we have introduced a salt-tolerant *Ncl* gene into soybean by marker selection and applied for variety registration in China. We also sequenced the genomic DNA of the pathogen of soybean Cercospora leaf blight, which is a problem in South America, and identified candidate genes related to pathogenicity. This information will be useful in formulating precise control measures according to pathogenicity characteristics and in developing diagnostic techniques for diseases.

[Indigenous crops and foods design]

For the design of crop breeding and food processing of indigenous resources to create new and diversified demands, we focused on the following research in FY 2021. We have characterized the whole genome structure of Lao black rice (H74) and a reference variety of white rice (R8). We obtained the first generation (BC_1F_1) seeds of backcross between Lao black rice (H50) and white rice (Kao Non), and the first generation (F_1) seeds of hybrid between H50 and white rice (Leuam Phua). We prepared a manual for the analysis of ginger samples for gingerol, which has anti-inflammatory and immune-boosting effects. We analyzed the amylose content of rice sold in Laotian markets, with the results suggesting that Laotian non-glutinous rice tends to be low in amylose. We established a small-scale trial production of koji amazake and analyzed the components involved in nutritional and functional properties (phytic acid, a mineral absorption inhibitor, and isomaltose, an intestinal regulator), and confirmed that the small-scale trial production of koji amazake is applicable to analytical evaluation of koji amazake using practical koji strains.

[Transboundary pest management]

For the development of environment-friendly management system against transboundary plant pests based on ecological characteristics, we focused on the following research in FY 2021. We have shown that in Mauritania, desert locusts in the gregarious phase lay larger eggs than those in the solitarious phase because female adults in the gregarious phase absorb a higher proportion of developing eggs. We have prepared rearing manuals for *Pardosa pseudoannulata* and *Cyrtorhinus lividipennis*, which are considered to be important natural enemies of the rice planthoppers in Vietnam, and have begun rearing them according to the manuals. We quantified the frequency of adult infestation of fields in Thailand by surveying the number of egg masses of the fall armyworm, and identified points to be considered in the development of control techniques. In addition, we found that in Mauritania, sexually mature adults of the gregarious-phase desert locust form groups of males and females, and that females fly to the groups of males to mate during the day and lay eggs in the group at night.

[Ecosystem approach to aquaculture]

For the development and dissemination of sustainable aquaculture technologies in the tropical area based on the eco-system approach, we focused on the following research in FY 2021. We have developed a manual for observing bivalve aquacultural grounds in Southeast Asia and established the procedure for a real-time observation of aquacultural ground that also utilizes ICT. We selected the target species for aquaculture in northeastern Thailand, including carp species for which a seedling production technology has not yet been established, and conducted ecological surveys. We investigated the use of dried juzumo as feed for black tiger prawn, and clarified that the sun-drying and shade-drying methods would be effective. We selected a candidate site in the Philippines as an intermediate nursery site for aquaculture seedlings, and with the cooperation of the Japan Fisheries Research and Education Agency, conducted an ecological survey of the Haneji sea cucumber at a coastal area of Ishigaki Island, and developed a stock flow diagram to understand the socio-economic structure of the aquaculture community using domestic fishing data as a model case. In addition, since it is important to preserve existing genetic diversity to prevent genetic degradation of aquaculture populations and to produce superior strains, we established a method for cryopreservation and thawing of germ cells of banana and black tiger prawn belonging to the prawn family (SATREPS Global Strategic Fish).

[Africa rice farming system]

For the development of sustainable rice cultivation and food production system in Africa, we focused on the following research in FY 2021. We have developed a numerical elevation model for understanding meteorological data and waterlogging conditions in a potential test site in Tanzania. We selected major rice and tomato cultivars in Tanzania and elsewhere and introduced useful traits through crosses. We also selected promising lines at the World Vegetable Center in Taiwan based on the evaluation of productivity and nutritional performance of amaranth genetic resources. We developed a genomic prediction model to predict high-yielding and high-zinc-containing rice varieties in low-fertility environments based on genomic information and detected promising lines with high seed zinc content. We showed from a household survey in rural Madagascar that crop diversity has a positive effect on dietary diversity, and that legume cropping in particular has an effect on improving people's iron and zinc intake. In addition, we showed that in Tanzania, the introduction of marketable vegetable crops in the upper paddy fields can lead to higher incomes for farmers and more efficient water use in irrigated areas as a whole (MAFF grant). Lastly, we have released two new rice varieties that have shown excellent productivity in nutrient-poor soils and good eating quality in Madagascar (SATREPS Madagascar).

[Africa upland farming system]

For technology development towards supporting farmers' decision-making to boost sustainable upland farming system in Africa, we focused on the following research in FY 2021. We selected the study villages (15 villages in total) from 60 villages in northern Ghana, taking into account the combination of major crops used and their geographical location, and ensuring the heterogeneity of the natural and social environment, and conducted a rural survey to understand technology use and its challenges. We began to examine the effects of applying inputs such as phosphate rock processed fertilizer and superior rhizobium inoculants to soybean. We collected and analyzed information on livestock use and feed resources in Ghana, and found that many small-scale farmers in the northern part of the country keep ruminants on natural pasture, which does not meet the nutritional requirements of the livestock. We selected four of the ten reservoirs with irrigation potential identified through field visits, taking into account their regional characteristics, linkages with other issues, and dam size, and prepared hydrological observations for runoff modeling. In addition, to improve the nutrition of dairy cows through effective use of local feed resources, we compared the characteristics of a new strain of lactic acid bacteria, MOZ1, selected in Mozambique, with those of commercial lactic acid bacteria products, and clarified its excellent acid resistance, high temperature tolerance, lactic acid fermentation ability, and silage quality improvement effect. We have also applied for a patent for a rapid soil diagnostic method using plasma emission spectrometry.

TOPIC 1

Identification and validation of a major QTL for primary root length in soybean

The root system absorbs water and nutrients, which are essential for plant growth, from the soil. The phenomenal formation of a robust and extensive root system is extremely important in crop plants because it ensures their adaptability to the surrounding environment and their improved resource acquisition in the low input environment. However, roots are the hidden part of plants and have high adaptive plasticity in various environments. Therefore, the characterization of the root system requires considerable efforts in field conditions. The large variation observed in root traits suggested that the improvement of soybean by the genetic alteration of root traits is feasible. In this study, genetic analysis was conducted with an aim to identify quantitative trait loci (QTL) associated with primary root length (PRL) in soybean.

A total of 103 F_7 recombinant inbred lines (RILs) derived from a cross between "K099" (short primary root) and "Fendou 16" (long primary root) were used to identify QTL for PRL. "Fendou 16" is a soybean cultivar from Shanxi, China, and "K099" is a Korean soybean cultivar. Linkage groups were constructed with 223 simple sequence repeat markers from the 20 chromosomes. Phenotyping for PRL was performed in hydroponic conditions. QTL analysis identified a major QTL (*qRL16.1*) on chromosome 16 between SSR markers Sat_165 and Satt621, explaining 30.25% of the total phenotypic variation (Fig. 1). The effect of *qRL16.1* was confirmed using *qRL16.1* near-isogenic lines (NILs). PRL was significantly longer in NILs possessing the *qRL16.1* allele

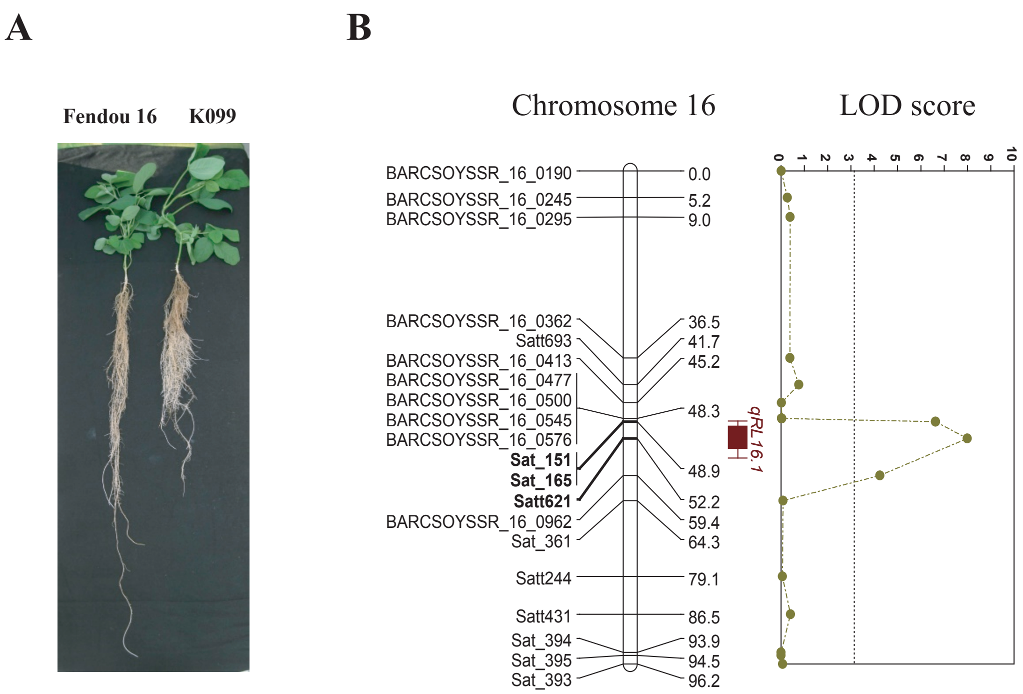


Fig. 1. The primary root length QTL (*qRL16.1*) detected on chromosome 16 in the RIL population derived from a cross between "K099" and "Fendou 16"
(A) Comparison of root architecture between "Fendou 16" and "K099" grown in hydroponic conditions. (B) Position and LOD score of the primary root length QTL (*qRL16.1*).

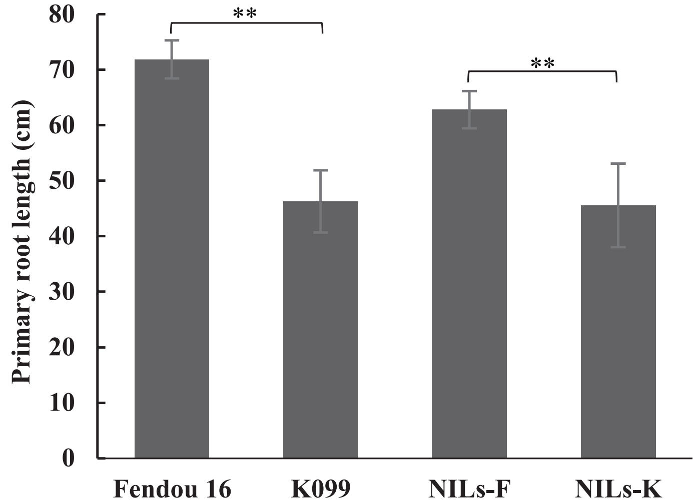


Fig. 2. Effect of the *qRL16.1* allele on primary root length of two near isogenic lines, NILs-F and NILs-K
NILs-F: "Fendou 16" genotype; NILs-K: "K099" genotype. Error bars indicate SD (n = 8). **: $P < 0.01$.

of "Fendou 16" compared to allele of "K099" (Fig. 2). In addition, to validate *qRL16.1* in a different genetic background, QTL analysis was performed in another F_6 RIL population derived from a cross between "Union" (medium primary root) and "Fendou 16," in which a major QTL was detected again in the same genomic region as *qRL16.1*, explaining 14% of the total phenotypic variation for PRL.

qRL16.1 is a novel QTL for primary root length in soybean which provides important information for understanding the genetic control of root development. Identification of this major QTL will facilitate positional cloning and DNA marker-assisted selection for improvement of root traits in soybean.

Reference

Chen H et al. (2021) *BMC Genomics*, 22:132. https://doi.org/10.1186/s12864-021-07445-0

Figures reprinted/modified with permission.

(D. Xu, H. Chen [Jiangsu Academy of Agricultural Sciences, P.R. China], K. Giriraj [ICAR-Indian Institute of Soybean Research, India], Y. Yan [Xinjiang Academy of Agricultural Sciences, P. R. China.], B. Fan [Hebei Academy of Agricultural and Forestry Sciences, P. R. China)

TOPIC 2

A major and stable quantitative trait locus *qSS2* for seed size and shape traits in soybean

Soybean [*Glycine max* (L.) Merr.] is one of the world's most economically important food and oil crop. It is a rich source of edible oil and protein, and provides substrate for several important food products. Seed size traits such as length, width, thickness, and single seed weight, and seed shape traits such as length-to-width, length-to-thickness and width-to-thickness, are important determinants of seed yield and appearance quality in soybean. Understanding the genetic architecture of these traits is important to enable their genetic improvement through efficient and targeted molecular breeding by design in soybean, and for the identification of underlying causal genes.

To identify quantitative trait locus (QTL) controlling seed size and shape traits in soybean, a recombinant inbred line (RIL) population developed from K099 (small seed size) × Fendou 16 (large seed size) was phenotyped in three growing seasons (2012, 2016, and 2017) in field conditions. A genetic map of the RIL population was developed using 1,485 genotyping by random amplicon sequencing-direct (GRASDi) and 177 SSR markers. QTL analysis was conducted using the QTL IciMapping software. As a result, a total of 53 significant QTLs for seed size traits and 27 significant QTLs for seed shape traits were identified. Six of these QTLs (*qSW8.1, qSW16.1, qSLW2.1, qSLT2.1, qSWT1.2,* and *qSWT4.3*) were identified with LOD scores of 3.80–14.0 and R^2 of 2.36%–39.49% in at least two growing seasons. Among the above significant QTLs, 24 QTLs were grouped into 11 QTL clusters, with three major QTLs (*qSL2.3, qSLW2.1,* and *qSLT2.1*) clustered into a major QTL on chromosome 2, named as *qSS2*. The effect of *qSS2* was validated in a pair of near isogenic lines, and its candidate genes (*Glyma.02G269400, Glyma.02G272100, Glyma.02G274900, Glyma.02G277200,* and *Glyma.02G277600*) were mined.

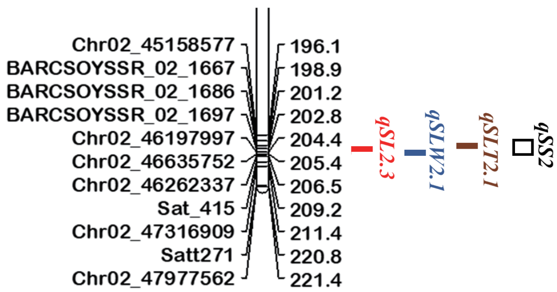


Fig. 1. Map position of a QTL cluster (*qSS2*) for seed size and shape traits on chromosome 2 in the K099 × Fendou 16 RIL population
Distances in cM are indicated to the right of the linkage groups and names of markers are shown on the left. *qSL2.3, qSLW2.1,* and *qSLT2.1* represent QTLs for seed length, length-to-width, and length-to-thickness, respectively.

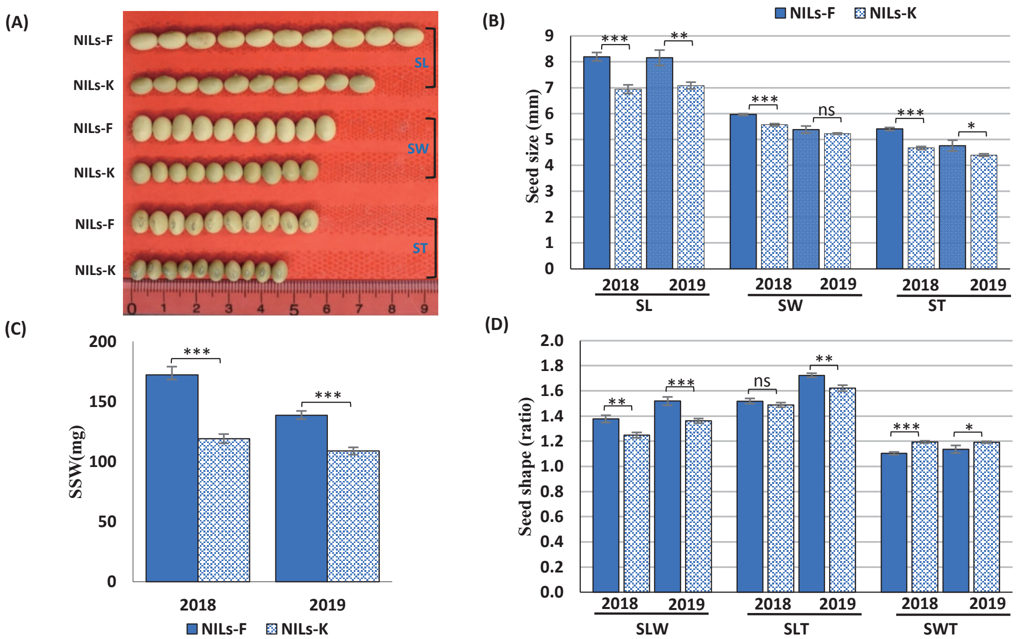


Fig. 2. Seed size and shape phenotypes of near isogenic lines, NILs-F and NILs-K, in 2018 and 2019. (A) phenotypic appearance, (B) SL, seed length; SW, seed width; ST, seed thickness, (C) single seed weight (SSW), and (D) seed shape traits (SLW, ratios of seed length-to-width; SLT, seed length-to-thickness; and SWT, seed width-to-thickness)
Error bars represent means ± SD of three replicates. Asterisks indicate significant differences between NILs-F and NILs-K at 5% (*), 1% (**), and 0.1% (***); ns indicates no significant difference at the 5% level in Student's *t*-test.

The identified QTLs will pave the way for positional cloning of genes regulating seed size and shape traits and for further understanding of their molecular mechanism in soybean. The results of this study will assist in breeding programs aimed at improving seed size and shape traits in soybean.

Reference

Kumawat G and Xu D (2021) *Frontiers in Genetics*, 12:646102. https://doi.org/10.3389/fgene.2021.646102

Figures reprinted/modified with permission.

(D. Xu, H. Chen [Jiangsu Academy of Agricultural Sciences, P.R. China], K. Giriraj [ICAR-Indian Institute of Soybean Research, India])

TOPIC 3

Functional analysis of genes in quinoa using a virus vector system

Quinoa (*Chenopodium quinoa* Willd.) is an annual protein-rich pseudocereal native to the Andean region of South America. Quinoa has been recognized as a potentially important crop in terms of global food and nutrition security since it can thrive in harsh environments and has an excellent nutritional profile. JIRCAS and collaborative researchers have been analyzing the complex and heterogeneous allotetraploid genome of quinoa, and have recently overcome the challenges, with the whole genome-sequencing of quinoa and the creation of genotyped inbred lines (Research Highlights 2016, B03: Draft genome sequence of an inbred line of *Chenopodium quinoa*, an allotetraploid pseudocereal crop with high nutritional properties and tolerance to abiotic stresses; Research Highlights 2020, B08: Genetic and phenotypic variation of agronomic traits and salt tolerance among quinoa inbred lines). However, the lack of technology to analyze gene function *in planta* is a major limiting factor in quinoa research.

In this study, we demonstrate that the virus-mediated transient gene expression or repression techniques can be used in quinoa plants (Fig. 1). We show that apple latent spherical virus (ALSV) vector can induce gene silencing of a quinoa carotenoid biosynthesis gene, phytoene desaturase (*CqPDS1*) (Fig. 2). Virus-mediated silencing of *CqPDS1* induces decreased accumulation of carotenoids and causes photobleaching symptoms in quinoa plants (Fig. 3). We also show that ALSV-mediated gene silencing can also be used in a broad range of

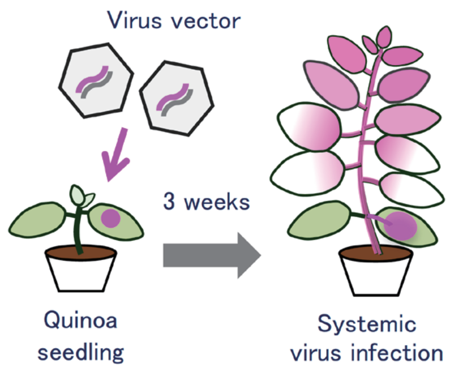


Fig. 1. Schematic of the virus vector system in quinoa plants

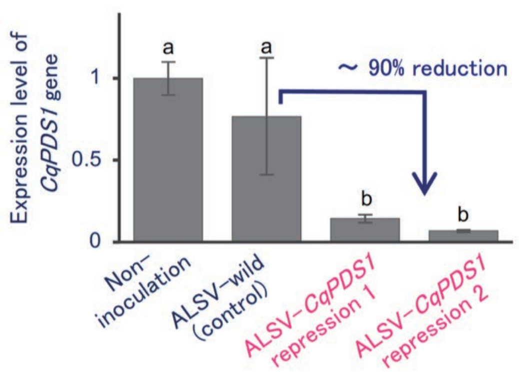


Fig. 2. ALSV induces silencing of carotenoid biosynthesis genes *CqPDS1* in quinoa.
RT-qPCR quantification of *CqPDS1* transcripts in the uninoculated upper leaves of plants inoculated with the indicated inocula. Data are normalized and are shown as means ± SD (n = 3). Different letters indicate significant differences ($p < 0.05$).

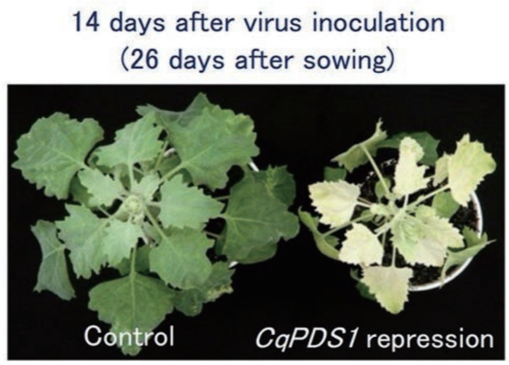


Fig. 3. Silencing of CqPDS1 induces photobleaching phenotypes in quinoa plants.
A representative image of quinoa plants (inbred Iw line) at 14 days after virus inoculation with ALSV-wild (control) and ALSV-*CqPDS1* is shown.

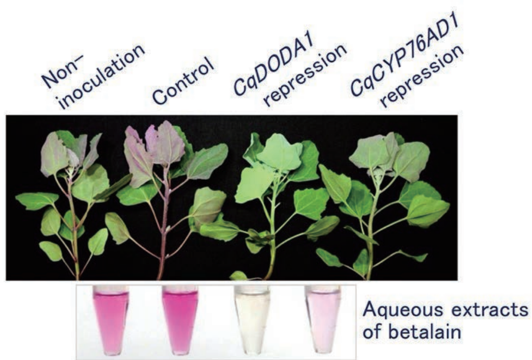


Fig. 4. Functional analysis of genes for betalain pigments biosynthesis in quinoa using the virus vector system
Virus-mediated silencing of *CqDODA1* and *CqCYP76AD1* inhibits betalain production in quinoa. Representative images of quinoa plants (inbred J056 lines) and aqueous extracts from the uninoculated upper leaves are shown. Quinoa plants inoculated with ALSV-wild were used as a control.

quinoa inbred lines derived from the northern and southern highland and lowland sub-populations. Our data also indicate that repression of a quinoa 3,4-dihydroxyphenylalanine 4,5-dioxygenase gene (*CqDODA1*) or a cytochrome P450 enzyme gene (*CqCYP76AD1*) reduces accumulation of red-violet betalain pigments in quinoa plants (Fig. 4).

Our data demonstrate that the virus vector system is a useful tool for evaluating gene function in quinoa, where molecular breeding techniques such as genetic transformation have not been developed yet. Functional validation of quinoa genes, utilizing the published genomic information, could provide gene resources for molecular breeding of quinoa.

Reference

Ogata T et al. (2021) *Frontiers in Plant Science* 12: 643499

Figures reprinted/modified with permission.

(T. Ogata, M. Toyoshima, C. Yamamizo-Oda, Y. Kobayashi, K. Fujii, Y. Nagatoshi, Y. Fujita, K. Tanaka [Actree Corporation], T. Tanaka [Actree Corporation], H. Mizukoshi [Actree Corporation], Y. Yasui [Kyoto University], N. Yoshikawa [Iwate University])

TOPIC 4

Genome sequence of the soybean fungal pathogen, *Cercospora kikuchii*

Diseases caused by *Cercospora* spp. are threats to soybean production in South American countries such as Argentina. *Cercospora kikuchii* (Tak. Matsumoto & Tomoy.) M. W. Gardner is a pathogen of Cercospora leaf blight and purple seed stain in soybean. The symptoms appear on several parts of soybean plant, for instance, leaves, petioles, and seeds. Fungicide is one of the main management methods against this devastating disease. However, it was reported that some agrochemicals are losing effectiveness against the pathogen. High-quality genomic information of *C. kikuchii* can provide fundamental insights toward understanding the disease, and such studies will contribute to designing a molecular diagnosis method for the disease.

We selected the *C. kikuchii* isolate MAFF 305040 for this research. This was isolated in Japan and deposited to the Genebank of the National Agriculture and Food Research Organization (Tsukuba, Ibaraki, Japan). Sufficient depth of genome sequencing generated a high-quality genome assembly of this pathogen. The final genome assembly contained nine contigs comprising 34.44 Mb (Table 1, Fig. 1). The number of genes predicted from the genome assembly was 13,001 (Table 1). Completeness of the dataset was estimated using BUSCO (Table 1). From the predicted coding sequences,

Table 1. Description of the genome assembly

Features	Value
Isolate name	MAFF 305040
Assembly size (bp)	34,440,063
Number of contigs	9
Number of predicted genes	13,001
BUSCO completeness	99.4%
Accession number*	BOLY00000000

*DDBJ/EMBL/GenBank accession number

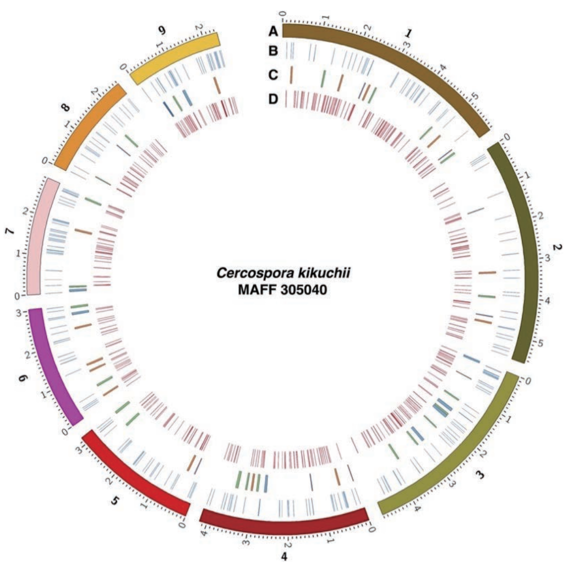


Fig. 1. Graphical summary of the genome assembly
Circos plot of the genome assembly. Track A indicates nine contigs of the genome assembly. Minor ticks indicate 0.1 Mb. Positions of the predicted pathogenicity-related genes, namely, effector candidates (B), secondary metabolite gene clusters (C), and CAZyme genes (D) are also shown.

candidates for pathogenicity-related genes, namely, effector genes, secondary metabolite gene clusters, and genes of carbohydrate-active enzymes (CAZymes) were selected (Fig. 1).

The genome sequence was deposited in public databases (Table 1). The data can be used as a source in *C. kikuchii* genomic studies. Coding regions and functions of encoding proteins in this genome sequence should be validated since these were predicted from the assembled genomic sequence based on the database of genes/proteins of other organisms.

Reference

Kashiwa T and Suzuki T (2021) G3: *Genes|Genomes|Genetics*, 11 (10), jkab277. https://doi.org/10.1093/g3journal/jkab277

Figure and table reprinted/modified with permission.

(T. Kashiwa, T. Suzuki [Utsunomiya University])

TOPIC 5

The pathogenicity of Asian soybean rust pathogen in Mexico can be grouped into two broad trends

Asian soybean rust (ASR) caused by *Phakopsora pachyrhizi* is the most important soybean disease in tropical and subtropical soybean cultivation areas. In Mexico, domestic soybean production is increasing each year, and with it, ASR disease has become a major problem. Plant disease control through the introduction of resistant varieties is advantageous in terms of low cost and low environmental impact, but resistance genes must be selected for breeding according to the virulence of the target pathogen. Thus, we analyzed the virulence of *P. pachyrhizi* populations in the major soybean production areas in Mexico.

ASR samples were taken from major soybean production areas in Mexico. Four samples were collected in Tamaulipas and San Luis Potosi states in 2015, and 19 samples were collected in Tamaulipas and Chiapas states from 2016 to

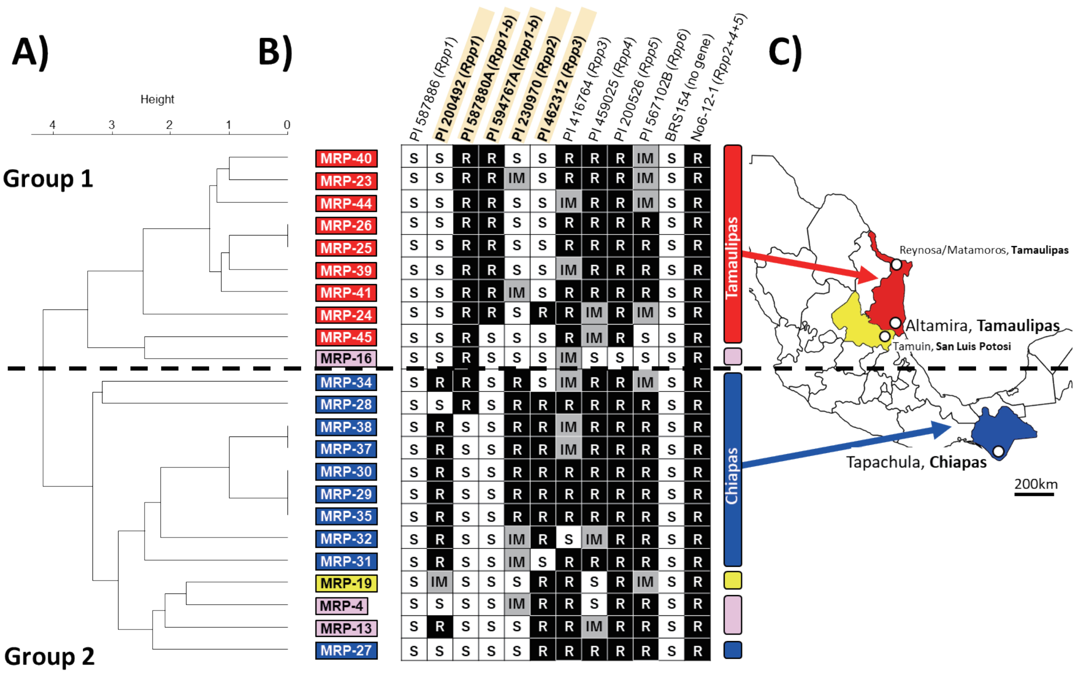


Fig. 1. A dendrogram of Asian soybean rust samples (MRPs) collected in Mexico based on their virulence (A), reaction profiles of the differential varieties (B), and regions where they were collected (C)
Samples obtained in 2016-2019 in Tamaulipas state are shown in red, samples obtained in 2015 in pink, samples obtained in 2015 in San Luis Potosi state in yellow, and samples obtained in 2018 in Chiapas state in blue. The parentheses after the name of the differential varieties indicate the resistance gene (*Rpp*) possessed by R, IM, and S for resistant, intermediate, and susceptible types, respectively.

2019. These 23 samples were inoculated onto 12 ASR differential varieties and the reactions were evaluated as resistant, intermediate, or susceptible types. Clustering analysis showed that these ASR samples were classified into two groups (Group 1 and Group 2) that exhibited different virulence characteristics (Fig. 1A). Group 1 consisted of ASR samples collected from Tamaulipas, where soybean varieties carrying the resistance gene *Rpp1-b* were resistant and effective for disease control. However, soybean PI 200492 carrying *Rpp1*, PI 230970 carrying *Rpp2*, and PI 462312 carrying *Rpp3* showed susceptibility to ASR infection in most samples, thus the genes were not effective. (Figs. 1B and 1C). These characteristics were consistent with those exhibited by many of the ASR pathogens in South America. Group 2, on the other hand, consisted mainly of ASR samples collected from Chiapas. Five differential varieties with four resistance genes showed opposite reaction patterns to those from Tamaulipas. The virulence characteristics of this group were consistent with those reported for many ASR fungi in North America. It is rare to observe such clear geographic variation in virulence within a small area of a single country.

The present study found that Mexico has diverse ASR pathogen populations with the virulence characteristics of those reported from both South and North America. We also found a highly virulent ASR sample, MRP-16, which is pathogenic to all seven resistance genes except *Rpp1-b* of PI 587880A. The gene-pyramided line (No6-12-1) carrying the three resistance genes *Rpp2*, *Rpp4*, and *Rpp5* was resistant to all ASR samples, including MRP-16, and effective in controlling the disease (Fig. 1B). This gene-pyramided line, which is effective against Mexican ASR, is also known to show high resistance, making it a promising breeding material in Mexico. In addition, identifying factors that contribute to the large differences in virulence detected in this study may be helpful in ASR control.

References

García-Rodríguez JC et al. (2017) *Mexican Journal of Phytopathology*, 35(2):338-349. https://doi.org/10.18781/r.mex.fit.1701-5, and
García-Rodríguez JC et al. (2021) *PhytoFrontiers*, 2(1). https://doi.org/10.1094/PHYTOFR-06-21-0044-R

Figure reprinted/modified with permission.

(N. Yamanaka, J.C. García-Rodríguez [National Institute for Forestry, Agriculture and Livestock Research, Mexico])

TOPIC 6

Gregarized desert locust females and males encounter just before oviposition in West Africa

Desert locusts are found in semi-arid regions from West Africa to India, and often cause serious agricultural damage. Since desert locusts are found in vast areas and adults in particular fly long distances, it is difficult to control them by spraying pesticides, and in order to mitigate the damage, it is necessary to develop control technologies based on desert locust ecology. To solve this problem, it is important to understand the behavioral patterns of desert locusts, especially how adult desert locusts mate and lay eggs in the field during the breeding season. Therefore, we conducted a field survey from 2011 to 2019 with the aim of elucidating the reproductive strategies of desert locusts in the Sahara Desert.

In this study, we conducted a field survey in the Sahara Desert, which stretches across Mauritania in West Africa, the habitat of desert locusts. We simultaneously recorded the sex ratio, mating status, and degree of ovarian development of a gregarized population. The results showed that the sex ratio of the population was skewed towards either sex. In the female-biased population, most of the female desert locusts were developing ovaries and were not mating, but most of the females in the male-biased population had large eggs that were about to be laid and were mating (Fig. 1). A closer look at the male-biased population revealed that during the daytime, gravid female desert locusts flew into the male group (Fig. 2) just before oviposition. After mating, the male remained on the female's back and continued their post-mating guarding (Fig. 3). In the evening, they gathered in the open sand near where they met, and we also found that they spawned in pairs at night (Fig. 3). It can be

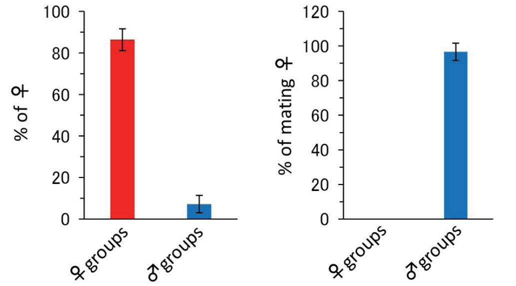


Fig. 1. Sex ratios and percentage of mating females of either groups of female- or male-biased sex ratios

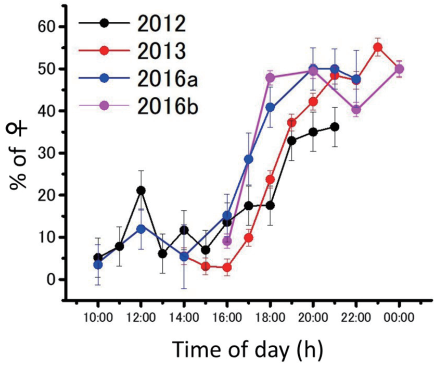


Fig. 2. Diel changes in the percentages of females in male-biased sex groups based on data from transect (2 m × 25 m)

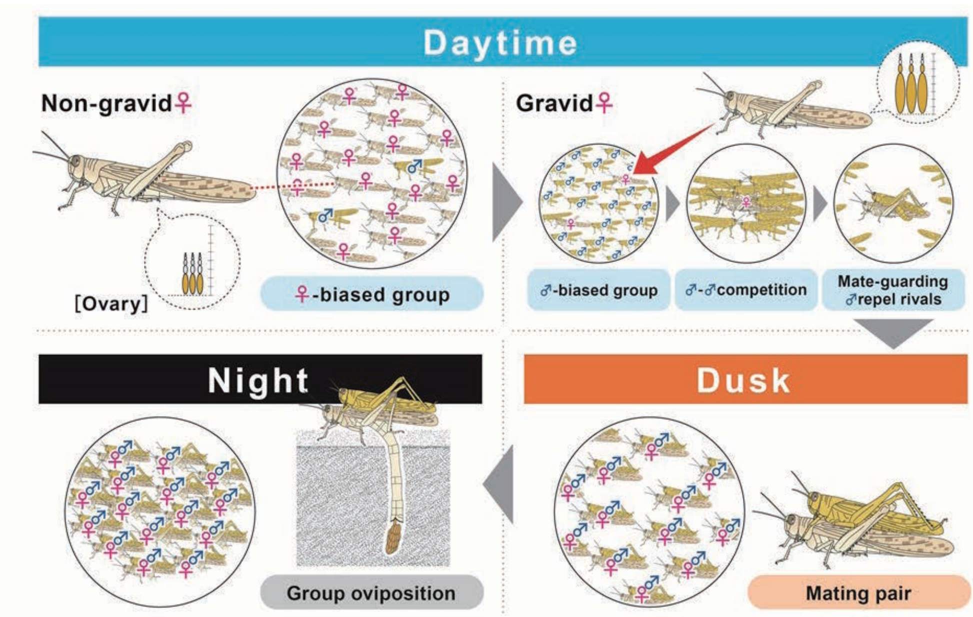


Fig. 3. During the day, female desert locusts with developing ovaries stay in groups with a skewed sex ratio toward females and do not mate. When females ready to lay eggs fly into a group of males, many males compete to mate. When one male rides on the back of the female, the other males give up, no further fighting occurs and then they mate. In the evening, they move in pairs to sandy areas suitable for oviposition and begin to aggregate. At night, they oviposit in groups.

inferred that the male and female desert locusts are able to meet their partners efficiently while resolving sexual conflicts by living separately in groups. Pairs that are spawning in groups remain in place for several hours, making them good targets for pest control. If a group of male desert locusts is found, it is possible to reduce the amount of pesticides used by waiting for the group to spawn until nighttime instead of immediately controlling them.

As recommended by the Food and Agriculture Organization of the United Nations, intensive pesticide application timed to coincide with the identified periods of desert locust inactivity will lead to an environmentally and health-conscious pest control that does not use more pesticides than necessary.

Reference

Maeno KO et al. (2021) *PNAS USA*, 118 (42). https://doi.org/10.1073/pnas.2104673118

Figures reprinted/modified with permission.

(K.O. Maeno, P. Cyril [The French Agricultural Research Centre for International Development], S. Ould Ely [The Mauritanian National Anti-Locust Centre (CNLA)], M.E.H. Jaavar [CNLA], S. Ould Mohamed [CNLA], M.A. Ould Babah Ebbe [CNLA], S. Ghaout [The Moroccan National Anti-Locust Centre])

Predicting body growth and body mass index of farmed milkfish in the Philippines from water temperature

Information on the growth of farmed fish is important for aquaculture production planning and cost management. It also helps aquaculture managers understand the quality (fat content) and health status of farmed fish, including milkfish. Milkfish is the most important aquaculture target species in the Philippines. However, although milkfishes are actually raised in open-air conditions, only a few previous studies have focused on water temperature. Therefore, this study aimed to clarify the impact of changes in open-air water temperature on milkfish growth and body mass index.

A logistic model for growth (weight) of farmed milkfish was proposed as the most applicable statistical model, with data sampling conducted

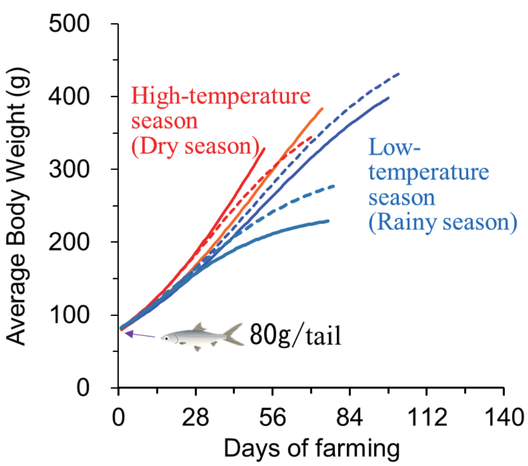


Fig. 1. Examples of weight growth estimation for different conditions as seasons
Solid and dashed lines are different farm facility locations. Experiments were conducted three times during the high-temperature season and four times during the low-temperature season. Starting with seedlings weighing 80 g/tail.

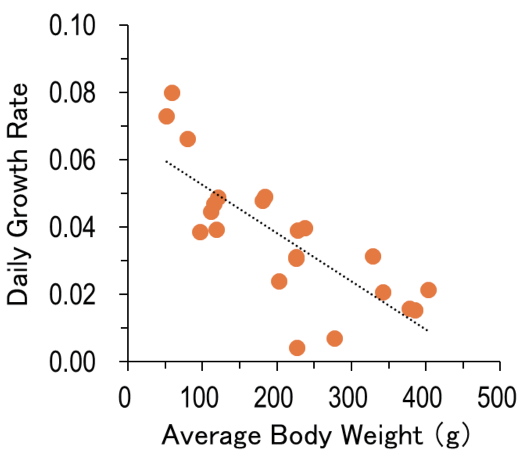


Fig. 2. Relationship between daily growth rate and fish weight
Daily growth rate = 100 × exp (((ln(Wf) –ln(Wi))/farming period) –1).
Wf is the weight at the time of measurement (g) and Wi is the weight at the beginning of farming (g).

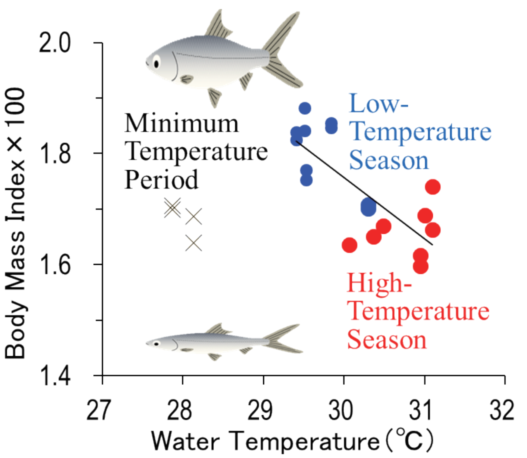


Fig. 3. Relationship between body mass index and water temperature
Body Mass Index = weight (g)/(length (cm))^2. Red dots correspond to BMI during high-temperature season, blue dots correspond to BMI during low-temperature season, and X marks indicate BMI during minimum temperature period.

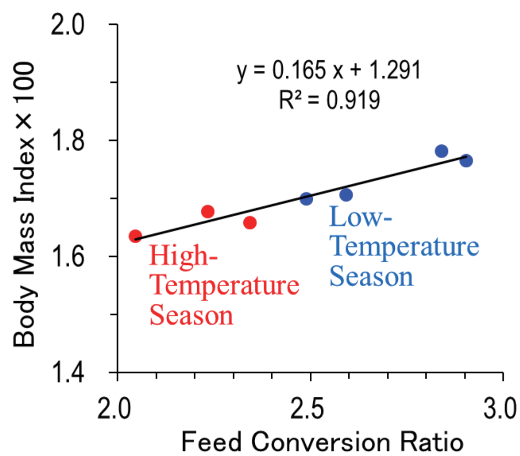


Fig. 4. Relationship between body mass index and feed conversion ratio
Feed conversion ratio = total feed consumed (g)/total weight of product produced (g). Data of the minimum temperature period are not included.

in high-temperature and low-temperature seasons (Fig. 1). In accordance with common fish farming practice, the experiment was conducted with satiated (full) feeding. The results show that the daily growth rate decreases as milkfish size increases (Fig. 2). The growth model also reflects these physiological characteristics. Regarding the relationship between body mass index and water temperature, body mass index (fat content) increases during low-temperature season (around 29 – 30°C) and decreases during high-temperature season (>30°C). The body mass index also decreases during the minimum temperature period (27 – 28°C) in low-temperature season (Fig. 3). As for the relationships among body mass index, water temperature, and feed conversion rate, feed conversion rate and body mass index decrease during high-temperature season. Conversely, they increase during low-temperature season (Fig. 4).

Previous studies have generally used linear regression analysis for estimating fish growth, which tended to exceed growth estimates up to the shipping size (300 – 400 g/fish). However, this model can be adjusted for such overestimates, and farm managers can utilize the model for more accurate growth and shipping forecasts. Based on the relationship between fish weight and growth rate, it is possible to predict the optimal size of fish to ship for efficient aquaculture business. However, because cost is not analyzed, it is not possible to estimate the optimal size for operating an aquaculture business from this research. Body mass index can be estimated from water temperature using the results; however, further data collection and model modification are needed to make more precise predictions. This research can provide insights for the amount of feed that should be fed at certain temperatures, for example, reducing the amount of feed during low-temperature season and keeping the level of fat constant throughout the year. Feeding cost represents the largest proportion of costs in fish aquaculture business, and the results of this research can contribute to guideline development and cost reduction.

Reference

Kodama M et al. (2021) *JARQ* 55: 191−200. https://doi.org/10.6090/jarq.55.191

Figures reprinted/modified with permission.

(M. Kodama [Japan Fisheries Research and Education Agency], R. A. Diamante [Southeast Asian Fisheries Development Center (SEAFDEC)], N. Salayo [SEAFDEC], R. J. Castel [SEAFDEC], J. Sumbing [Yokohama National University])

TOPIC 8

Germ cell cryopreservation to conserve genetic diversity in shrimps

Establishing sustainable aquaculture requires the development of techniques to prevent genetic deterioration of aquaculture populations and to produce superior strains such as disease-resistant strains. For this purpose, it is extremely important to preserve existing genetic diversity. In recent years, germ cell cryopreservation techniques and germ cell transplantation techniques for producing sperm, eggs, and larvae derived from cryopreserved germ cells have been developed for several fish species and are the only effective methods for preserving all genetic information in fish in which egg cryopreservation has not been available. However, such technology has not yet been developed for crustaceans, which are important species in fisheries. The only way to preserve genetic diversity of crustacean species is to keep a huge number of live individuals in aquariums or cages. To address this issue, this study will develop the first germ cell cryopreservation technique in crustacean for two species of prawns, the black tiger shrimp (*Penaeus monodon*) and banana shrimp (*Fenneropenaeus merguiensis*), both of which belong to Penaeidae.

In this study, we compared three commonly used cryoprotectants — dimethyl sulfoxide (DMSO), glycerol, and magnesium chloride ($MgCl_2$) — and found that 10% glycerol or 10% DMSO resulted in higher germ cell viability after cryopreservation in both species (Fig. 1). In terms of recovery rates, 10% glycerol and 10% DMSO resulted in higher recovery rates than other cryoprotectants in black tiger shrimp and banana shrimp, respectively (Fig. 2). Considering the survival and recovery rates together, it was concluded that 10% glycerol and 10%

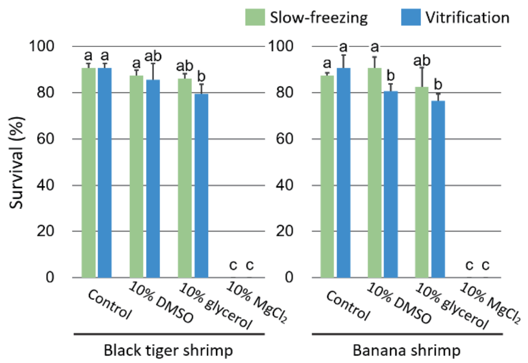


Fig. 1. Survival rates of the germ cells
Different letters indicate significant differences ($p < 0.05$).
Slow-freezing method is freezing at a rate of –1ºC/min. The vitrification method is a rapid freezing method using liquid nitrogen after dehydration and complete replacement of intracellular water with a cryoprotectant.

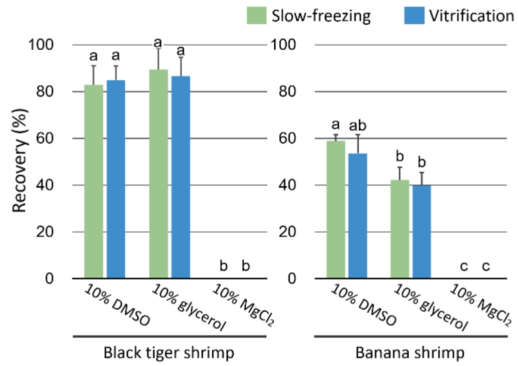


Fig. 2. Recovery rates of the germ cells
Recovery rate (%) = the number of live germ cells obtained after freezing and thawing x 100 / the number of live germ cells before freezing and thawing. Different letters indicate significant differences ($p < 0.05$).

DMSO were suitable cryoprotectants for black tiger shrimp and banana shrimp, respectively. Furthermore, for both species, the vitrification method was found to be more suitable for long-term preservation than the slow-freezing method (Fig. 3).

Based on this study, the following are expected: 1) Since germ cells can be cryopreserved in liquid nitrogen storage containers, this technique will enable the preservation of genetic diversity of the black tiger shrimp and banana shrimp semipermanently without genetic deterioration and with less space and labor than rearing of live individuals; 2) cryopreservation of germ cells makes it possible to prevent genetic deterioration of aquaculture populations and to secure genetic breeding material which will be used in future breeding programs to produce superior strains before genetic diversity is lost, which can lead to sustainable shrimp aquaculture technology; and 3) based on this study, it is expected that germ cell cryopreservation techniques can be developed for other species of prawns, including many species with high economic value, to conserve the existing genetic diversity of these species. In addition to this study, if germ cell transplantation techniques are developed in crustaceans, it will also be possible to regenerate individuals from frozen germ cells.

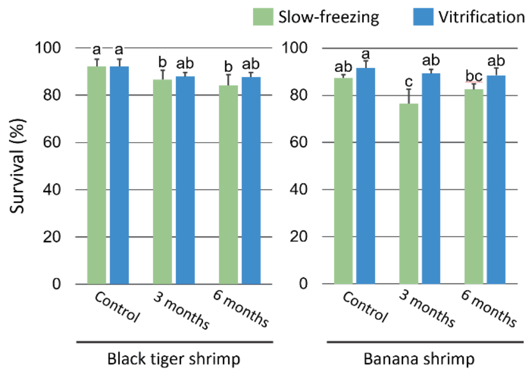


Fig. 3. Survival rates of the germ cells after long-term cryopreservation
Different letters indicate significant differences ($p < 0.05$).

Reference

Rakbanjong N et al. (2021) *Marine Biotechnology* 23: 590–601. https://doi.org/10.1007/s10126-021-10048-1
Figures reprinted/modified with permission.

(T. Okutsu, N. Rakbanjong [Prince of Songkhla University (PSU), Thailand], W. Chotigeat [PSU], A. Songnui [Department of Fisheries, Thailand], M. Wonglapsuwan [PSU])

Increase of rice yield in response to phosphorus fertilizer application can be predicted by soil phosphorus retention capacity

Phosphorus (P) fertilizer application is essential for increasing crop productivity in tropical agroecosystems in sub-Saharan Africa (SSA), where P-deficient weathered soils are dominant. Farmers in SSA generally have limited capacity to purchase expensive chemical fertilizers. Therefore, P fertilizer should be efficiently applied to croplands with high response to P fertilizer application based on soil diagnosis. Soils have the capacity to fix soluble P (P retention capacity). It causes the immobilization of applied P soon after fertilizer application and decreases P availability for crops. However, there is little quantitative information on the relationship between soil P retention capacity and crop response to P fertilizer application in P-deficient soils in SSA. In this study, we clarified the relationship between soil P retention capacity and rice yield when P fertilizer was applied in the central highlands of Madagascar. Furthermore, soil physicochemical properties were investigated to verify whether our finding can be applied to other regions in SSA.

Multi-site field trials were conducted to evaluate the response of rice yield to the application of P fertilizer (ΔYield) at farmers' P-deficient paddy fields in two communes (A and B) in the central highlands of Madagascar. The ΔYield ranged from −0.4 to 2.1 t ha^{-1} among the fields and it was better predicted by soil P retention capacity than by soil available P content of the fields (Fig. 1). The ΔYield decreased with increasing soil P retention capacity. There was no response of rice yield to P fertilizer application when soil P retention capacity was higher than 35% in Commune A with mean temperature of 22.2°C during the cultivation period. On the other hand, the increase in rice yield by P fertilizer application was not observed when soil P retention capacity exceeded 53% in Commune B with mean temperature of 20.8°C. Multiple regression analysis revealed that active aluminum (oxalate-extractable Al, Alox) content was the most important factor of soil P retention across all the soils collected from 213 paddy fields in the central highlands of Madagascar (Table 1). This indicates that rice plants grown on soils with higher Alox and P retention capacity are less sensitive to P fertilizer application.

We found that the increase in rice yield in response to P fertilizer application can be predicted by soil P retention capacity. Our finding

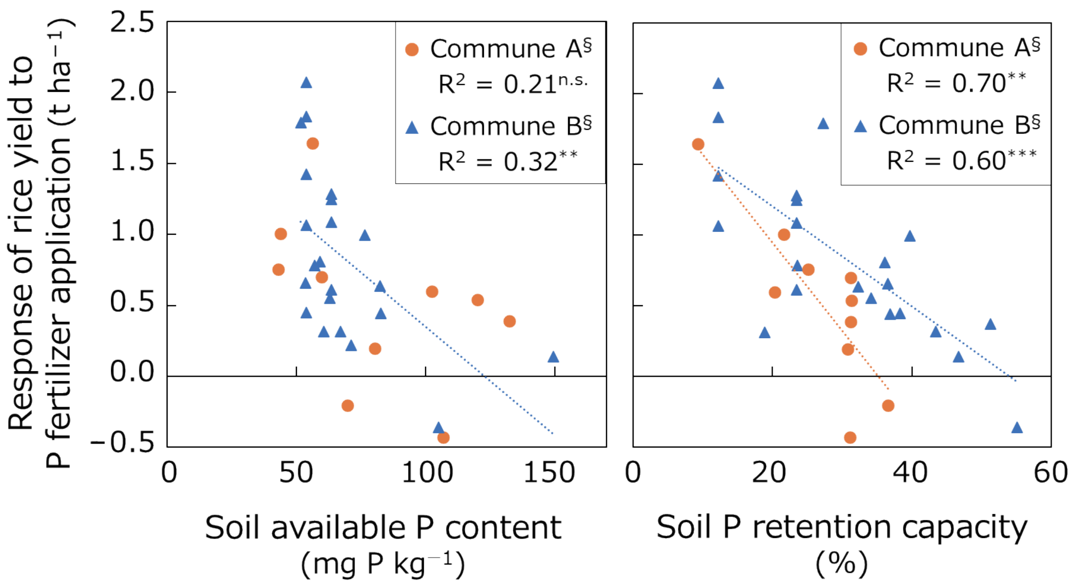


Fig. 1. Relationship between response of rice yield to P fertilizer application and soil available P content and soil P retention capacity

Yield increase in response to P fertilizer application was calculated by the difference between the rice yields of N fertilizer plot and N+P fertilizer plot in the field trials. N fertilizer was applied at 80 kg N ha^{-1} as urea, while P fertilizer was applied at 50 kg P ha^{-1} as triple super phosphate. Soil available P content was determined by acid ammonium oxalate extraction method. §Mean temperature during the cropping period was 22.2°C and 20.8°C at Communes A and B, respectively. $^{***}p < 0.001$, $^{**}p < 0.01$, $^{n.s.}p > 0.1$.

Table 1. Standard partial regression coefficients for soil P retention capacity and soil physicochemical properties

Alox¶	Clay	Feox¶	Base saturation
0.646***	0.305***	0.184***	0.173***

Multiple regression analysis detected soil physicochemical properties which significantly controlled soil P retention capacity for soils collected from 213 paddy rice fields in the central highlands of Madagascar. ¶Oxalate-extractable Al and Fe content. ***$p < 0.001$.

can help farmers facing P deficiency to identify the most responsive fields to P fertilizer prior to its application and, thus, to utilize efficiently a limited amount of P fertilizer in their fields. Since soils with Alox and low available P content are often seen in SSA, our finding is applicable to wide regions in SSA other than Madagascar. Further study should verify its applicability on different crops.

Reference

Nishigaki T et al. (2021) *Geoderma* 402: 115326. https://doi.org/10.1016/j.geoderma.2021.115326

Figure and table reprinted/modified with permission.

(T. Nishigaki, Y. Tsujimoto, H. Asai, T. Rakotoson [University of Antananarivo (UA)], M. Rabenarivo [UA], A. Andriamananjara [UA], H.B. Andrianary [UA], H. Rakotonindrina [UA], T. Razafimbelo [UA])

TOPIC *10*

A model for estimating soil phosphorus availability in diverse tropical ecosystems by deep learning

Since soil phosphorus (P) availability is low in tropical regions, it is necessary to accurately assess the soil P availability and implement appropriate nutrient management to realize sustainable crop production and land use. So far, we have developed a method to rapidly assess oxalate-extractable P (Pox) using visible and near-infrared (Vis-NIR) spectroscopy (JIRCAS Research Highlights 2019: "Soil phosphorus availability for rice plants can be rapidly estimated by laboratory visible and near-infrared spectroscopy"). However, this method based on partial least squares (PLS) regression strongly depends on the spectral characteristics of the training dataset, and thus, building a single model is difficult in soils with different land uses (paddy fields, crop fields, forests, etc.) and meteorological conditions. On the other hand, deep learning, in which the machine automatically discriminates wavelength characteristics, can develop a comprehensive model independent from land use. Deep learning requires a large amount of training data, but higher predictive accuracy than PLS regression can be expected. In this study, we aimed to develop a single model for estimating soil Pox in various tropical ecosystems by deep learning of spectral data.

Soil samples (n = 318) were collected from the surface layer (0–15 cm depth) in rice fields, crop fields, forests, fallow lands, and bare lands in the east coast and the central highlands of Madagascar (110–1,667 m above sea level). The spectral data was measured in the Vis-NIR region (400–2400 nm) in a dark room using a portable spectroradiometer (FieldSpec, ASD Inc.) for 2 mm sieve-passing air-dried soil. The content of soil available P was determined by acid ammonium oxalate method (Pox). The deep learning model trained the relationship between spectral data and soil Pox content using a one-dimensional convolutional neural network (1D-CNN). The 1D-CNN model can be applied to soil Pox estimation for diverse ecosystems, and its accuracy (R^2 = 0.878) is higher than that of PLS model (R^2 = 0.792) (Fig. 1). Based on the sensitivity analysis, the 1D-CNN model has high sensitivity of related wavebands (432, 590, 1433 nm) of iron oxide and water content in the soils, which are in line with PLS regression coefficients. This result suggests that these wavebands are strongly associated with the soil Pox estimation across diverse ecosystems (Fig. 2).

The developed 1D-CNN model using soil spectral data enables safe and quick estimation

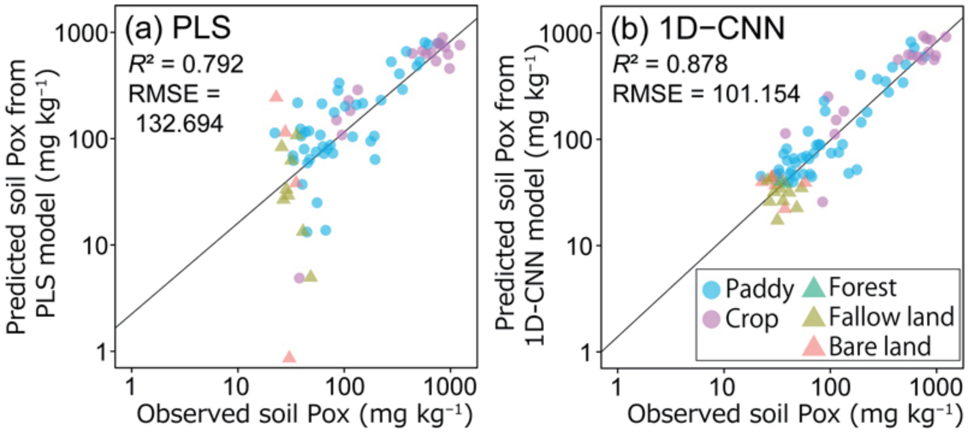


Fig. 1. Relationship between observed and predicted values of soil oxalate-extractable phosphorus (Pox) using (a) PLS model and (b) 1D-CNN model
The *x*- and *y*-axes are displayed on a log scale. RMSE: Root mean squared error

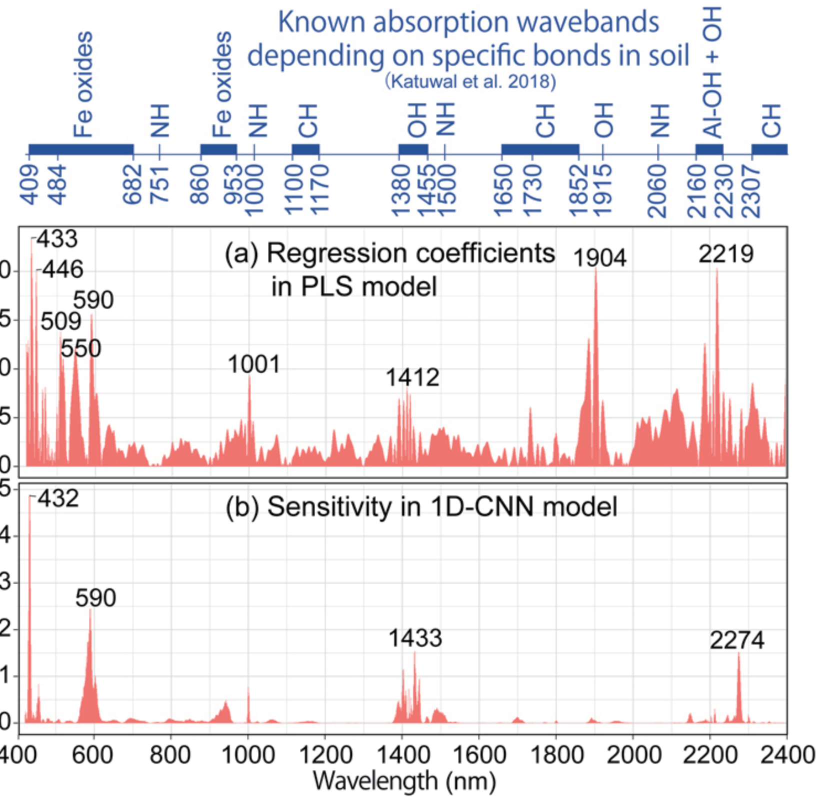


Fig. 2. (a) Regression coefficients in PLS model and (b) sensitivity in 1D-CNN model
Red lines and numbers: Importance and wavelength in the estimation of soil availability (Pox). Fe oxides are the absorption wavelengths of iron oxide. OH is the absorption wavelength of the water content.

of soil Pox without chemical analysis, and can be used for designing optimum fertilizer application. Since the dataset for the current model covers a range of soil types and elevations in the tropics, the model can be also applied to tropical regions other than Madagascar.

Reference

Kawamura et al. (2021) *Remote Sensing* 13: 1519. https://doi.org/10.3390/rs13081519
Figures reprinted/modified with permission.

(K. Kawamura, T. Nishigaki, Y. Tsujimoto, A. Andriamananjara [University of Antananarivo (UA)], H. Rakotonindrina [UA], M. Rabenarivo [UA], T. Razafimbelo [UA])

Efficient phosphorus application strategy to improve rice yields under cold stress-prone and P-deficient environments

Despite a general perception that phosphorus (P) deficiency delays phenological development in annual crops, the impacts of interaction between this phenological delay and climatic conditions on crop productivity remain poorly understood. On-farm experiments were conducted in the central highlands of Madagascar, where P deficiency and late-season low temperature stress frequently restrict rice yields. Rice X265 was grown under four different fertilizer treatments with different combinations of N and P during early and late transplanting dates (ETP and LTP, respectively). Plants subjected to no fertilizer or single N treatments (-P) showed delayed heading by 9–16 days relative to the single P and N and P combined plots on average (Table 1). The delay in phenological development without P application (-P) and the delay in transplanting date (LTP) additively increased the risk of low temperature stresses at the heading periods (Fig. 1). As a result, -P plots at LTP increased the cooling degree days and spikelet sterility while the delay in phenological development without P application little affected the cooling degree days and spikelet sterility when transplanted early or ETP (Fig. 2). With this significant interaction between P application and transplanting dates on cold stresses, the effect of P on rice yield was much greater in LTP than in ETP because P application alleviated not only P deficiency but low temperature stress as well by shortening day to heading (Table 1). This study provides field evidence that the effects of P application on rice yield were greatly dependent on transplanting date via their impact on phenological development under P-deficiency in climate stress-prone environments. Changes in phenological development due to plant nutrient status and its interaction with climate-induced stress needs further attention for improving fertilizer management practice.

Table 1. Effect of P application and transplanting date on days to heading and yield of rice grown on P-deficient fields

		Days from transplanting to heading			Yield (t ha^{-1})		
		-P	+P	Difference between +P and -P	-P	+P	Difference between +P and -P
ETP	Field1	111	95	−16	2.2	3.1	0.8
	Field2	110	98	−11	2.4	3.2	0.8
LTP	Field1	109	96	−12	1.9	3.1	1.2
	Field2	105	96	−9	1.8	3.1	1.3

−P indicates the means of the plots without fertilizer and with N applied as urea at the rate of 80 kg N ha^{-1}.
+P indicates the means of plots with P applied as triple super phosphate at the rate of 50 kg P_2O_5 ha^{-1} and with N and P combined.
ETP refers to early transplanting plots (November 28–29).
LTP refers to late transplanting plots (December 27–30).
Underlined values indicate significant differences between -P and +P plots at 5% by Tukey HSD.
ANOVA detected a significant interaction between P treatment and transplanting dates on yield.

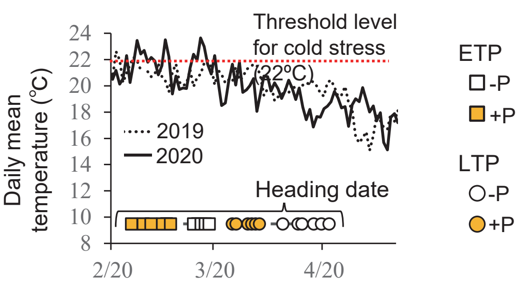


Fig. 1. Changes in daily mean temperatures at the heading periods as affected by transplanting dates and P application

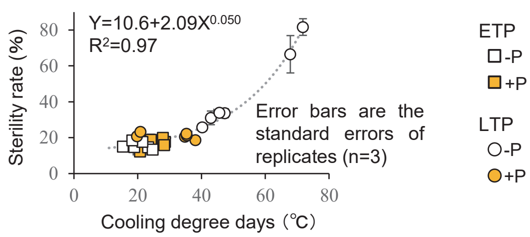


Fig. 2. Effect of transplanting dates and P application on the cooling degree days (CDD) and spikelet sterility
CDD is the sum of daily mean temperatures below 22ºC from 15 days before to 7 days after heading.

References

Andrianary et al. (2021) *Field Crops Research* 271: 108256. https://doi.org/10.1016/j.fcr.2021.108256, and Rakotoson et al. (2022) *Field Crops Research* 275: 108370. https://doi.org/10.1016/j.fcr.2021.108370

(Y. Tsujimoto, A.Z. Oo, T. Nishigaki, B. Andrianary [University of Antananarivo (UA), LRI], H. Rakotonindrina [UA, LRI], M. Rabenarivo [UA, LRI], N. Ramifehiarivo [UA, LRI], H. Razakamanarivo [UA, LRI], T. Rakotoson [UA, LRI])

TOPIC 12

Meta-analysis reveals the effect of fertilizer application on upland rice cultivation in Africa

Rainfed upland is one of the dominant ecosystems for rice production in sub-Saharan Africa, where yields are very low (approx. 2.1 t ha^{-1}). To overcome such low productivity, fertilizer application is necessary, and its effective use is key for improving rice yield and farmer's livelihood. Previous studies often reported that fertilizer application did not result in sufficient yield increase. It is partly because yield gain with fertilizer could be affected by biophysical factors such as precipitation and soil texture; however, their interaction remained poorly understood. Hence, a meta-analysis was performed for the dataset collected from fertilizer trials conducted in 8 countries in sub-Saharan Africa, where the environmental backgrounds varied considerably, in order to quantify the effect of soil texture and precipitation on yield gain with fertilizer.

The dataset was composed of 151 paired observations of control and fertilizer treatment from fertilizer trials using NERICA 4 from 8 countries (Table 1). Soils were classified into low clay soil (≤ 20% clay content) and high clay soil (> 20% clay content). Yield gain with fertilizer application (YG), i.e., the yield difference between fertilizer treatment and control, was evaluated in relation to nitrogen (N), phosphorus (P) and potassium (K) fertilizer application rates and the amount of precipitation. Regression analysis showed no correlation between YG and P and K fertilization rates ($p > 0.05$, data not shown). Precipitation closely correlated with YG, irrespective of soil type ($p < 0.001$, Fig. 1 left). N fertilizer rate was correlated with YG in high clay soil, ($p < 0.001$, Fig. 1 right,) but not in low clay soil ($p > 0.05$). Bayesian estimation clarified that YG would increase by 0.168 and 0.145 t ha^{-1} for low and high clay soil with a 100 mm increase in precipitation (Table 2). YG was also expected to increase by 0.653 t ha^{-1} in high clay soil with a 100 kg increase in N fertilizer rate, but in low clay soil, 95% posterior credibility intervals included zero, indicating that YG did not always increase with N fertilizer rate. Overall, these results recommend the fine-tuning of N fertilizer input based on soil type and expected precipitation.

Table 1. Description of fertilizer trials using upland rice (NERICA 4) in 8 countries in Africa

Country	Num.	Soil type (clay content)[2]		Fertilizer effect			
		Low clay (≤20%)	High clay (>20%)	NPK	N	P	K
Gambia	4	4	0	4	0	0	0
Guinea	2	2	0	2	0	0	0
Mali	2	2	0	2	0	0	0
Benin	65	65	0	53	12	0	0
Uganda	50	0	50	20	10	10	10
Nigeria	15	3	12	0	13	1	1
Kenya	12	12	0	2	6	4	0
Madagascar	1	0	1	1	0	0	0
Total	151	88	63	84	41	15	11

[1] Database: https://ars.els-cdn.com/content/image/1-s2.0-S0378429021002306-mmc1.xlsx
[2] Tanaka et al. (2017)

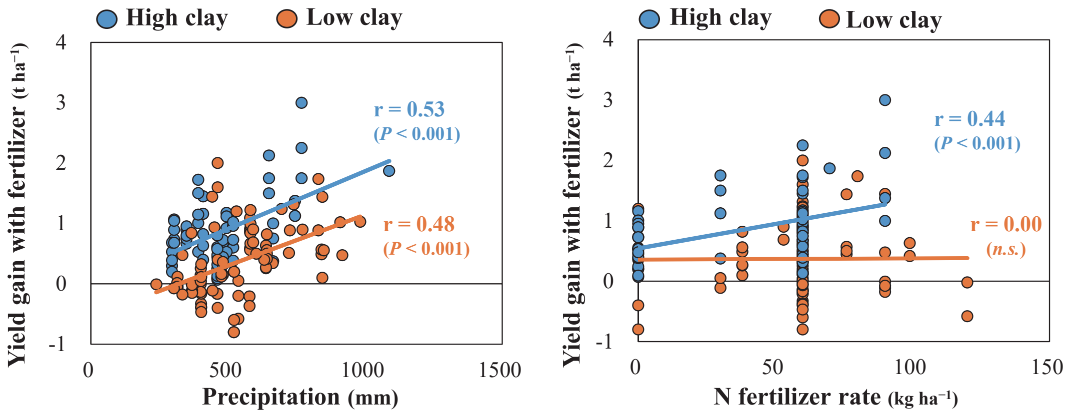


Fig. 1. The relationship of yield gain with fertilizer (YG) with precipitation (left) and N fertilizer application rate (right)

Table 2. Posterior probability distribution of the effect of precipitation and N fertilizer rate on yield gain with fertilizer under different soil types

Soil type	Precipitation ($t\ ha^{-1}\ 100mm^{-1}$)			N fertilizer rate ($t\ ha^{-1}\ 100kg^{-1}$)		
	Average	95% credible interval [1]		Average	95% credible interval [1]	
		2.5%	97.5%		2.5%	97.5%
High clay	0.145	0.068	0.22	0.653	0.253	1.05
Low clay	0.168	0.103	0.236	0.164	−0.352	0.679

[1] Credible interval is the range containing a 95% percentage of probable values estimated by Bayesian statistics.

The obtained results will allow the policy maker or private sector to predict the fertilizer-suitable areas for technical dissemination and commercial sale at the regional and/or national level. However, trends at the regional level may not be directly applicable to individual fields or to regions where the yields are constrained by other nutrient deficiencies such as phosphorus deficiency etc. In addition, further assessments are required for varieties other than NERICA 4.

Reference

Asai, H et al. (2021) *Field Crops Research* 272: 108284. https://doi.org/10.1016/j.fcr.2021.108284

Figure and tables reprinted/modified with permission.

(H. Asai, K. Kawamura, K. Saito [Africa Rice Center])

TOPIC 13

Introducing vegetables upstream of irrigation areas may increase farm income and lead to equitable water distribution

In sub-Saharan Africa, the development of irrigated rice techniques has been promoted in response to increasing demand for rice, resulting in high yields. However, in recent years, the decline in the amount of irrigation water due to unstable river flows and deteriorating irrigation facilities, as well as uneven irrigation water distribution between upstream and downstream, have emerged as factors constraining further rice production and farmer economy. On the other hand, demand for horticultural crops is growing in local markets, creating a condition for farmers to increase their incomes through agricultural diversification.

We examined the effects of changing the cropping system on water-saving, productivity, and profitability, based on the idea that converting double rice cropping to rice-upland crop system will lead to more efficient water use without sacrificing farm income. The field experiments and farmer surveys were conducted in the Lower Moshi Irrigation Scheme in northern Tanzania.

The main results are summarized as follows. First, conversion of rice to maize reduces

Table 1. Estimation of irrigation water requirements by crop (per crop season, 2018-19)

	Lowland rice[1]	Lowland maize[1]	Vegetables[2]
Irrigation period (day)	110	25	13.2
Daily irrigation amount (mm/day)	13	13	NA
Total irrigation amount (mm)	1,430	325	NA

[1] Canal irrigation. Measured in cultivation trial
[2] Interviews (n=9) in the irrigation scheme, vegetables are grown by private pump irrigation due to lack of canal water supply. The pumps used by the farmers have a capacity of less than 15 mm/day. African nightshade, amaranth, onion, bell pepper, Chinese cabbage, and squash are produced for market.

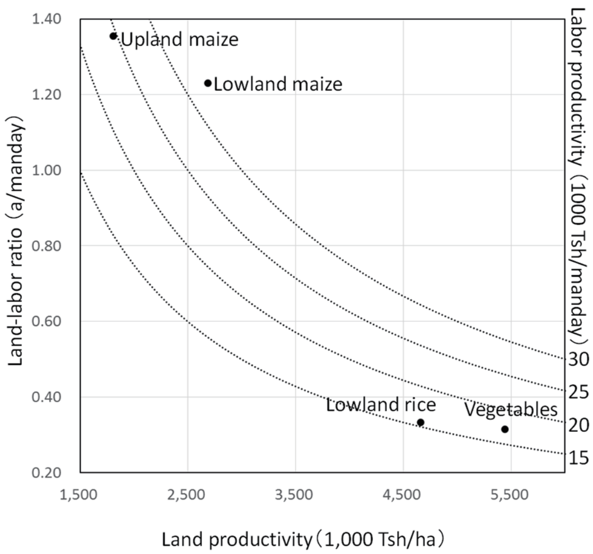


Fig. 1. Land and labor productivity by crop

1) Horizontal axis is land productivity (value added/area)
2) Vertical axis is land labor ratio (area/labor input) Higher values indicate land-use crops, lower values indicate labor-intensive crops
3) The dotted line is the iso-labor productivity curve Labor productivity (value added/labor input) = land productivity x land-labor ratio
4) Tsh is Tanzanian shilling 1 Tsh = 0.047 yen (November 18, 2019)

Table 2. Production cost and management indicators by crop (2018-19)

	Rice	Maize		Vegetables
Condition of irrigation (Sample number)	Irrigated lowland (78)	Irrigated lowland after rice (10)	Irrigated upland (5)	Well irrigation (9) [1]
Farm size (ha)	0.83	0.94	2.3	1.2
Surveyed plot (ha)	0.29	0.54	1.04	0.23
Yield (t/ha)	6.62	5.71	3.74	NA
Gross product: A (1000 Tsh/ha)	5,919	3,847	2,411	6,243
Cost (1000 Tsh/ha)				
Current input,	1,263	1,165	605	802 [2]
Hired labor	973	395	403	1,165
Family labor: B [3]	480	541	378	2,088
Total: C	2,717	2,101	1,386	4,056
Income : A – C + B (1,000 Tsh/ha)	3,682	2,287	1,405	4,276
Profit : A – C (1,000 Tsh/ha) [4]	3,202 (0.44)	1,746 (0.95)	1,027 (1.19)	2,188 (2.28)

[1] Private pump irrigation using shallow well
[2] Irrigation cost is imputed based on the rate for lowland maize.
[3] Imputed based on market wage rate
[4] The number in parentheses is the coefficient of variation, representing the variability of profit as a proxy indicator of risk.

irrigation water by 77%. Vegetables, which require the least number of irrigation days, are expected to save even more water (Table 1). Second, land productivity measured by value added (gross output minus non-labor expenditures) is higher in the order of vegetables > lowland rice > lowland maize > upland maize, and labor productivity is higher in the order of lowland maize > upland maize > vegetables > lowland rice. In case of strict land constraints, vegetables and rice are economically rational, while for farmers facing labor shortage, maize is advantageous over rice and vegetables (Fig. 1). Third, income not counting family labor as a cost is higher in the order of vegetables > lowland rice > lowland maize > upland maize. When taking family labor into account as a cost, profit is higher in the order of lowland rice > vegetables > lowland maize > upland maize. If vegetables are introduced after rice in lowland, the income can be expected to exceed that of double rice system. However, for households with high opportunity cost for family labor, the economic incentive to introduce vegetables is weak (Table 2).

The above findings suggest that in irrigation schemes where rice cultivation has been increasingly constrained due to water shortage, introducing vegetables upstream and allocating surplus irrigation water downstream for rice may lead to efficient use of irrigation and farmer income increase for the irrigation scheme as a whole. It should be noted that first, to introduce commercial vegetables, due consideration of water drainage techniques, marketing arrangements, and risk management is crucial; and second, reducing staple food crops (rice and maize) and specializing in commercial vegetables, which have large profit fluctuations and no storage potential, may reduce food security at the household level.

Reference

Yokoyama (2022) *Japanese Journal of Farm Management* 59(4): 69–74.

(S. Yokoyama)

Program C
Information

"Strengthening function as an international hub for providing strategic information on agriculture, forestry and fisheries, and mobilizing new research partnerships"

Strengthening function as an international hub for providing strategic information on agriculture, forestry and fisheries is one of the pillars of the JIRCAS Fifth Medium to Long-term Plan (FY2021-2025) which began in April 2021. The 'Information Program' aims to collect data and analyze challenges affecting the agriculture, forestry and fisheries sector and global food systems in an increasingly complicated and multifaceted world, and provide strategic and evidence-based information on potential solutions.

[Information hub]

In recent years, the momentum to solve global issues has been accelerating, while the continuous progress of science and technology has brought about a great change in the world. We are now in an era where international competitiveness depends on the difference in strategies such as cooperation in different fields and the introduction of cutting-edge technologies. In order to promote the transition to a healthy and sustainable global food system for both the earth and humankind, the collection, analysis, and provision of comprehensive information linking socioeconomics, food nutrition, and technological development is expected.

The "Information hub" project systematically organizes information on international agriculture, forestry, and fisheries, through the use of dashboards and the creation of original content in our endeavor to establish our position as among Japan's leading information centers over scientific topics related to global food security, climate change, as well as food systems. In FY 2021, our original articles "Pick Up" succeeded in increasing the number of views by approximately 1.5 times compared to that of the previous year, effectively reaching the target audience.

In addition to the analysis of these trends, we are also working on the development of economic models that can evaluate the impacts of climate change and/or their mitigation/adaptation policies on the global agriculture, forestry, and fisheries sectors, such as models to evaluate the environmental, nutritional, and other socioeconomic impacts of agricultural technologies.

[Research applications/ventures]

In order to respond to the needs of society both domestically and internationally in an accurate and timely manner, and in accordance with the "Law on the Revitalization of Science, Technology and Innovation Creation" promulgated in FY 2019, JIRCAS has recognized that it is important to promote more actively the societal implementation of research results/ technologies generated by JIRCAS researchers. This project is composed of three main pillars: 1) commercial deployment of shrimp seed production/recirculating aquaculture technology developed by JIRCAS, 2) promotion of JIRCAS's Asian Monsoon Plant Factory System, and 3) establishment of a platform to support and promote practical application/societal implementation of JIRCAS's research results.

In FY 2021, regarding work relating to shrimp, JIRCAS established its first institute-related business venture, ShrimpTech JIRCAS, Inc., in February 2022. This commercial enterprise will conduct consulting activities related to re-circulating aquaculture of the Pacific whiteleg shrimp, and research enabling the development of seed production technology suitable for commercial usage.

In regard to plant factory-related research, at JIRCAS's Tropical Agriculture Research Front, located on Ishigaki Island, staff researchers worked closely with the private sector and Japan's National Agriculture and Food Research Organization (NARO) to develop year-round systems for cultivating tomatoes and strawberries under controlled conditions.

Finally, regarding the establishment of our platform for promoting research results, several technologies developed under JIRCAS's Fourth Medium-term Plan (FY2016-2020), were selected for further development/societal promotion as follows: 1) soybean varieties showing high resistance to soybean rust disease in Argentina, 2) rice varieties suitable for stable production in the Philippines and other relevant countries, and 3) a rice huller roll suitable for use with long-grain rice in Thailand. Furthermore, for the soybean and rice technologies, JIRCAS has executed service contracts to test these varieties on-site in several locations, and in addition has obtained basic trait data that will allow plant variety registration under the auspices of the relevant country authorities.

[Digital agriculture]

There are growing expectations on the role of smart agriculture in solving food problems caused by climate change and constraints on the agricultural workforce in developing regions, as it enables the use of advanced technology and digital information to make agriculture more efficient and labor-saving. The digitalization of agriculture is progressing rapidly in sub-Saharan Africa and is positioned as an important area that will drive agriculture in the region. However, since the development stage of agricultural digital technologies varies greatly from country to country, ensuring regional representation is a challenge. Therefore, this project appropriately collects, analyzes, and disseminates information on the problems and regional characteristics of each country.

This project also carries out a small pilot project in Ethiopia with its national partner to test commercially available digital tools and equipment developed by a Japanese software company, to understand logistical challenges to install them, to evaluate their functionability to collect agronomic data, and to identify any technical and institutional constraints for the extension systems/farmers to adopt them.

[Tropical crop genetic resources]

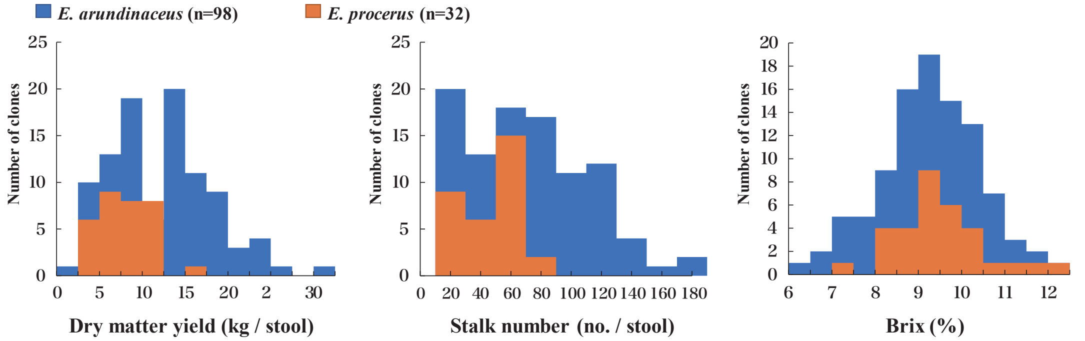
JIRCAS maintains diverse genetic resources of sugarcane, indica rice, tropical fruits, and *Brachiaria* (tropical grass). These tropical crops play important roles as food, energy production, calorie and nutrient sources, cash crops, and fodder in the production areas particular to developing countries/areas. Amid concerns about global climate change, the sustainable and stable production of these tropical crops is an urgent issue. In addition, the introduction of tropical crops, and their cultivation and dissemination technologies is expected to be one of the measures to combat global warming in Japan and contribute to the expansion of production areas and the diversification of food and nutrition sources.

The JIRCAS "Tropical crop genetic resources" project is promoting the development of strategic genetic resources information, breeding technologies, varieties and materials, and cultivation and dissemination technologies based on the problems and research needs of each crop in Japan and overseas, taking advantage of the diverse and abundant genetic resources of tropical crops and the geographical advantage of the subtropical island research facility. In addition, by sharing and providing information and technologies, we aim to strengthen collaboration that will lead to the formation of networks with domestic and overseas research institutions for the advancement of tropical crop genetic resource utilization.

TOPIC 1

Information on the genetic diversity in agronomic traits of Thai *Erianthus* germplasm under multiple ratooning systems

Erianthus spp., one of the genetic resources of a closely related genus of sugarcane, show considerable potential as breeding material for sugarcane improvement and as a new biomass crop due to its high biomass productivity under multiple ratooning systems. Strong ratooning ability is a desirable trait not only because it is key to improving sugar and fiber production, but also because it avoids the need for frequent replanting, thus playing an important role in ensuring sustainable cultivation with lower production costs and energy input as well as in preventing soil erosion. However, the lack of scientific information on the genetic diversity of agronomic traits, especially under multiple ratooning systems, prevents us from the effective breeding use of this genetic resource. To utilize *Erianthus* for sugarcane breeding and biomass production effectively, JIRCAS and Khon Kaen Field Crops Research Center, Department of Agriculture, Thailand, collected *E. arundinaceus* and *E. procerus* germplasm from all over Thailand, which is presumed to host diverse *Erianthus* genetic resources due to its location between India, Indonesia, and China. In this study, we evaluated the genetic variation of important agronomic traits in Thai *Erianthus* germplasm in multiple ratooning systems as an initial screening of a large number of clones with diverse genetic backgrounds to obtain basic



	Avg.	Multiple-Ratoon Index
E. arundinaceus	12.1	0.63 (0.10 - 1.81)
E. procerus	8.0	0.33 (0.13 - 0.79)
Sugarcane	5.2	0.11
Napier	6.6	0.16

	Avg.	Multiple-Ratoon Index
E. arundinaceus	80.3	1.06 (0.33 - 2.19)
E. procerus	57.6	0.66 (0.31 - 1.28)
Sugarcane	18.3	0.94
Napier	38.1	0.43

	Avg.	Multiple-Ratoon Index
E. arundinaceus	9.3	1.13 (0.57 - 1.96)
E. procerus	9.5	1.14 (0.71 - 1.59)
Sugarcane	19.1	0.78
Napier	9.1	1.07

Fig. 1. Agronomic traits in *E. arundinaceus* and *E. procerus* under multiple ratooning systems
The experiment was conducted in KKFCRC. Each experimental plot was planted with a single stool with 2 m inter-hill and row spacing and three replications. The field was planted in June 2011 and harvested from the end of February to early March in 2012 to 2015. The data in the figure used the average values of the four years of harvesting. The Multiple-Ratoon Index defined the ratio of third ratoon crop to first ratoon crop values. Sugarcane variety TPJ03-452 is a BC_1 hybrid derived from interspecific hybridization between sugarcane and *S. spontaneum* and registered in 2015 as a cultivar for sugar and fiber production in northeast Thailand. King Napier is a Napier grass variety used commercially in northeast Thailand.

Table 1. Genetic correlation coefficient between dry matter yield and other agronomic traits

Traits	*E. arundinaceus* (n=98)	*E. procerus* (n=32)
Stalk number	0.958 **	0.541 **
Single stalk weight	−0.240 *	0.295 n.s.
Stalk length	0.932 **	0.210 n.s.
Stalk diameter	0.032 n.s.	0.149 n.s.
Brix	−0.502 **	0.019 n.s.

The genetic correlation coefficients were calculated using four-year average values for each trait. ** and * indicate significant differences at $p = 0.01$ and $p = 0.05$, respectively; n.s. not significant

Fig. 2. Breeding materials with high dry matter yield under multiple ratooning systems
The pictures were taken in March 2013 at the Khon Kaen Field Crops Research Center. The pictures show, from left to right, *E. arundinaceus* ThE03-7, ThE10-6, and *E. procerus* ThE99-133.

information and identify potentially valuable materials for breeding of sugarcane and new biomass crop in Thailand.

The 98 *E. arundinaceus* and 32 *E. procerus* clones collected in Thailand showed large genetic variation in agronomic traits related to biomass productivity under multiple ratooning systems, and many clones have higher dry matter yield than sugarcane variety and Napier grass (Fig. 1). There is also a large variation in Multiple-Ratoon Index (the ratio of 3rd ratoon to 1st ratoon), and many clones provided better dry matter yields and lower yield reductions in ratoon crops than a sugarcane cultivar, highlighting the importance of identifying and using clones as breeding materials with excellent dry matter yields and Multiple-Ratoon Index. Furthermore, the dry matter yield showed a strong genetic correlation with stalk number, but not with single stalk weight, stalk diameter, or Brix, allowing selection of breeding materials with higher dry matter yield in multiple ratooning systems and superior single stalk weight, stalk diameter, or Brix. Based on the results, clones with various combinations of advantageous traits were identified as promising genetic resources.

The information about agronomic traits in the multiple ratooning systems provided in this study, as well as the clones selected, should enhance the use of *Erianthus* germplasm in sugarcane breeding in Thailand and around the world. Furthermore, our results could also be used to explore the practical utilization of *Erianthus* itself as a biomass crop.

Reference

Terajima Y et al. (2021) *Crop Science*. https://doi.org/10.1002/csc2.20697

Figures and table reprinted/modified with permission.

(Y. Terajima, A. Sugimoto, H. Takagi, W. Ponragdee [Khon Kaen Field Crops Research Center (KKFCRC)], T. Sansayawichai [KKFCRC], A. Tippayawat [KKFCRC], S. Chanachai [KKFCRC], M. Ebina [National Agriculture and Food Research Organization], H. Hayashi [University of Tsukuba])

TOPIC 2

Development of a simple shoot-tip grafting method for virus-free passion fruit

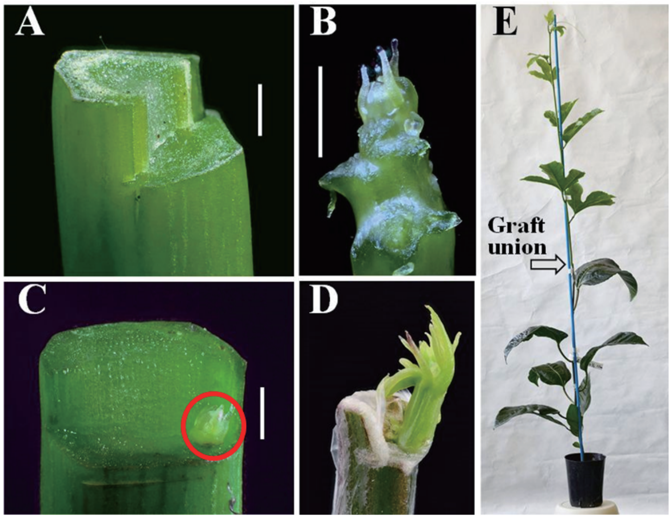
Passion fruit (*Passiflora edulis*) is the third most important tropical fruit produced in Japan after pineapple and mango. The plant consists of a woody vine that grows rapidly under warm humid conditions, while fruits can be harvested about five months after planting. Commercial cultivation of passion fruit is therefore possible before winter, even in temperate regions where survival is not possible during the cold months. As a result, cultivation of passion fruit is gaining increasing attention in Japan as one of several alternative crops to replace those increasingly suffering from heat stress under climate change.

Management of virus diseases is one of the most important subjects in commercial production of passion fruit. The basic treatment for virus disease control is to introduce virus-free seedlings. However, depending on the type of virus, it is often difficult to detect the external symptoms of the disease such as those caused by the Passiflora latent virus (PLV), thus making the procurement of virus-free plants challenging. In such cases, infected plants must be made virus-free and used as mother trees for propagation. To address the above problem, a technology for virus-free propagation of passion fruit using a simple shoot-tip grafting method has been developed (Fig. 1).

The shoot-tip was *in vivo* grafted and examined to obtain PLV-free passion fruit from infected plants. The scion length required to eliminate PLV was ≤ 2 mm (Table 1). The method required no aseptic handling and the procedure was relatively simple, and resulted in more than ten grafts in one hour, allowing it to be conducted at an individual farm level. Rapid growth of the scion after grafting was also observed due to the use of fully established seedlings as rootstock. Leaf samples for analysis of PLV infection could therefore be obtained about two months after grafting with fruit harvest possible about four months later (Fig. 1).

In vivo shoot-tip grafting was conducted with a scion length of 0.5–1 mm from September to November to determine the optimal air temperature conditions. The graft success rate increased from 18% to 58% with a decrease in the average air temperature from September (28.6°C) to November (23.3°C), although there was no significant difference in PLV-free rates between months (73% to 80%) (Table 2). Accordingly, *in vivo* shoot-tip grafting of passion fruit is not recommended under high air temperature conditions.

The effect of scion shoot storage conditions was also examined, revealing that *in vivo* shoot-tip grafting using shoots stored for one day could be performed without difficulty, whereas the rate of graft success and PLV-free rate were close to



A: A 1~2-mm-long half-cylinder section of the cut end of a rootstock was removed using a razor blade.
B: The shoot-tip was used as a scion, with young leaves and leaf primordia removed before excision.
C: The cambium on the L-shaped cut end of the rootstock to which the excised shoot-tip (scion) was attached. The graft was then covered with laboratory film to prevent drying.
D: Sprouting of the scion about one month after *in vivo* shoot-tip grafting. The sprouting scion self-pierced the laboratory film, so removal of the the film was not necessary.
E: The growing scion about two months after micrografting, ready for virus detection.

Fig. 1. *In vivo* shoot-tip grafting of passion fruit
Bars in A, B, and C: 1 mm

Table 1. Effect of shoot-tip (scion) length on the elimination of Passiflora latent virus (PLV) via *in vivo* shoot-tip grafting

Shoot-tip (scion) length (mm)	Shoot-tip grafting		PLV
	Number of grafts	Success rate (%)	Virus-free rate (%)
1	8	63	60
2–3	5	100	40
5	8	100	0
Significance[a]		*	*

[a] : 5% level in Fischer's exact test

Table 2. Effect of grafting time on grafting success and elimination of Passiflora latent virus (PLV) via in vivo shoot-tip grafting

Grafting time	Shoot-tip grafting			PLV	Air temperature (ºC)		
	Number of grafts	Success rate (%)	Days to sprouting	Virus-free rate (%)	Max.	Ave.	Min.
September	60	18	32 ± 11	73	35.9	28.6	24.9
October	24	33	31 ± 22	80	30.4	24.4	21.1
November	65	58	29 ± 19	73	29.0	23.3	20.1
Significance[a]		*		NS			

[a] : 5% level in Fischer's exact test

Table 3. Effect of scion shoot storage conditions on the elimination of Passiflora latent virus (PLV) via in vivo shoot-tip grafting

Storage conditions	Shoot-tip grafting		PLV
	Number of grafts	Success rate (%)	Virus-free rate (%)
5ºC 1day	17	59	80
25ºC 1day	18	50	56
Significance[a]		NS	NS

[a] : 5% level in Fischer's exact test

those obtained using shoots selected less than 30 min before (Table 3). These findings suggest that with this method, virus-free plants can be obtained using PLV-infected shoots selected in the field one day earlier. In conclusion, our *in vivo* shoot-tip grafting technique is useful for eliminating PLV from infected plants without any aseptic treatment or specific equipment, and could therefore contribute as a practical method to control virus diseases in passion fruit.

Reference

Ogata T and Yamanaka S (2021) *Horticulture Journal*, 90(3), 280–295. https://doi.org/10.2503/hortj.UTD-259

Figure and tables reprinted/modified with permission.

(T. Ogata, S. Yamanaka)

Training and Invitation Programs

Information Events

Invitation Programs at JIRCAS

To establish and maintain its role as an international research center, JIRCAS has implemented several invitation programs for foreign researchers and administrators from counterpart organizations. These invitation programs are designed to facilitate the exchange of information and opinions on agriculture, forestry, and fisheries research, and their implementation and administration simultaneously provide an opportunity to strengthen research ties among scientists and administrators in participating countries, mostly in developing regions. However, due to the continuing COVID-19 pandemic, most of the scheduled invitation programs of JIRCAS were affected in FY 2021. Below is an overview of JIRCAS's invitation programs implemented in FY 2021.

Administrative Invitation Program

Under the Administrative Invitation Program, JIRCAS invites administrators and managers from counterpart organizations to its Tsukuba premises to engage in discussions and reviews of ongoing research to ensure that the collaborative projects run effectively. This invitation program exposes the current activities of JIRCAS and other MAFF-affiliated National Research and Development Agencies (NRDAs) to the administrators. It also provides opportunities to exchange information and opinions relating to policymaking and project design at the administrative level, thus contributing to a deep and mutual understanding for enhancing international collaboration. However, due to the continuing pandemic situation, the Administrative Invitation Program for FY 2021 was canceled, the same as last year.

Counterpart Researcher Invitation Program

The Counterpart Researcher Invitation Program provides invitations to researchers engaged in collaborative work with JIRCAS research staff for a period of up to six months. Generally, counterparts conduct in-depth research at JIRCAS, at other MAFF-affiliated NRDAs, at prefectural research institutes, or at national universities. This invitation program aims to enhance the quality of research conducted overseas and facilitate exchanges of individual research between JIRCAS and its counterpart institutions. However, due to the impact of COVID-19, only one researcher from the Chinese Academy of Agricultural Sciences was invited to this Program in FY 2021.

Project Site Invitation Program

Since 2007, JIRCAS has been carrying out the Project Site Invitation Program. The objective of this invitation program is to invite researchers from developing countries to the project sites where JIRCAS researchers are engaged in JIRCAS-funded collaborative research projects on various research themes related to the projects. However, the Project Site Invitation Program for FY 2021 was also canceled due to the global pandemic of COVID-19.

Counterpart Researcher Invitation (April 2021 to March 2022)

Name	Institution/Organization	Research Theme	Duration
Xiang Gao	Chinese Academy of Agricultural Sciences, Institute of Agricultural Resources and Regional Planning, China	Nitrogen dynamics and plant physiological analysis in field trials of BNI-enabled crops (wheat and sorghum)	Jun. 9, 2021 - Dec. 8, 2021

Fellowship Programs at JIRCAS

JIRCAS Visiting Research Fellowship Program

The JIRCAS Visiting Research Fellowship Program began in FY 1992 with the launching of the JIRCAS Visiting Research Fellowship Program at Okinawa, where 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). In October 1995, a similar program (JIRCAS Visiting Research Fellowship Program at Tsukuba) began implementation at JIRCAS's Tsukuba premises, with the aim to promote collaborative research activities that address various problems confronting countries in developing regions. In the year 2006, these fellowship programs were modified and combined. In FY 2021, six researchers were selected and offered the JIRCAS Fellowship Program, and they planned to conduct research at JIRCAS HQ in Tsukuba. However, due to the ongoing COVID-19 pandemic and entry restrictions, only one researcher was accepted at JIRCAS in FY 2021, with the remaining five fellows scheduled to start their research in the next fiscal year when they arrive in Japan between April to June 2022 following the relaxation of entry restrictions from March 2022. The final presentation of their research outputs and awarding of JIRCAS Fellowship completion certificates will be held in 2023.

JIRCAS Visiting Research Fellowship Program at Project Sites

This fellowship program has been implemented since May 2006 in collaboration with research institutions located in developing countries where collaborative research is being carried out by JIRCAS researchers. This program aims to promote the effective implementation of ongoing collaborative research at the project sites with the participation of local research staff. Through this fellowship program, JIRCAS also intends to contribute to the capacity-building of the collaborating research institutions. In 2021, no invitation was released for the Project Sites Program.

For inquiries on the JIRCAS Visiting Research Fellowship Program, please contact the International Relations Section (IRS) (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 Researcher Program of JIRCAS considers scientists who have an excellent record of research achievements and conducting overseas research on agriculture, forestry, and fisheries in tropical and subtropical regions under overseas research institutions or universities. Unfortunately, the Visiting Researcher Program for FY 2021 was also canceled due to COVID-19, as it was last year.

Last but not least, the Government of Japan sponsors a post-doctoral fellowship program and a researcher exchange program for foreign scientists through the Japan Society for the Promotion of Science (JSPS). The program places post-doctoral and sabbatical fellows in national research institutes throughout Japan according to research theme and prior arrangement with host scientists for the period of one month to three years. Fellows can be taken in at any of the ministries of Japan, and many fellows are currently working at various NRDAs affiliated with MAFF.

JIRCAS Visiting Research Fellowship Program at Tsukuba (October 2021 - March 2022)

Name	Institution/Organization	Research Theme	Duration
Elsie Akua Serwaa Sarkodee-Addo	Department of Soil Science, University of Ghana, Accra, Ghana	Establishment of screening methods for microbiological resources toward improved crop phosphorus (P) uptakes under highly P-deficient soils in the tropics	Jan. 24, 2022 - Jan. 24, 2023

Workshops

Tokyo Nutrition for Growth (N4G) Summit Official Side Event: Symposium on “Fruits and Vegetables – Research and Action Opportunities for Human and Planetary Health”

The symposium “Fruits and Vegetables – Research and Action Opportunities for Human and Planetary Health,” organized by JIRCAS and co-organized by the FAO Liaison Office in Japan (FAO-LOJ), in cooperation with the National Agriculture and Food Research Organization (NARO), was held online on December 6, 2021. It was an official side event of the Tokyo Nutrition for Growth (N4G) Summit 2021, which was held on the following days (December 7-8) by the Japanese government.

Fruit and vegetables are an important food group to focus on in the recent food system transformation due to their nutritional and health benefits and relatively low environmental impact. The year 2021 was also the International Year of Fruits and Vegetables as designated by the United Nations. This symposium introduced the research potential and advanced technologies for fruit and vegetables and its contribution to health, development, and the environment. It also highlighted the gaps that exist in the world, particularly in developing regions, and discussed the challenges and areas that require research and policy intervention.

JIRCAS President Osamu Koyama and FAO-LOJ Director Eriko Hibi opened the symposium with their welcome remarks. JIRCAS Food Program Director Kazuo Nakashima followed by introducing and explaining the outline and purpose of the symposium. FAO Chief Scientist Ismahane Elouafi “set the stage” for the symposium by providing an overview of the contribution of fruit and vegetables for planetary and human health.

Dr. Elouafi’s speech was followed by three presentations that touched on smart technologies and supply and demand. Dr. Hiroshi Ezura (Professor, University of Tsukuba) introduced high GABA tomato as a case study to apply new breeding technologies to fruit and vegetable improvement; Dr. Koji Sugahara (Group Leader, Institute of Vegetable and Floriculture Science, NARO) described emerging opportunities to apply smart technologies, taking production forecasting systems for stable supplies of cabbages and lettuces as an example; and Dr. Sakiko Shiratori (Senior Researcher, JIRCAS) reviewed the status and prospects of production, distribution, and consumption of fruit and vegetables in the global vs. local contexts, especially in developing regions.

“Moving forward,” Dr. Marco Wopereis (Director-General, World Vegetable Center) identified the research and action priorities on fruit and vegetables. After that, a Q&A session was held, and the symposium ended with a closing speech from JIRCAS Vice President Yukiyo Yamamoto. MC duties were carried out by FAO Senior Advisor Hiroto Mitsugi.

Almost all speeches were conducted in English, and simultaneous interpretation between English and Japanese was made available. The number of registrants was 446, and the

Screenshot

total number of real-time viewing participants (excluding duplicates and panelists) was 364. The participants included not only researchers but also others from a wide range of fields, such as university students, private company employees, and the general public. There were about 50 overseas participants from 22 countries. The symposium video has been archived on the JIRCAS YouTube channel (split into five parts as below).

https://youtu.be/ne5lfDP_FLM (1/5)
https://youtu.be/MtKxyQ4iwmk (2/5)
https://youtu.be/1Qyn_BM_dLY (3/5)
https://youtu.be/mSkYyX9koYw (4/5)
https://youtu.be/o2xCaJ25YLg (5/5)

JIRCAS-CCFS Society Workshop on the "Effects of Climate Change and the Spread of COVID-19 on Food Supply and Demand: Food Security under Uncertainty"

The global average air temperature has increased by about 1.2°C since the Industrial Revolution in the mid-18th century. This worrying trend has prompted experts to warn that such a surge in air temperature could lead to more frequent extreme weather events and have profound effects on food and nutrition security.

In line with the above, JIRCAS and the CCFS Society held an online workshop, titled "Effects of Climate Change and the Spread of COVID-19 on Food Supply and Demand: Food Security under Uncertainty," on December 17, 2021. The workshop was held to share and discuss the team's findings to a broad audience interested in the effects of climate change on the agricultural sector focusing on the cost of adaptation to climate change and the impacts of climate change on agricultural markets. Furthermore, issues relating to the effects of the spread of COVID-19, which has been a major issue in the last two years, on future food supply were also presented.

In his opening remarks, JIRCAS President Osamu Koyama presented the history and future of targets and methods of the food supply and demand analysis. In his keynote address, Dr. David Dawe of the FAO Regional Office for Asia and the Pacific discussed the impacts of COVID-19 on food security and nutrition in Asia.

In the first session, themed "Adaptation to Climate Change," Dr. Toshichika Iizumi of the National Agriculture and Food Research Organization (NARO) presented the estimated costs of implementing adaptation measures and the amount of damages which cannot be managed by the counter measures. Dr. Tomoaki Nakatani of the University of Tokyo expressed the progress of test method for exogeneity of variables in an economic model, and Dr. Daisuke Sawauchi of Hokkaido University showed the result of an analysis relating to crop supply stability using variance and covariance.

In the second session, themed "Effects of COVID-19 and Climate Change," Dr. Eiichi Kusano of JIRCAS talked about the concept of food security and the interpretability of world food models for nutrition supply. Dr. Jun Furuya of JIRCAS and Dr. Gen Furuhashi of the Policy Research Institute, MAFF, explained the effects of COVID-19 on global food supply and nutrition and the effects of climate change on global indica and japonica rice markets, respectively.

In the panel session chaired by Program Director Miyuki Iiyama of JIRCAS, the speakers presented countermeasures to climate change and the spread of COVID-19, and they exchanged views on common measures against both phenomena. In the closing address, Dr. Toshihiro Hasegawa of NARO discussed the future of the whole food system.

The workshop, with each topic and presentation having a deep significance on global food security, left the audience satisfied. The number of registrants was 239, and the number of livestream viewers was 166 including 60 students.

Screenshot of presenters

International Symposiums, Workshops, and Seminars, FY 2021			
1	5th Technical Committee Meeting for the "Study on improving water efficiency in irrigation schemes in Africa (WEIRS for Rice)"	April 8, 2021	Held online
2	International Science Symposium on Sustainable Use of Land (Theme: "Access to Agricultural Materials for Sustainable Land Management: Challenges Faced by Small Farmers in Africa")	May 17-20, 2021	Ougadougou, Burkina Faso
3	Kick-off Meeting for the collaborative research project "Development of sustainable land management under extreme weather condition in the Sudan Savanna"	May 25, 2021	Held online
4	6th Technical Coordinating Committee Meeting for the "Project on establishment of fertilizing crop cultivation promotion model using Burkina Faso phosphate rocks"	June 29, 2021	Held online
5	Confirmation Meeting on the specification of drones under development for the "Technical Base Development for Secure and Reliable Drones" project of the Ministry of Economy, Trade and Industry	July 1, 2021	JIRCAS, Tsukuba, Japan
6	OECD-FAO Agricultural Outlook Launch Event	July 14, 2021	Held online (live)
7	ACSAC10 (10th Asian Crop Science Association Conference)「Special Session 3.1. Temperature Stress」	September 9, 2021	Held online
8	4th Research Network Meeting on "Reducing Greenhouse Emissions in the Livestock Sector"	September 16, 2021	Held online
9	International Workshop of the Southeast Asia Research-based Network on Climate Change Adaptation Science (SARNCCAS)	September 16-17, 2021	Held online
10	3rd 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 29, 2021	Held online

(Continued on next page)

(Continued)

11	The 2nd edition of the World Conference on Byproducts of Palms and their Applications (ByPalma) Special Issue: Value-Added Technology for OPT and EFB in SATREPS Project	September 29, 2021	Held online
12	5th Joint Coordination Committee Meeting for the SATREPS project “FertilitY sensing and Variety Amelioration for Rice Yield (FY VARY)”	October 12, 2021	Antananarivo, Madagascar (hybrid format)
13	7th Technical Coordinating Committee Meeting for the “Project on Establishment of fertilizing crop cultivation promotion model using Burkina Faso phosphate rocks”	November 10, 2021	Held online
14	RICE Close-out Webinar 2021	November 16, 2021	Held online
15	JIRCAS International Symposium 2021 (Theme: “The Role of Science, Technology and Innovation in Achieving Sustainable Food Systems in the Asia Monsoon Region: A Platform for International Collaboration”)	November 17, 2021	Held online
16	Kick-off Meeting for the SATREPS Bolivia Superfoods project titled “Strengthening of Resilience in Arid Agro-Ecosystems Vulnerable to Climate Change, Through Research on Plant Resources and Technological Applications”	November 19, 2021	Held online
17	Joint Meeting on the “Yama-Sato-Umi agrosystem connectivity” collaborative research project	November 26, 2021	Held online
18	Kick-off meeting for the project titled “Technology development towards supporting farmers' decision-making to boost sustainable upland farming system in Africa”	November 29, 2021	Held online
19	Annual Meeting for the project titled “Development and dissemination of sustainable aquaculture technologies in the tropical area based on the eco-system approach” and review of project achievements from the previous term	December 6-7, 2021	Held online
20	Symposium titled “Fruits and Vegetables - Research and Action Opportunities for Human and Planetary Health”	December 6, 2021	Held online
21	Achievement Briefing Meeting on Asian Monsoon Plant Factory System (AMPFS) Follow-up Activities	December 9, 2021	TARF, Ishigaki, Japan (hybrid format)
22	JIRCAS-CCFS Society Workshop titled “Effects of Climate Change and the Spread of COVID-19 on Food Supply and Demand: Food Security under Uncertainty”	December 17, 2021	Held online
23	Overview of the Climate Change Measures Project of the Japan International Research Center for Agricultural Sciences (JIRCAS) and Exploring Future Collaborations with the Asian Development Bank (ADB)	January 28, 2022	Held online
24	Balancing Agricultural Production and Environmental Conservation on Tropical Islands	February 14, 2022	Ishigaki, Japan (hybrid format)
25	6th Technical Committee Meeting on the Africa Water Resources Utilization Efficiency Survey	February 24, 2022	Moshi, Kilimanjaro, Tanzania (hybrid format)
26	Explanatory Seminar for the Manual	February 25, 2022	
27	The 69th Annual Meeting of the Ecological Society of Japan (ESJ69) Symposium themed “Global Warming and Methane Uptake in Upland Soils as Key Processes for Future Climate Change”	March 19, 2022	Fukuoka, Japan (hybrid format)

Appendix

Publishing at JIRCAS

English

1. JARQ (Japan Agricultural Research Quarterly)

Vol. 55 No. 3 (Published in July 2021)

Vol. 55 No. 4 (Published in October 2021)

Vol. 55 Special Issue (Published in December 2021)

Vol. 56 No. 1 (Published in January 2022)

Vol. 56 No. 2 (Published in April 2022)

2. Annual Report

2020 (Published on 29 October 2021)

3. JIRCAS Newsletter

No.91 (Published on 29 October 2021)

No.92 (Published on 25 March 2022)

Japanese

1. Kōhō JIRCAS

Vol. 8 (Published on 28 September 2021)

Vol. 9 (Published on 18 February 2022)

2. JIRCAS News

No.91 (Published on 29 October 2021)

No.92 (Published on 25 March 2022)

Refereed Journal Articles 2021-2022

Program A

Anzai, T., Saito, T., Inosako, K., Goto, S., Ando, S., Okamoto, K. and Santillana, I.S. (2021) Monitoring nitrogen leaching under different fertiliser applications during the early growth stage of sugarcane using GS3 sensors: a case study on Negros Island, Philippines. *Environmental Technology*, DOI: 10.1080/09593330.2021.1942558.

Arai, H., Hosen, Y.*, Chiem, N. H., Inubushi, K. (2021) Alternate wetting and drying enhanced the yield of a triple-cropping rice paddy of the Mekong Delta. *Soil Science and Plant Nutrition* (*SSPN*), DOI: 10.1080/00380768.2021.1929463.

Arai, T., Aikawa, S., Sudesh, K., Kondo, T. and Kosugi, A.* (2021) Electrotransformation of thermophilic bacterium *Caldimonas manganoxxidans*. *Journal of Microbiological Methods*, DOI: 10.1016/j.mimet.2021.106375.

Chhe, C., Uke, A., Baramee, S., Tachaapaikoon, T., Pason, P., Waeonukul, R., Ratanakhanokchai, K., Kosugi, A.* (2021) Characterization of a thermophilic facultatively anaerobic bacterium Paenibacillus sp. strain DA-C8 that exhibits xylan degradation under anaerobic conditions. *Journal of Biotechnology*, DOI: 10.1016/j.jbiotec.2021.10.008.

團晴行*, 南雲不二男, ダビンガ ジョナス, バロ アルベール (2022) ブルキナファソにおける石積み工と列状植栽工の複合技術. 農業農村工学会誌「水土の知」90(2) : 17-22.

de Klein, C.A.M.*, Bowatte, S., Simon, P., Arango, J., Cardenas, L., Chadwick, D.R., Pijlman, J., Rees, R.M., Richards, K.G., Subbarao, G.V. and Whitehead, D. (2022) Accelerating the development of biological nitrification inhibition as a viable nitrous oxide mitigation strategy in grazed livestock systems. *Biology and Fertility of Soils,* DOI: 10.1007/s00374-022-01631-2.

Fatmawati, N.V., Ketbot, P., Phitsuwan, P., Waeonukul, R., Tachaapaikoon, C., Kosugi, A., Ratanakhanokchai, K. and Pason, P.* (2021) Efficient biological pretreatment and bioconversion of corn cob by the sequential application of a *Bacillus firmus* K-1 cellulase-free xylanolytic enzyme and commercial cellulases. *Applied Microbiology and Biotechnology*, DOI: 10.1007/s00253-021-11308-9.

Fukuda, M.*, Soma, D.M., Iwasaki, S., Nakamura, S., Kanda, T., Ouattara, K. and Nagumo, F. (2021) Site-specific responses of lowland rice to acidulated and calcined phosphate rock fertilizers in the Center-West region of Burkina Faso. *PLoS ONE*, DOI: 10.1371/journal.pone.0250240.

Furuya, J.*, Mar, S.S., Hirano, A. and Sakurai, T. (2021) Optimum Insurance Contract of Flood Damage Index Insurance for Rice Farmers in Myanmar. *Paddy and Water Environment*, DOI: 10.1007/s10333-021-00859-2.

Ghatak, A.*, Schundler, F., Bachmann, G., Bajaj, D.E.P., Brenner, M., Fragner, L., Varshney, R.K., Subbarao, G.V., Chaturvedi, P. and Weckwerth, W.* (2021) Root exudation of contrasting drought-stressed pearl millet genotymes conveys varying biological nitrification inhibition (BNI) activity. *Biology and Fertility of Soils*, DOI: 10.1007/s00374-021-01578-w.

堀川直紀 (2021) 熱帯モンスーン地域の多目的貯水池における貯水池運用. 農業農村工学会誌 89(5) : 17-20.

Huong, D.T.B., Ketbot, P., Phitsuwan, P., Waeonukul, R., Tachaapaikoon, C., Kosugi, A., Ratanakhanokchai, K. and Pason, P.* (2021) Bioconversion of untreated corn hull into L-malic acid by trifunctional xylanolytic enzyme from *Paenibacillus curdlanolyticus* B-6 and *Acetobacter tropicalis* H-1. *Journal of Microbiology and Biotechnology*, DOI: 10.4014/jmb.2105.05044.

Iwasaki, S., Fukuda, M.*, Ikazaki, K., Nakamura, S., Ouattara, K. and Nagumo, F. (2021) Optimal P fertilization using low-grade phosphate rock-derived fertilizer for rice cultivation under different ground-water conditions in the Central Plateau of Burkina Faso. *Soil Science and Plant Nutrition*, DOI: 10.1080/00380768.2021.1932584.

Iwasaki, S., Ikazaki, K., Bougma, A. and Nagumo, F. (2022) Appropriate Use of Local Phosphate Rock Increases Phosphorus Use Efficiency and Grain Yield of Sorghum and Cowpea in the Sudan Savanna. *Frontiers in Soil Science*, DOI: 10.3389/fsoil.2021.709507.

Jindo, K.*, Kozan, O., Iseki, K., Maestrini, B., van Evert, F.K., Wubengeda, Y., Arai, E., Shimabukuro, Y.E., Sawada, Y. and Kempenaar, C. (2021) Potential utilization of satellite remote sensing for field-based agricultural studies. *Chemical and Biological Technologies in Agriculture*, DOI: 10.1186/s40538-021-00253-4.

加藤亮, 乃田啓吾, 木村匡臣, 大倉芙美, 堀切友紀子, 小山知昭 (2021) ラオス国首都近郊の水環境整備におけるグリーンインフラの実装可能性. 水土の知（農業農村工学会誌）89(11) : 843-846.

加藤亮, 大倉芙美, 飯田俊彰, 吉田修一郎, 髙橋修 (2021) 新たな土地改良長期計画に沿った循環灌漑の環境保全と水利用効率の向上. 水土の知（農業農村工学会誌）89(12) : 923-926.

Kayo, C.*, Kalt, G., Tsunetsugu, Y., Hashimoto, S., Komata, H., Noda R. and Oka, H. (2021) The default methods in the 2019 Refinement drastically reduce estimates of global carbon sinks of harvested wood products. *Carbon Balance and Management, DOI*: 10.1186/s13021-021-00200-8.

木村健一郎*, 羽佐田勝美, ザヤラス　シンコン (2021) ラオス中山間地で食用される野生動物のデータベースの開発―ビエンチャン県N村の事例―. 開発学研究 32(2) : 10-16.

Kobayashi M.J.*, Ng K.K.S., Lee S. L., Muhammad N. and Tani N.* (2021) Effect of leaves on the regulation of intermittent stem growth in a tropical evergreen tree, *Shorea leprosula. JARQ*, DOI: 10.6090/jarq.55.273.

Kondo, M.*, Iizumi, Y., Watanabe, T., Man, L.H., Son, D.H., Thu, N.K. and Chiem, N.H. (2021) Climatic Factors Related to Low Rice (Oryza sativa L.) Yield in the Wet Season under Double Cropping in the Mekong Delta, Vietnam. *JARQ*, DOI: 10.6090/jarq.55.217.

Leon, A.*, Subbarao, G.V., Kishii, M., Matsumoto, N. and Kruseman, G. (2021) An ex-ante life cycle assessment of wheat with high biological nitrification inhibition capacity. *Environmental Science and Pollution Research*, DOI: 10.1007/s11356-021-16132-2.

Limsakul, P., Phitsuwan, P., Waeonukul, R., Pason, P., Tachaapaikoon, C., Poomputsa, K., Kosugi, A. and Ratanakhanokchai, K.* (2021) A novel multifunctional arabinofuranosidase/endo-xylanase/β-xylosidase GH43 from *Paenibacillus curdlanolyticus* B-6 and its synergistic action to produce arabinose and xylose from cereal arabinoxylan. *Applied and Environmental Microbiology*, DOI: 10.1128/AEM.01730-21.

Minamikawa, K.*, Huynh, K.C., Uno, K., Tran, N.S. and Nguyen, C.H. (2021) Cattle biogas effluent application with multiple drainage mitigates methane and nitrous oxide emissions from a lowland rice paddy in the Mekong Delta, Vietnam. *Agriculture, Ecosystems and Environment*, DOI: 10.1016/j.agee.2021.107568.

Muranaka, S., Fukuta, Y., Subbarao, G.V. and Yoshihashi, T. (2021) The CGIAR–JIRCAS Partnerships for Sustainable Food Systems: Rice Blast Differential Systems and Biological Nitrification Inhibition as Examples. *JARQ*, 55(Special issue): 501-509.

Murata, Y., Nwuche, C.O., Nweze, J.E., Ndubuisi, I.A. and Ogbonna, J.C. (2021) Potentials of multi-stress tolerant yeasts, *Saccharomyces cerevisiae and Pichia kudriavzevii* for fuel ethanol production from industrial cassava wastes. *Process Biochemistry*, DOI: 10.1016/j.procbio.2021.11.014.

Nagano, H.*, Nakayama, M., Katata, G., Fukushima, K., Yamaguchi, T., Watanabe, M., Kondo, T., Atarashi-Andoh, M., Kubota, T., Tateno, R. and Koarashi, J. (2021) Soil microbial community responding to moderately elevated nitrogen deposition in a Japanese cool temperate forest surrounded by fertilized grasslands. *Soil Science and Plant Nutrition*, DOI: 10.21203/rs.3.rs-47616/v2.

Neha, Yadav, G.*, Yadav, R.K.*, Kumar, A., Rai, A.K., Onishi, J., Omori, K. and Sharma, P.C. (2022) Salt removal through residue filled cut-soiler simulated preferential shallow sub surface drainage improves yield, quality and plant water relations of mustard (*Brassica juncea* L.). *Sustainability*, DOI: 10.3390/su14074146.

Neha, Yadav, G.*, Yadav, R.K., Kumar, A., Rai, A.K., Sehwag, M., Onishi, J., Omori, K. and Sharma, P.C. (2022) Desalinization effect of simulated Cut-soiler based residue filled preferential shallow sub surface drainage improve physiology and yield of rain-fed pearl millet. *Land Degradation & Development*, DOI: 10.1002/ldr.4237.

Neha, Yadav, G.*, Yadav, R.K., Kumar, A., Rai, A.K., Sehwag, M., Onishi, J., Omori, K. and Sharma, P.C. (2022) Response of saline water irrigated mustard crop growth and yield under Cut-soiler PSSD salinity management, *Agricultural Mechanization in Asia, Africa and Latin America*, 53(2):6025-6037.

Ng K.K.S*, Kobayashi M.J., Fawcett J.A., Hatakeyama M., Paape T., Ng C.H., Ang C.C, Tnah L.H., Lee C.T., Nishiyama T., Sese J., O'Brien M.J., Copetti D., Isa M.N.M, Ong R.C., Putra M, Siregar I.Z., Indrioko S., Kosugi Y., Izuno A., Isagi Y., Lee S.L.* and Shimizu K.K.* (2021) The genome of *Shorea leprosula* (Dipterocarpaceae) highlights the ecological relevance of drought in aseasonal tropical rainforests. *Communications Biology*, DOI: 10.1038/s42003-021-02682-1.

Nguyen, T.V., Maeda, K.*, Nishimura, Y., Nguyen, T.H.T., La, V.K., Nguyen, D.D. and Suzuki, T. (2022) Emission factors for Vietnamese beef cattle manure sun-drying and the effects of drying on manure microbial community. *PLoS ONE*, DOI: 10.1371/journal.pone.0264228.

Nguyen, T.L., Nanseki, T.*, Ogawa, S. and Chomei, Y. (2021) Determination of Paddy Rice Yield in the Context of Adoption of Multiple Technologies in Colombia. *International Journal of Plant Production*, DOI: 10.1007/s42106-021-00173-1.

Nhim, S., Waeonukul, R., Uke, A., Baramee, S., Ratanakhanokchai, K., Tachaapaikoon, C., Pason, P., Liu, Y.J. and Kosugi, A.* (2022) Biological Cellulose Saccharification using a Coculture of *Clostridium thermocellum* and *Thermobrachium celere* Strain A9. *Applied Microbiology and Biotechnology*, DOI: 10.1007/s00253-022-11818-0.

Noda, I.*, Himmapan, W., Vacharangkura, T., Sukchan, S., Wichiennopparat, W. and Furuya, N. (2021) Effects of topography, soil organic matter, and chemical properties on the growth of teak (*Tectona grandis*) plantations in Northeast Thailand. *Japan Agricultural Research Quarterly*, DOI: 10.6090/jarq.55.379.

Nwe, Y.Y., Sengebau, F., Taro, T., Kitalong, C., Olegeriil, J. and Omae, H. (2021) Effect of tillage, bed shape, and land cover on yield of upland root crop and soil erosion in Palau. *Tropical Agriculture and Development*, 65(2): 59-67.

Oda, M., Yin Yin Nue and Omae, H. (2022) Locally measured USLE K factor expands sustainable agricultural land in Palau. *F1000Research*, DOI: 10.12688/f1000research.22229.4.

Ogawa, R.*, Hiratab, M., Gebremedhin, B.G., Uchida, S., Sakai, T., Koda, K. and Takenaka, K. (2021) Spatial modeling of soil erosion and identification of high-risk spots with the GIS-RUSLE model for the Adi Zaboy watershed, eastern Tigray region, Ethiopia. *Journal of Arid Land Studies（沙漠研究）*, DOI: 10.14976/jals.31.1_1.

Ogino, A.*, Nguyen, V.T., Hosen, Y., Izumi, T., Suzuki, T., Sakai, T., Ando, S., Osada, T. and Kawashima, T. (2021) Environmental impacts of a rice-beef-biogas integrated system in the Mekong Delta, Vietnam evaluated by life cycle assessment. *Journal of Environmental Management*, DOI: 10.1016/j.jenvman.2021.112900.

Ohtani, M., Tani, N., Ueno, S., Uchiyama, K., Kondo, T., Lee, S.L., Ng, K.K.S., Muhammad, N., Finkeldey, R., Gailing, O., Na'iem, M., Indrioko, S., Widiyatno, Siregar, I., Kamiya, K., Harada, K., Diway, B. and Tsumura, Y. (2021) Genetic structure of an important widely distributed tropical forest tree, *Shorea parvifolia*, in Southeast Asia. *Tree Genetics and Genomes*, DOI: 10.1007/s11295-021-01525-8.

Onishi, J.*, Paluashova, G.K., Shrokova, S.I. and Fujimaki, H. (2021) Salt removal by combining a permanent skip furrow irrigation and salt removal sheet. *Frontiers in Agronomy*, DOI: 10.3389/fagro.2021.659722.

Ono, K.*, Fujimoto, K., Hairata, Y., Tabuchi, R., Taniguchi, S., Furukawa, K., Watanabe, S., Suwa, R. and Lihpai, S. (2021) Estimation of total fine root production using continuous inflow methods in tropical mangrove forest on Pohnpei Island, Micronesia: Fine root necromass accumulation is a substantial contributor to blue carbon stocks. *Ecological Research*, DOI: 10.1111/1440-1703.12280.

Otaka, J., Subbarao, G.V., Ono, H. and Yoshihashi, T.* (2021) Biological Nitrification Inhibition in Maize – Isolation and Identification of Hydrophobic Inhibitors from Root Exudates. *Biology and Fertility of Soils*, DOI: 10.1007/s00374-021-01577-x.

Qi, K., Chen, C., Yan, F., Feng, Y.A., Bayer, E.A., Kosugi, A., Cui, Q. and Liu, Y.J.* (2021) Coordinated β-glucosidase activity with the cellulosome is effective for enhanced lignocellulose saccharification. *Bioresource Technology*, DOI: 10.1016/j.biortech.2021.125441.

Rathnappriya, R.H.K.*, Sakai, K.*, Okamoto, K., Kimura, S., Haraguchi, T., Nakandakari, T., Setouchi, H. and Bandara, W.B.M.A.C. (2022) Examination of the Effectiveness of Controlled Release Fertilizer to Balance Sugarcane Yield and Reduce Nitrate Leaching to Groundwater. *Agronomy*, 12(3):695, DOI: 10.3390/agronomy12030695.

Sakai, T.*, Omori, K., Aung Naing Oo, Swe Swe Ma and Yan Naung Zaw (2021) Decadal changes in the rice-cropping system in the Ayeyarwady Delta using a large archive of satellite imagery from 1981 to 2020. *Paddy and Water Environment*, DOI: 10.1007/s10333-021-00857-4.

Shiraki, S.*, Aung, K.T., Matsuno, Y. and Shinogi, Y. (2021) Simple and two-level hierarchical Bayesian approaches for parameter estimation with one- and two-layer evapotranspiration models of crop fields. *Water*, DOI: 10.3390/w13243607.

Shiraki, S.*, Thin, M.C., Matsuno, Y., Shinogi, Y. (2021) Evapotranspiration and crop coefficient of ratoon rice crop determined by water depth observation and Bayesian inference. *Agronomy*, DOI: 10.3390/agronomy11081573.

Subbarao, G.V.*, Kishii, M., Bozal-Leorri, A., Oritz-Monasterio, I., Gao, X.A., Ibba, M.I., Karwat, H., Gonzalez-Moro, M.B., Gonzalez-Murua, C., Yoshihashi, T., Tobita, S. Kommerell, V., Braun, H.J. and Iwanaga, M. (2021) Enlisting wild grass genes to combat nitrification in wheat farming: A nature-based solution. *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*, DOI: 10.1073/pnas.2106595118.

Subbarao, G.V. and Searchinger, T.D.* (2021) Opinion: A "more ammonium solution" to mitigate nitrogen pollution and to boost crop yields. *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*, DOI: 10.1073/pnas.2107576118.

Takenaka, K.*, Ikazaki, K., Simporé, S., Kaboré, F., Thiombiano, N. and Koala, J. (2021), Changes in Woody Vegetation over 31 Years in Farmed Parkland of the Central Plateau, Burkina Faso. *Land (MDPI)*, DOI: 10.3390/land10050470.

Teuscherova, N., Vazquez, E., Trubac, J., Villegas, D.M., Subbarao, G.V., Pulleman, M. and Arango, J. (2021) Gross N transformation rates in soil system with contrasting Urochloa genotypes do not confirm the relevance of BNI as previously assessed in vitro. *Biology and Fertility of Soils*, DOI: 10.1007/s00374-021-01610-z.

Uke, A., Chhe, C., Baramee, S., Tachaapaikoon, C., Pason, P., Waeonukul, R., Ratanakhanokchai, R., Kosugi, A.* (2021) Draft genome sequence data of *Paenibacillus cisolokensis* strain LC2-13A and *Xylanibacillus composti* strain K-13. *Data in Brief*, DOI: 10.1016/j.dib.2021.107361.

Uke, A., Nakazono-Nagaoka, E., Chuah, J.A., Zain, N.A.A., Amir, H.G., Sudesh, K., Abidin, N.Z.H.A.Z, Hashim, Z. and Kosugi, A. (2021) Effect of decomposing oil palm trunk fibers on plant growth and soil microbial community composition. *Journal of Environmental Management*, DOI: 10.1016/j.jenvman.2021.113050.

Uno, K.*, Ishido, K., Loc, N. X., Chiem, N. H., Minamikawa, K. (2021) Multiple drainage can deliver higher rice yield and lower methane emission in paddy fields in An Giang Province, Vietnam. *Paddy and Water Environment*, DOI: 10.1007/s10333-021-00861-8.

宇野健一*, 進藤惣治(2021) ベトナムでの間断灌漑の温室効果ガス排出削減効果と普及に向けた課題. 水土の知（農業農村工学会誌）89(11) : 23-26.

Vongkhamho, S.*, Imaya, A., Yamamoto, K., Takenaka, C. and Yamamoto, H. (2022)

Influence of Topographic Conditions on Teak Growth Performance in Mountainous Landscapes of Lao PDR. *Forests*, DOI: 10.3390/f13010118.

Wirasatriya, A.*, Pribadi, R., Iryanthony, S.B., Maslukah, L., Sugianto, D.N., Helmi, M., Ananta, R.R., Adi, N.S., Kepel, T.L., Ati, R.N.A., Kusumaningtyas, M.A., Suwa, R., Ray, R., Nakamura, T. and Nadaoka, K. (2022) Mangrove Above-Ground Biomass and Carbon Stock in the Karimunjawa-Kemujan Islands Estimated from Unmanned Aerial Vehicle-Imagery. *Sustainability*, 14:706, DOI: 10.3390/su14020706.

Ye, C., Ishimaru, T., Lambio, L., Li, L., Long, Y., He, Z., Htun, T.M., Tang, S. and Su, Z. (2021) Marker assisted pyramiding of QTLs for heat tolerance and escape upgrades heat resilience in rice (*Oryza sativa* L.). *Theoretical Applied Genetics*, DOI: 10.1007/s00122-022-04035-w.

Yoshikai, M.*, Nakamura, T., Suwa, R., Sharma, S., Rollon, R., Yasuoka, J., Egawa, R., Nadaoka, K. (2022) Predicting mangrove forest dynamics across a soil salinity gradient using an individual-based vegetation model linked with plant hydraulics. *Biogeoscience*, DOI: 10.5194/bg-19-1813-2022.

Zhang, M.X., Zeng, H.Q., Afzal, M.R., Gao, X.A., Li, Y.X., Subbarao, G.V.* and Zhu, Y.Y. (2021) BNI-release mechanisms in plant root systems: current status of understanding. *Biology and Fertility of Soils*, DOI: 10.1007/s00374-021-01568-y.

Program B

Andrianary, B.H., Tsujimoto, Y.*, Rakotonindrina, H., Oo, A.Z., Rabenarivo, M., Ramifehiarivo, N. and Razakamanarivo, H. (2021) Phosphorus application affects lowland rice yields by changing phenological development and cold stress degrees in the central highlands of Madagascar. *Field Crops Research*, DOI: 10.1016/j.fcr.2021.108256.

Asai, H.*, Saito, K. and Kawamura, K. (2021) Application of a Bayesian approach to quantify the impact of nitrogen fertilizer on upland rice yield in sub-Saharan Africa. *Field Crops Research*, DOI: 10.1016/j.fcr.2021.108284.

Asai, H.*, Rabenarivo, M., Andriamananjara, A, Tsujimoto, Y., Nishigaki, T., Takai, T., Rakotoson, T., Rakotoarisoa, N. and Razafimbelo, T. (2021) Farmyard manure application increases spikelet fertility and grain yield of lowland rice on phosphorus-deficient and cool-climate conditions in Madagascar highlands. *Plant Production Science*, DOI: 10.1080/1343943X.2021.1908150.

Azhikodan, G., Hlaing, N.O., Yokoyama, K.* and Kodama, M. (2021) Spatio-temporal variability of the salinity intrusion, mixing, and estuarine turbidity maximum in a tide-dominated tropical monsoon estuary. *Continental Shelf Research*, DOI: 10.1016/j.csr.2021.104477.

Chin, L., Miyata, T., Saito, H. and Ishikawa, S.* (2021) Fishing gears, fishing grounds, target species and labor forces of marine small-scale fishery in Kampot Province, Cambodia. *La Mer*, DOI: 10.32211/lamer.59.1-2_1.

團晴行*, 足立忠司, 廣内慎司, Agodzo, S. (2022) ガーナ国において植生工が水田水利施設の浸水崩壊耐性に与える影響, 農業農村工学会論文集, 90(1):I_29-I_36, DOI: 10.11408/jsidre.90.I_29.

de Oliveira, F.K., Da-Silva, C.J.*, Garcia, N.D.S, Agualongo, D.A.P., de Oliveira, A.C.B., Kanamori, N., Takasaki, H., Urano, K., Shinozaki, K., Nakashima, K., Yamaguchi-Shinozaki, K., Nepomuceno, A.L., Henning, L.M.M. and do Amarante, L. (2021) The overexpression of NCED results in waterlogging sensitivity in soybean. *Plant Stress*, DOI: 10.1016/j.stress.2021.100047.

Du, Z.M., Lin, Y.L, Sun, L., Yang, F.Y.* and Cai, Y.M.* (2021) Microbial community structure, co-occurrence network and fermentation characteristics of woody plant silage. *Journal of the Science of Food and Agriculture*, DOI: 10.1002/jsfa.11457.

Du, Z.M., Sun, L., Lin, Y., Chen, C., Yang*, F. and Cai, Y.M.* (2022) Use of Napier grass and rice straw hay as exogenous additive improves microbial community and fermentation quality of paper mulberry silage. *Animal Feed Science and Technology*, DOI: 10.1016/j.anifeedsci.2022.115219.

Du, Z.M., Sun, L., Lin, Y.L., Yang, F.Y.* and Cai, Y.M.* (2021) The use of PacBio SMRT technology to explore the microbial network and fermentation characteristics of woody silage prepared with exogenous carbohydrate additives. *Journal of Applied Microbiology*, DOI: 10.1111/jam.15124.

Du, Z.M., Yamasaki, S., Oya, T., Nguluve, D., Euridse, D., Tinga, B., Macome, F. and Cai, Y.M.* (2022) Microbial Co-occurrence Network and Fermentation Information of Natural Woody-Plant Silage Prepared with Grass and Crop by-product in Southern Africa. *Frontiers in Microbiology*, 13(756209), DOI: 10.3389/fmicb.2022.756209.

Fernando, A.*, Selvaraj, M., Ishitani, M., Nakashima, K., Shinozaki, K. and Yamaguchi-Shinozaki, K. (2021) How utilizing the genes involved in drought tolerance could tackle the climate change-related food crisis, *Molecular Plant*, 14(10):1601-1603, doi: 10.1016/j.molp.2021.08.002, 2021.10

Fukuta, Y., Telebanco-Yanoria, M.J., Koide, Y., Saito, H., Kobayashi, N., Obara, M. and Yanagihara, S. (2022) Near isogenic lines for resistance to blast disease, in the genetic background of Indica Group rice (*Oryza sativa* L.) cultivar IR 64. *Field Crops Research*, DOI: 10.1016/j.fcr2022.105506.

García-Rodrígues, J.C., Vicente-Hernández, Z., Grajales-Solís, M., Yamanaka N.* (2021) Virulence diversity of *Phakopsora pachyrhizi* in Mexico. *PhytoFrontiers*, DOI: 10.1094/PHYTOFR-06-21-0044-R.

羽佐田勝美*，丸井淳一朗，小林慎太郎，Phonesanith Phonhnachit (2021) ビエンチャン特別市におけるパデークの消費者購買行動と満足度評価. 開発学研究 32(2) : 1-9.

Hayes, P.E., Adem, G.D., Pariasca-Tanaka, J. and Wissuwa, M. (2021) Leaf phosphorus fractionation in rice to understand internal phosphorus-use efficiency. *Annals of Botany*, DOI: 10.1093/aob/mcab138/6432224.

Heredia, M.C., Kant, J., Prodhan, A., Dixit, S. and Wissuwa, M.* (2021) Breeding rice for a changing climate by improving adaptations to water saving technologies. *Theoretical and Applied Genetics*, DOI: 10.1007/s00122-021-03899-8.

廣瀬千佳子, 廣内慎司*, 山田雅一, 岡直子, 降籏英樹, 堀野晴彦(2022) ガーナ国北部州既存ため池における回帰分析を用いたカーブナンバー推定モデルの提案. 農業農村工学会論文集 DOI: 10.11408/jsidre.90.II_29.

Hoshikawa, K.*, Pham, D., Ezura, H., Schafleitner, R. and Nakashima, K.* (2021) Genetic and molecular mechanisms conferring heat stress tolerance in tomato plants. *Frontiers in Plant Science*, DOI: 10.3389/fpls.2021.786688.

Iseki, K.*, Olaleye, O., Matsumoto, R. (2021) Effect of leaf thinning on shoot growth and tuber yield of white Guinea yam. *Plant Production Science*, DOI: 10.1080/1343943X.2021.1943466.

Ishimaru, T.*, Hlaing, K.T., Oo, Y.M., Lwin, T.M., Sasaki, K., Lumanglas, P.D., Simon, E.V.M., Myint, T.T., Hairmanris, A., Susanto, U., Ayyenar, B., Muthurajan, R., Hirabayashi, H., Fukuta, Y., Kobayasi, K., Matsui, T., Yoshimoto, M. and Htun, T.M. (2021) An early-morning flowering trait in rice can enhance grain yield under heat stress field conditions at flowering stage. *Field Crops Research*, DOI: 10.1016/j.fcr.2021.108400.

Ishimaru, T.*, Sasaki, K., Nozaki, I., Ichihashi, M., Shimizu, H., Wakayama, M. and Hirabayashi, H. (2021) Effect of the light and dark conditions on flower opening time between cultivated rice (*Oryza sativa*) and a near-isogenic early-morning flowering line. *AoB PLANTS*, DOI: 10.1093/aobpla/plab040.

Kashima, M., Sakamoto, R.L., Saito, H., Ohkubo, S., Tezuka, A., Deguchi, A., Hashida, Y., Kurita, Y., Iwayama, K., Adachi, S. and Nagano, A.J.* (2021) Genomic basis of transcriptome dynamics in rice under field conditions. *Plant Cell Physiology*, DOI: 10.1093/pcp/pcab088.

Kashiwa, T.*, Lavilla, M.A., Paleo, A.D., Ivancovich, A.J.G., Yamanaka, N. (2021) The use of detached leaf inoculation for selecting *Cercospora kikuchii* resistance in soybean genotypes. *PhytoFrontiers*, DOI: 10.1094/PHYTOFR-01-21-0002-TA.

Kashiwa, T., Motoyama, T., Yoshida, K., Yun, C.-S., Osada, H. (2021) Tenuazonic acid production is dispensable for virulence, but its biosynthetic gene expression pattern is associated with the infection of *Pyricularia oryzae. Bioscience, Biotechnology, and Biochemistry*, DOI: 10.1093/bbb/zbab195.

Kashiwa, T.*, Suzuki, T. (2021) High-quality genome assembly of the soybean fungal pathogen *Cercospora kikuchii. G3: Genes, Genomes, Genetics*, DOI: 10.1093/g3journal/jkab277.

Kato, M.*, Soares, R.M. (2021) Field trials of a Rpp-pyramided line confirm the synergistic effect of multiple gene resistance to Asian soybean rust (*Phakopsora pachyrhizi*). *Tropical Plant Pathology*, (Online First) DOI: 10.1007/s40858-021-00471-z.

Kawamura, K., Nishigaki, T., Andriamananjara, A., Rakotonindrina, H., Tsujimoto, Y., Moritsuka, N., Rabenarivo, M., Razafimbelo, T. (2021) Using a one-dimensional convolutional neural network on visible and near-infrared spectroscopy to improve soil phosphorus prediction in Madagascar. *Remote Sensing*, DOI: 10.3390/rs13081519.

Kirk, G.J.D., Manwaring, H.R., Ueda, Y., Semwal, V.K. and Wissuwa, M. (2021) Below-ground plant-soil interactions affecting adaptations of rice to iron toxicity. *Plant, Cell & Environment*, DOI: 10.1111/pce.14199.

Koide, J.*, Yokoyama, S., Hirouchi, S., Hirose, C., Oka, N., Oda, M. and Yanagihara, S. (2021) Exploring climate-resilient and risk-efficient cropping strategies using a new pond irrigation system: An experimental study in northern Ghana. *Agricultural Systems*, DOI: 10.1016/j.agsy.2021.103149.

Kumawat, G. and Xu, D. (2021) A Major and Stable Quantitative Trait Locus qSS2 for Seed Size and Shape Traits in a Soybean RIL Population. *Frontiers in Genetics*, DOI: 10.3389/fgene.2021.646102.

Kuppe, C.W.*, Kirk, G.J.D., Wissuwa, M. and Postma, J.A. (2022) Rice increases phosphorus uptake in strongly sorbing soils by intra-root facilitation. *Plant, Cell & Environment*, DOI: 10.1111/pce.14285.

Ma, J., Ma, L., Chen, X., Zhou, H.Y., Wang, Z., He, Y., Fujita, K.* and Luan, G.Z.* (2021) Rheological behavior of batter and quality of gluten-free bread based on non-glutinous rice flour and tartary buckwheat flour. *Cereal Chemistry*, DOI: 10.1002/cche.10517.

Maeno, K.O.*, Piou, C., Ely, S.O., Mohamed, S.O., Jaavar, M.E.H., Ghaout, S. and Babah Ebbe, M.A.O. (2021) Density-dependent mating behaviours reduce male mating harassment in locusts. *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*, DOI: 10.1073/pnas.2104673118.

Maeno, K.O.*, Piou, C. and Ghaout, S. (2021) Allocation of more reproductive resource to egg size rather than clutch size of gregarious desert locust (*Schistocerca gregaria*) through increasing oogenesis period and oosorption rate. *Journal of Insect Physiology*, DOI: 10.1016/j.jinsphys.2021.104328.

Maeno, K.O.*, Piou, C., Kearney, M.R, Ely, S.O., Mohamed, S.O., Jaavar, M.E.H., and Babah Ebbe, O.A.O. (2021) A general model of the thermal constraints on the world's most destructive locust, *Schistocerca gregaria. Ecological Applications*, DOI: 10.1002/eap.2310.

Marinho, J.P., Pagliarini, R.F., Morinari, M.D.C., Marcolino-Gomes, J., Caranhoto, A.L.H., Marin, S.R.R., de Oliveira, M.C.N., Foloni, J.S.S., de Melo, C.L.P., Kidokoro, S., Mizoi, J., Kanamori, N., Yamaguchi-Shinozaki, K., Nakashima, K., Nepomuceno, A.L. and Mertz-Henning, L.M.* (2021) Overexpression of full-length and partial DREB2A enhances soybean drought tolerance. *Agronomy Science and Biotechnology*, DOI: 10.33158/ASB.r141.v8.2022.

Matsumoto, R., Amele, A.A., De Koeyer, D., Muranaka, S., Yoshihashi, T., Ishikawa, H., Adebola, P.O. and Asiedu, R. (2021) Variation in tuber dry matter content and starch pasting prop-erties of white Guinea yam (*Dioscorea rotundata*) genotypes grown in three agroecologies of Nigeria. *Agronomy*, DOI: 10.3390/agronomy11101944.

Morioka, S., Phomikong, P., Avakul, P. and Jutagate, T. (2021) Morphometric development in laboratory-reared larval and juvenile *Puntioplites proctozysron* (Cypriniformes: Cyprinidae). *Ichthyological Research*, DOI: 10.1007/s10228-021-00841-2.

Morioka, S.*, Vongvichith, B., Chantasone, P. and Phommachan, P., (2021) Descriptive morphology of early developmental stages of laboratory-reared black sharkminnow *Labeo chrysophekadion* (Cypriniformes: Cyprinidae). *Ichthyological Research*, DOI:

10.1007/s10228-021-00821-6.

Nakashima, K., Urao, T., Xu, D.H., Ando, S. and Kato, M. (2021) Technology Development for Stable Agricultural Production under Adverse Environments and Changing Climate Conditions. *Japan Agricultural Research Quarterly*, DOI: 10.6090/jarq.55.295.

Nakashima, K., Yanagihara, S., Muranaka, S. and Oya, T. (2022) Development of Sustainable Technologies to Increase Agricultural Productivity and Improve Food Security in Africa. *JARQ*, 56(1): 7-18.

Nishigaki, T.*, Tsujimoto, Y., Rakotoson, T., Rabenarivo, M., Andriamananjara, A., Asai, H., Andrianary, H.B., Rakotonindrina, H. and Razafimbelo, T. (2021) Soil phosphorus retention can predict responses of phosphorus uptake and yield of rice plants to P fertilizer application in flooded weathered soils in the central highlands of Madagascar. *Geoderma*, DOI: 10.1016/j.geoderma.2021.115326.

Nosaki, S., Hoshikawa, K., Ezura, H. and Miura, K., (2021) Transient protein expression systems in plants and their applications. *Plant Biotechnology*, DOI: 10.5511/plantbiotechnology.21.0610a.

Obara, M.*, Kaneta, Y., Kodama, K., Matsumoto, S, Kawamoto, T., Ishiyama, K., Mae, T. and Makino, A. (2022) Contribution of the grain size QTL GS3 to yield properties and physiological nitrogen-use efficiency in the large-grain rice cultivar 'Akita 63'. *Breeding Science*, DOI: 10.1270/jsbbs.21043.

Ogasawara, S., Ezaki, M., Ishida, R., Sueyoshi, K., Saito, S., Hiradate, Y., Kudo, T., Obara, M., Kojima, S., Uozumi, N., Tanemura, K., Hayakawa, T. (2021) Rice amino acid transporter-like 6 (OsATL6) is involved in amino acid homeostasis by modulating the vacuolar storage of glutamine in roots. *Plant Journal*, DOI: 10.1111/tpj.15403.

Oo, A.Z., Tsujimoto, Y.*, Mukai, M., Nishigaki, T., Takai, T. and Uga, Y. (2021) Synergy between a shallow root system with a DRO1 homologue and localized P application improves P uptake of lowland rice. *Scientific Reports*, DOI: 10.1038/s41598-021-89129-z.

Piou, C., Zagaglia, G., Medina, H.E., Trumper, E., Rojo Brizuela, X., Maeno, K.O. (2021) Band movement and thermoregulation in *Schistocerca cancellata*. *Journal of Insect Physiology*, DOI: 10.1016/j.jinsphys.2021.104328.

Rakbanjong, N., Okutsu, T., Chotigeat, W., Songnui, A., Wonglapsuwan, M.* (2021) Cryopreservation of germ cells of banana shrimp (*Fenneropenaeus merguiensis*) and black tiger shrimp (*Penaeus monodon*). *Marine Biotechnology* DOI: 10.1007/s10126-021-10048-1.

Rakotoson, T., Tsujimoto, Y.* and Nishigaki, T. (2021) Phosphorus management strategies to increase lowland rice yields in sub-Saharan Africa: A review. *Field Crops Research*, DOI: 10.1016/j.fcr.2021.108370.

Ramahaimandimby, Z., Shiratori, S., Sakurai, T.* (2022) Comparison of Two Pathways Linking Agriculture to Child Health: Dietary Diversity and Micronutrient Intake in the Malagasy Highlands. *Japanese Journal of Agricultural Economics*, 24: 46-51.

Saito, H., Tomita, A., Yoshida, T., Nakamura, M. Suzuki, T., Ikeda, A., Kato, T., Nakajima, Y., Tanimoto, R., Tani, T. Hayashi, N., Hirabayashi, H., Ando, I. and Fukuta, Y. (2022) Characterization of six partial resistance genes and one QTL to blast disease using near isogenic line with a susceptible genetic background of Indica Group rice (*Oryza sativa* L.). *Phytofrontiers*, DOI: 10.1094/PHYTOFR-06-21-0042-R.

Shompoosang, S.*, Marui, J., Varichanan, P., Dueramae, S. and Panthavee, W. (2022) Improving the texture and color of khanomjeen, a Thai fermented rice noodle, using a modified rice fermentation method. *Food Science and Technology Research*, 28(1):95-103, DOI: 10.3136/fstr.FSTR-D-21-00146.

Takai, T.*, Lumanglas, P., Fujita, D., Sasaki, K., Rakotoarisoa, N.M., Tsujimoto, Y., Kobayashi, N., Simon, E.V. (2021) Development and evaluation of pyramiding lines carrying early or late heading QTLs in the indica rice cultivar 'IR64'. *Breeding Science*, DOI: 10.1270/jsbbs.21045.

Tanaka, R., Mandaharisoa, S.T., Rakotondramanana, M., Ranaivo, H.N., Pariasca-Tanaka, J., Kanegae, H.K., Iwata, H. and Wissuwa, M. (2021) From gene banks to farmer's fields: Using genomic selection to identify donors for a breeding program in rice to close the yield gap on smallholder farms. *Theoretical and Applied Genetics*, DOI: 10.1007/s00122-021-03909-9.

Tran, L.T.*, Nguyen, A.T.*, Nguyen, M.H., Nguyen, L.T., Nguyen, M.T., Trinh, L.T., Tran, D.T., Ta, S.V., Hoshikawa, K., Sugimoto, K. and Ezura, H. (2021) Developing new parthenocarpic tomato breeding lines carrying iaa9-3 mutation. *Euphytica*, DOI: 10.1007/s10681-021-02853-5.

Tsujimoto, Y.*, Tanaka, A. and Rakotoson, T. (2021) Sequential micro-dose fertilization strategies for rice production: Improved fertilizer use efficiencies and yields on P-deficient lowlands in the tropical highlands. *European Journal of Agronomy*, DOI: 10.1016/j.eja.2021.126381.

Urano, K., Maruyama, K., Koyama, T., Gonzalez, N., Inze, D., Yamaguchi-Shinozaki, K. and Shinozaki, K. (2022) CIN-like TCP13 is essential for plant growth regulation under dehydration stress, *Plant Molecular Biology*, DOI: 10.1007/s11103-021-01238-5

Weiss, D., Northover, G., Hanif, M., Garcia-España, E., Vilar, R., Arnold, T., Markovic, T., Wissuwa, M. and Delgado, E. (2021) Isotope fractionation of zinc in the paddy rice soil-water environment and the role of 2'deoxymugenic acid (DMA) as zincophore under Zn limiting conditions. *Chemical Geology*, DOI: 10.1016/j.chemgeo.2021.120271.

Wissuwa, M. and Kant, J. (2021) Does half a mm matter? Root hairs for yield stability. A commentary on "Significance of root hairs for plant performance under contrasting field conditions and water deficit", *Annals of Botany*, DOI: 10.1093/aob/mcab027, .3

Yamaguchi, T., Hoshizaki, M., Minato, T., Nirasawa, S., Asaka, M., Niiyama, M., Imai, M., Uda, A., Chan, J., Takahashi, S., An, J., Saku, A., Nukiwa, R., Utsumi, D., Kiso, M., Yasuhara, A., Poon, V., Chan, C., Fujino, Y., Motoyama, S., Nagata, S., Penninger, J., Kamada, H., Yuen, K., Kamitani, W., Maeda, K., Kawaoka, Y., Yasutomi, Y., Imai, Y., Kuba, K* (2021) ACE2-like carboxypeptidase B38-CAP protects from SARS-CoV-2-induced lung injury. *Nature Communications*, DOI: 10.1038/s41467-021-27097-8.

横山繁樹(2022) タンザニア先進稲作地域における水資源制約下での水田利用合理化の課題. 農業経営研究 59(4) : 69-74.

Yoshimoto, M.*, Fukuoka, M., Tsujimoto, Y., Matsui, T., Kobayasi, K., Saito, K., van Oort, P., Inusah, B.I.Y., Vijayalakshmi, C., Vijayalakshmi, D., Weerakoon, W.M.W., Chandradasa, S., Tin Tin Myint, Phyo, Z.C., Manigbas, N.L., Tian, X.H., Lur, H.S., Yang, C.M., Tarpley, L., Manigbas, N.L. and Hasegawa, T. (2022) Monitoring canopy micrometeorology in diverse climates to improve the prediction of heat-induced spikelet sterility in rice under climate change. *Agricultural and Forest Meteorology*, 316(108860), DOI: 10.1016/j.agrformet.2022.108860.

Yurimoto, T.*, Kassim, F.M., Fuseya, R., Matsuoka, K. and Man, A. (2021) Food Availability Estimation of the Blood Cockle, *Anadara granosa* (Linnaeus, 1758), from the Aquaculture Grounds of the Selangor Coast, Malaysia. *International Journal of Aquatic Biology*, DOI: 10.22034/ijab.v9i2.1113.

Yurimoto, T.*, Tidaporn, C., Matsuoka, K. and Koolvara, S. (2021) Histological observations of the blood cockle, *Tegillarca granosa* (L.), after a mass mortality event in Welu estuary, Thailand. *Fisheries & Aquatic Life*, 29:230-238, DOI: 10.2478/aopf-2021-0025.

Zuo, Y., Dai, S., Song, Z., Xiang, Q., Li, W., Liu, G., Li, J., Xu, D. and Yan, Z.* (2022) Identification and characterization of wheat - *Aegilops comosa* 7M (7A) disomic substitution lines with stripe rust and powdery mildew resistance. *Plant Disease*, DOI: 10.1094/PDIS-11-21-2485-RE.

Program C

Hayashi, K.*, Llorca, L.P., Bugayong, I.D., Agustiani, N. and Capistrano, A.O.V. (2021) Evaluating the predictive accuracy of the weather-rice-nutrient integrated decision support system (WeRise) to improve rainfed rice productivity in Southeast Asia. *Agriculture*, DOI: 10.3390/agriculture11040346.

Iiyama, M., Watson, C. and Miyamoto, M.

(2021) Agroforestry System Research - Identification of land use change drivers and scaling up of trees on farms for transforming livelihoods and landscapes. *Japan Agricultural Research Quarterly*, DOI: https://www.jircas.go.jp/ja/publication/jarq/20ss15.

Ishida, T., Ohara, S., Sasaki, Y., Shirai, T. Terajima, Y., Sugimoto, A. and Kawashima, T. (2021) Physical characteristics of *Erianthus arundinaceus* as a bedding material for livestock. *Grassland Science*, DOI: 10.1111/grs.12333.

Jannat, A., Ishiwata, Y.I. and Furuya, J.* (2021) Assessing the Impact of Climate Variations on the Potato Production in Bangladesh: A Supply and Demand Model Approach. *Sustainability*, DOI: 10.3390/su13095011.

Kanamori, N.* and Iiyama, M.* (2021) Changing agendas of CGIAR's international agricultural research. *JARQ (Japan Agricultural Research Quarterly)*, DOI: https://www.jircas.go.jp/ja/publication/jarq/20ss17.

Kato, Y.* and Hayashi, K.* (2021) Japan and IRRI: Contributions to International Rice Research for Sustainable Development, Lessons Learned and Ways Forward, *JARQ*, 55(SI):483-487.

近藤友大*, 雨宮俊, 香西直子, 緒方達志, 米本仁巳, 樋口浩和 (2021) 果実の落下がパッションフルーツの品質と生理活性に及ぼす影響. 熱帯農業研究 14(2) : 59-66.

Kusano, E.* (2022) Nutrition as an integral dimension of global food security: Arguments in FAO's flagship publications. *Journal of Agricultural Development Studies*, 32(3): 18-27.

Muraoka, R.*, Furuya, J., Hirano, A. and Sakurai, T. (2021) Climate risk and agricultural technology adaption: evidence from rice farmers in the Ayeyarwady River delta of Myanmar. *Paddy and Water Environment*, DOI: 10.1007/s10333-021-00870-7.

Nakayama, M.*, Fujita, S., Watanabe, Y., Ando, T., Isozaki, M., Iwasaki, Y. (2021) The effect of greenhouse cultivation under a heat insulation film covering on tomato growth, yield, and fruit quality in a subtropical area. *The Horticulture Journal*, DOI: 10.2503/hortj.UTD-249.

農一シン, 銭小平,尹昌斌*, 万永全,付利波 (2021) 果園生草複合種養循環模式効応分析. 中国農業資源与区画(*Chinese Journal of Agricultural Resources and Regional Planning*), DOI :10.7621/cjarrp.1005-9121.20211102.

Ogata, T.* and Yamanaka, S. (2021) In vivo micrografting to eliminate Passiflora latent virus from infected passion fruit plants. *The Horticulture Journal*, DOI: 10.2503/hortj.UTD-259.

Sakai, T.*, Birhane, E., Abebe, B., and Gebremeskel, D. (2021) Applicability of Structure-from-Motion Photogrammetry on Forest Measurement in the Northern Ethiopian Highlands. *Sustainability*, DOI: 10.3390/su13095282.

Terajima, Y., Ponragdee, W., Sansayawichai, T., Tippayawat, A., Chanachai, S., Ebina, M., Sugimoto, A., Takagi, H. and Hayashi, H. (2022) Genetic variation in agronomic traits of *Erianthus* germplasm under multiple-ratoon crops in Thailand. *Crop Science*, DOI: 10.1002/csc2.20697.

Tsuruta S.*, Srithawong, S., Sakuanrungsirikul, S., Ebina, M., Kobayashi, M., Terajima, Y., Tippayawat, A. and Ponragdee, W. (2022) *Erianthus* germplasm collection in Thailand: genetic structure and phylogenetic aspects of tetraploid and hexaploid accessions. *BMC Plant Biology*, DOI: 10.1186/s12870-021-03418-3.

Yatabe, O.*, Kamiya, A., Chansri, P., Pongkaew, T., Ando, S., Terajima, Y. and Sugimoto, A. (2021) Developing high-yielding cultivation technology for sugarcane ratoon crops in Northeast Thailand: Evaluation of the effects of deeper planting on bud germination, one-stalk weights, the number of millable stalks, and yields of new plants and ratoon crops (Initial report). *Tropical Agriculture and Development*, DOI: 10.11248/jsta.65.49.

Others

Kusano, E.*, Marui, J. and Yoshihashi, T. (2021) Basic quality management for improving the business stability of small food enterprises in Southeast Asia: The case of a fermented rice noodle company in Thailand preventing noodle liquefaction. *Japan Agricultural*

Research Quarterly, 55(3): 253-264.

Matsuda, H.* and Ogata, T., (2021) Effects of Floral Disbudding on Mango Flowering and Fruit Set. *Tropical Agriculture and Development*, 65(3): 132-137.

Nong, Y.X., Yin, C.B., Yi, X.Y., Ren, J. and Chien, H.P.* (2021) Smallholder farmer preferences for diversifying farming with cover crops of sustainable farm management: A discrete choice experiment in northwest China. *Ecological Economics*, DOI: 10.1016/j.ecolecon.2021.107060.

進藤惣治, 泉太郎 (2021) 開発途上地域における農業研究と求められる人材. 農業農村工学会誌 89(6) : 11-14.

進藤惣治, 田尻淳, 金森秀行, 郷古雅春, 橋口幸正, 松原英治 (2022) 農業農村開発協力の特徴と経験継承の必要性. 農業農村工学会誌 90(2) : 7-10.

Yoshihashi, T.*, Abe, Y., Iwasaki, N., Sakanaka, H., Fujinaka, M. and Kido, R. (2021) Designing a polyurethane-based husker roll for long-grain rice using a finite element model. *JARQ*, 55(3): 245-251.

This list includes papers published by staff members of overseas collaborating research institutes.
Underline indicates researcher at JIRCAS.
*Corresponding author

Fifth Medium to Long-Term Plan of the Japan International Research Center for Agricultural Sciences

The Japan International Research Center for Agricultural Sciences (JIRCAS) has been contributing to the improvement of practices and technologies related to agriculture, forestry and fisheries in tropical and subtropical regions, as well as in other developing regions overseas, by conducting technical tests and research.

During the First Medium-Term Goal period (FY2001-2005), 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 (FY2006-2010), 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 the international operational activities of the former Japan Green Resources Agency (JGRA), and strengthened its field activities overseas.

During the Third Medium-Term Goal period (FY2011-2015), a program/project scheme was developed for three principal research areas, namely, 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.

During the Fourth Medium to Long-Term Goal period (FY2016-2020), environment and natural resource management, stable agricultural production, and high value-adding technologies were positioned as priority research areas, and innovations in research management were promoted to maximize R&D outcomes. In addition, operations related to the collection, analysis, and dissemination of information on international agriculture, forestry, and fisheries were strengthened.

In the Fifth Medium to Long-Term Goal period, JIRCAS will focus on research areas that address the growing expectations for the development of technologies in the agriculture, forestry, and fisheries sectors to achieve the Sustainable Development Goals (SDGs), in accordance with the “Basic Plan for Food, Agriculture, and Rural Areas” (approved by the Cabinet on March 31, 2020) and the new policy “Measures for Decarbonization and Resilience with Innovation (MeaDRI).” These research areas include the development of agricultural technologies for climate change, resource recycling and environmental conservation; technology development towards building a new food system with improved productivity, sustainability and resilience; and strengthening function as an international hub for providing strategic information on agriculture, forestry and fisheries, and mobilizing new research partnerships. In addition, with an eye on the post-coronavirus society, priority research resources will be allocated and new R&D and business management methods will be established.

Through these efforts, as the sole research institution in Japan mandated to carry out comprehensive research in international agriculture, forestry and fisheries, JIRCAS is committed to strengthen its framework of collaboration with related organizations, play a key role in research and development targeting developing regions, and contribute to solving global food problems and enhancing Japan’s research in agriculture, forestry and fisheries.

Section 1. Improving the Quality of Operations and Maximizing R&D Outcomes

The following four operational activities will be promoted as individual segments, and evaluated in accordance with the guidelines and criteria set by the Ministry of Agriculture, Forestry and Fisheries (MAFF).

- ○ Management of research and development activities (Planning Segment)
- ○ Development of agricultural technologies for addressing climate change, resource recycling and environmental conservation (Environment Segment)
- ○ Development of technologies towards building a new food system with improved productivity, sustainability and resilience (Food Segment)
- ○ Strengthening function as an international hub for providing strategic information on agriculture, forestry and fisheries, and mobilizing new research partnerships (Information Segment).

1. Management of research and development activities (Planning Segment)

(1) Strategic promotion of R&D in accordance with government policies

In order to strategically promote R&D for solving global issues related to mitigation of climate change and establishing new food systems that will benefit both Japan and the developing regions, JIRCAS will undertake the following efforts.

a) Establish a research agenda that can flexibly respond to local conditions, build a research promotion system that includes conducting research with international research institutions and research networks, and utilization of domestic research facilities, in order to address the risk of constraints on activities in the target regions.
b) Manage the progress of research projects based on a timetable, select and focus on projects based on results of evaluation, and review each project flexibly according to the progress of research and changes in social conditions.
c) Provide incentives to research staff at the discretion of the President, enhance the research environment, as well as to work actively to obtain external funding, and make efficient use of research funds.
d) Promote goal-oriented basic research that will lead to the creation of future technological seeds and the development of innovative technologies.
e) Establish a system utilizing ICT etc. that enables effective and efficient research to be conducted even under conditions where the movement of people is restricted due to the impact of COVID-19 pandemic.

(2) Strengthen industry-academia-government collaboration and cooperation

JIRCAS will actively promote international joint research and personnel exchange with research institutes and universities in developing regions and developed countries, international research institutions such as CGIAR, private organizations including NGOs, and international research networks, in order to contribute in raising the level of research and solving problems related to agriculture, forestry, and fisheries in developing regions.

In addition, JIRCAS will support the establishment of strategic partnerships in the Information Segment, and expand opportunities for exchange of information, personnel and research with the National Agriculture and Food Research Organization (NARO), Forest Research and Management Organization (FRMO), Japan Fisheries Research and Education Agency (FRA) and other organizations, to promote R&D and other activities that leverage the strengths of each research agency and bring about synergies. As the sole research institute in Japan that comprehensively conducts research on international agriculture, forestry and fisheries, JIRCAS will contribute to the advancement of R&D in domestic agriculture, forestry and fisheries by strengthening cooperation, including personnel exchange with NARO, FRMO, FRA and other organizations, while playing a central role in research on agriculture, forestry and fisheries in the tropical/subtropical regions and developing countries.

(3) Strategic promotion of intellectual property management

The R&D outcomes are considered as global public goods and will be handled from the perspective of promoting their utilization in developing regions. The following measures will be taken to promote strategic management of intellectual property for rapid social implementation and dissemination of technology.

a) The most appropriate method will be adopted based on the necessity and effectiveness of the invention in terms of confidentiality, rights (including agreement on the ownership/sharing ratio of rights, licensing policy, and handling of improved inventions), standardization, and public knowledge at the time of invention, as well as the release of patents and other rights after acquisition, exclusive licensing, and other measures.
b) In conducting joint research, a nondisclosure agreement will be concluded as necessary to prevent infringement of intellectual property, such as outflow of technology or leakage of information. In addition, the handling of intellectual property obtained through joint research will be stipulated in the joint research agreement.

(4) Strengthen efforts for social implementation of R&D outcomes

The following measures will be undertaken to promote the dissemination and social implementation of R&D outcomes, and to utilize investments, as well as human and technical support as necessary, in accordance with the Law on the Revitalization of Science, Technology and Innovation Creation (Act No. 63, 2008).

a) The possibility of obtaining rights and the need for confidentiality will be considered for R&D outcomes, and those results that are desirable to be made public knowledge will be published in the JIRCAS Annual Report and academic journals, etc.
b) In countries and regions where the results are expected to be utilized, seminars, workshops, and explanatory meetings for local residents will be held to promptly provide information to the beneficiaries.
c) Results that are expected to be of particular use will be selected as major research result for publication and dissemination to promote their actual utilization.
d) Support efforts in the Information Segment for technology dissemination and application through strategic partnerships with the development sector and businesses.
e) Conduct follow-up surveys on major R&D outcomes in a systematic manner and publicize them on the website, etc.

(5) Promote public relations activities and interactive communication with the public

The following efforts will be made to promote public understanding of the activities and achievements, the need for international research and development targeting developing regions, the contributions to science and technology diplomacy through research activities.

a) Support efforts of the Information Segment to provide strategic information. Expand opportunities for information dissemination and interactive communication both domestically and internationally by making effective use of the media, including press releases and media coverage, as well as by utilizing a variety of media and communication tools, such as printed publications, sending out e-mail newsletters, and participation in various external events.
b) In addition to the public open house, engage in outreach activities such as participation in exhibitions, science cafes, and visiting lectures, as well as in new types of outreach activities, such as online symposiums and seminars.
c) Promote efforts to enhance the understanding of local residents in the regions where the research is being conducted by holding on-site workshops and explanatory meetings, in collaboration with partner institutions of joint research and government agencies of those countries.

(6) Strengthen cooperation with government departments

The following efforts will be promoted in order to ensure appropriate R&D activities and measures that respond and contribute to national policies.

a) Coordinate closely with relevant government departments, exchange information at each stage of research from research design to dissemination and practical application of results, and request for their participation in annual review meetings to discuss and verify the results.
b) Respond to requests from government departments for cooperation in conducting emergency operations, holding liaison meetings and symposiums, and dispatching experts to international

organizations, academic conferences etc.

c) Respond to requests from national and local government, organizations, or universities etc. to perform analyses and appraisals that require expertise of staff and are difficult for other bodies to perform.

2. Development of agricultural technologies for climate change, resource recycling and environmental conservation (Environment Segment)

In order to cope with global climate change and prevent further environmental degradation in developing regions that depend heavily on agriculture, forestry, and fisheries, it is necessary to balance sustainable agriculture, forestry, and fisheries with appropriate resource management by maximizing resource use efficiency without crossing the so-called planetary boundaries, based on scientific assessment of risks related to the maintenance of the global system. To achieve this objective, the following research initiatives will be undertaken.

Develop water-saving cropping systems in rice paddies and their water management methods, and technologies to reduce greenhouse gas emissions by effectively utilizing livestock waste, etc. targeting developing regions, mainly in Asia, while also taking domestic benefits into consideration.

Develop carbon recycling technologies to convert agricultural waste into resources, using the power of microorganisms to break down and convert agricultural waste into raw materials for fuels and chemical products.

Develop low-impact agricultural production systems by utilizing biological nitrification inhibition (BNI) technology in order to reduce the environmental burden caused by fertilization using nitrogen compounds.

Develop afforestation technologies to enhance forestry productivity and environmental adaptability of tropical forests by utilizing the indigenous genetic resources of tropical forests in Southeast Asia and other regions.

In addition, environmental conservation technologies will be developed through the yama-sato-umi agroecosystem connectivity in subtropical islands, soil conservation technologies in drylands, and technologies to mitigate the risk of drought.

3. Development of technologies towards building a new food system with improved productivity, sustainability and resilience (Food Segment)

In order to respond to the diversified agricultural development needs of developing regions and to contribute to stable food production in the target regions as well as to international food supply and demand and food and nutrition security, a new food system that improves agricultural productivity and nutrition will be established. To achieve this objective, the following research initiatives will be undertaken.

Develop breeding materials and production technologies that contribute to enhancing the resilience of major crops and local indigenous crops, in order to contribute to sustainable production in harsh environments and improved nutrition in developing regions, by utilizing advanced technologies. In addition, technologies will be developed to acquire breeding materials, agricultural products, and food products that will benefit both Japan and developing regions, mainly in the Asian region, which shares a common food culture with Japan, by clarifying the characteristics of various indigenous crops, utilizing genetic resources, introducing IoT to cultivation management, and meeting new demand through food processing.

Develop efficient and environmentally friendly control technologies for transboundary pests, which are a global problem, in cooperation with international organizations.

Develop sustainable aquaculture technologies through community-based aquaculture management that maintains ecosystem functions in order to revitalize the fisheries industry through appropriate management of aquaculture fishing grounds.

Develop water management technologies, breeding materials, and cultivation technologies effective for doubling rice production in the Sub-Saharan Africa as contribution to the Coalition for African Rice Development (CARD).

Develop field crop systems that can improve productivity, profitability and sustainability of small-scale farming including field crops and livestock production, to contribute in the improvement of agricultural productivity and resilience in the African region.

4. Strengthening function as an international hub for providing strategic information on agriculture, forestry and fisheries, and mobilizing new research partnerships (Information Segment)

The following initiatives will be undertaken to disseminate information domestically and internationally.

To understand the challenges and development needs of agriculture, forestry, fisheries, and food systems in developing regions, JIRCAS will analyze the current status of food supply and demand, nutrition improvement, and food systems in other countries, forecast the future under various scenarios, and evaluate the impact of developed technologies. A system for continuous, systematic, and organized collection, organization, and dissemination of a wide range of information to researchers, government organizations, companies, etc. will be established. In addition, JIRCAS will actively participate in international discussions on food and the environment through the G20 Meeting of Agricultural Scientists (MACS) and other forums. High-quality information will be provided by creating original contents and effective dissemination methods to target audiences will be devised through various media and opportunities, including participation in external events, exhibitions, and creation of publications and videos.

As part of efforts for social implementation of R&D outcomes that also benefit Japan, cooperation in developing regions, participation in domestic and international forums related to R&D, and the establishment of strategic partnerships with domestic and foreign organizations will be promoted in order to disseminate developed technologies. Furthermore, demonstration tests for dissemination and commercial deployment, information gathering for the application of digital technologies such as ICT, and research on subtropical agriculture in Japan using the Tropical Agriculture Research Front (TARF) will be conducted.

In addition, the following efforts will be made by utilizing the center functions.

a) Cooperate in the promotion of domestic breeding and gene bank projects by utilizing the research environment possessed by JIRCAS.
b) Conduct international joint research projects and special projects for dispatch of researchers to foster researchers in developing regions and Japan, and to accept trainees from other national research institutes, universities, national and public institutions, the private sector, and overseas institutions to contribute to human resource development and the improvement of technical standards.

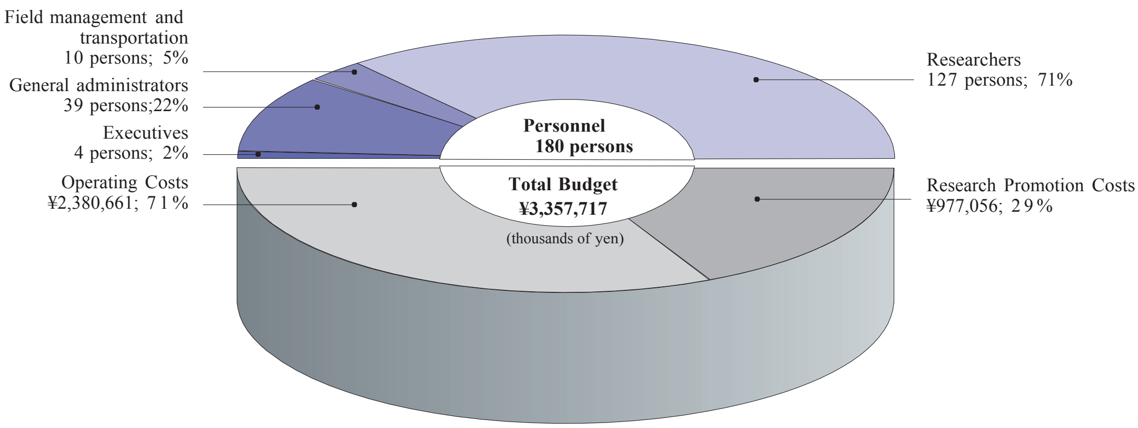
Financial Overview

Fiscal Year 2021

	thousands of yen
TOTAL BUDGET	**3,357,717**
OPERATING COSTS	**2,380,661**
Personnel (180)	2,075,203
President (1), Vice-President (1), Executive Advisor & Auditor (2)	
General administrators (39)	
Field management (10)	
Researchers (127)	
* Number of persons shown in ( )	
Administrative Costs	305,458

RESEARCH PROMOTION COSTS	**977,056**
Research and development	696,303
Overseas dispatches	133,113
Collection of research information	104,537
International collaborative projects	39,584
Fellowship programs	3,519

Budget FY 2021 (Graph)



Members of the External Evaluation Committee

Members of the JIRCAS External Evaluation Committee

Hironobu SHIWACHI	Professor, Department of International Agricultural Development, Faculty of International Agriculture and Food Studies, Tokyo University of Agriculture (Tokyo NODAI)
Yasuhiko TORIDE	Professor, Institute for International Strategy, Tokyo International University
Eriko HIBI	Director, FAO (Food and Agriculture Organization) Liaison Office in Japan

JIRCAS Staff in FY 2021

President

Osamu Koyama

Vice-President

Yukiyo Yamamoto

Auditors

Teruyoshi Kumashiro
Hiroko Isoda

Information and Public Relations Office

Keisuke Omori, Head

Public Relations and Publications Section
Kazuhiko Okada, Head
Takanori Hayashi, Information Management Expert

Regional Coordinator
Shotaro Ando, Representative of Southeast Asia Office (Thailand)

Project Leader
Norihito Kanamori, Plant Molecular Biology

Senior Researcher
Sakiko Shiratori, Agricultural Economics

Program Directors

Keiichi Hayashi, Program A: Environment
Kazuo Nakashima, Program B: Food
Miyuki Iiyama, Program C: Information

Research Planning and Partnership Division

Tomohide Sugino, Director

Research Planning and Management Office
Takeshi Watanabe, Head

Research Planning Section
Hiroshi Ikeura, Head

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

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

Communications Advisor
Baltazar Antonio

Research Support Office
Tadao Yatabe, Head

Research Coordination Section
Hideaki Nagoya, Head
Toshiki Kikuchi, International Affairs Expert
Mizuho Jin, Overseas Travel and Invitation Program Subsection Head
Gen-ichiro Hanaoka, Research Coordination Subsection Staff
Kenji Iwasa, Overseas Affairs Subsection Head
Misaki Ohashi, Overseas Affairs Subsection Staff

Research Support Section
Takashi Kamura, Head
Takayuki Yamamoto, Budget Subsection Head
Takehito Kato, Support Subsection Staff

Research Platform Office
Eizo Tatsumi, Head

Digital Technology Section
Akira Hirokawa, Head
Hiromi Miura, Information Security Expert
Shota Miyai, Information System Management Subsection Staff

Safety Management Section
Masaki Morishita, Head

Administration Division

Takaaki Shimura, Director

General Affairs Section
Takashi Oosato, Head
Takeshi Usuku, General Affairs Assistant Head
Jun Yatabe, Personnel Management Assistant Head
Hitomi Ogamino, Welfare Subsection Staff
Yoshiyuki Seki, Personnel Subsection 1 Head
Noriko Osonoe, Personnel Subsection 1 Staff
Kumi Ehara, Personnel Subsection 2 Head

Accounting Section
Koji Abe, Head
Koichi Fuse, Accounting and Examination Assistant Head
Yuji Shirata, Procurement and Asset Managing Assistant Head
Ryoichi Mise, Financial Subsection Head

Shoko Yoshida, Accounting Subsection Staff
Aki Tamura, Audit Subsection Staff
Yumekazu Yano, Procurement Subsection 1 Head
Mizuha Furukawa, Procurement Subsection 2 Staff
Yuma Sukegawa, Supplies/Equipment Subsection Staff
Tadahisa Akiyama, Facilities Subsection Head

Administration Section (Tropical Agriculture Research Front)
Hisashi Harima, Head
Hiroe Nagatomo, General Affairs Subsection Head
Maretomo Fujimoto, Accounting Subsection Head

Risk Management Office

Masato Oda, Head

Compliance Management Section
Sota Toyoshima, Management Subsection Staff

Audit Office

Yoshinori Kawasaki, Head

Rural Development Division

Soji Shindo, Director

Project Leaders
Taro Izumi, Rural Development
Jun-ya Onishi, Irrigation

Senior Researchers
Naoki Horikawa, Hydrology
Kazuhisa Koda, Agricultural Engineering
Shinji Hirouchi, Agricultural Engineering
Koichi Takenaka, Rural Development Forestry
Mamoru Watanabe, Rural Development
Naoko Oka, Agriculture Water Management
Haruyuki Dan, Rural Development
Masakazu Yamada, Agricultural Engineering
Shiraki, Rural Development
Ken-ichiro Kimura, Forest Chemistry
Katsumi Hasada, Rural Development
Ken-ichi Uno, Agricultural Engineering

Researchers
Shin-ya Iwasaki, Soil Science
Kayo Matsui, Soil Science
Fumi Okura, Irrigation and Drainage

Social Sciences Division

Jun Furuya, Director

Senior Researchers
Fumika Sen, Agricultural Economics
Shunji Oniki, Agricultural Economics
Kensuke Kawamura, Remote Sensing and Grassland Ecology
Akira Hirano, Geographic Information Systems
Eiichi Kusano, Agricultural Economics

Researchers
Toru Sakai, Remote Sensing and GIS
Rie Muraoka, Agricultural Economics
Junji Koide, Agricultural Economics
Ai Leon, Environmental Impact Assessment
Guenwoo Lee, Development Economics and International Cooperation Studies
Wenchao Wu, Agricultural Economics

Biological Resources and Post-harvest Division

Seiji Yanagihara, Director

Project Leaders
Yasunari Fujita, Plant Molecular Biology
Akihiko Kosugi, Molecular Microbiology
Tadashi Yoshihashi, Food Science
Kyonoshin Maruyama, Plant Molecular Biology

Senior Researchers
Kazuhiko Nakahara, Food Chemistry
Xu Donghe, Plant Molecular Genetics
Satoru Nirasawa, Food Functionality
Yoshinori Murata, Applied Microbiology
Naoki Yamanaka, Plant Molecular Genetics
Mitsuhiro Obara, Plant Physiology and Genetics
Takamitsu Arai, Molecular Microbiology
Jun-ichiro Marui, Molecular Microbiology
Yukari Nagatoshi, Plant Molecular Biology
Toshiaki Kondo, Molecular Ecology
Kaori Fujita, Crop Science and Food Engineering
Kotaro Iseki, Crop Science and Breeding

Researchers
Shimpei Aikawa, Applied Microbiology
Takuya Ogata, Plant Molecular Biology
Takeshi Kashiwa, Plant Pathology
Kazuhiro Sasaki, Plant Breeding and Genetics
Ken Hoshikawa, Horticulture Science
Junnosuke Otaka, Natural Products Chemistry
Park Cheolwoo, Plant Breeding and Genetics
Yasufumi Kobayashi, Plant Molecular Biology
Ayaka Uke, Molecular Microbiology

Crop, Livestock and Environment Division

Seishi Yamasaki, Director

Project Leaders
Satoru Muranaka, Plant Physiology
Yoichi Kobori, Entomology
Yasuhiro Tsujimoto, Crop Science

Senior Researchers
Cai Yimin, Animal Science
Naruo Matsumoto, Soil Fertility and Nutrient Cycling
Matthias Wissuwa, Physiology and Genetics
Tetsuji Oya, Crop Science
Kazunori Minamikawa, Biogeochemistry
Toshiyuki Takai, Crop Science and Genetics
Koki Maeda, Environmental Science, Manure Management and Microbial Ecology
Sarr Papa Saliou, Soil Microbiology
Aung Zaw Oo, Crop Science
Kenta Ikazaki, Soil Science
Satoshi Nakamura, Soil Science
Kotaro Maeno, Entomology
Hidetoshi Asai, Crop Science
Fujio Nagumo, Soil Science

Researchers
Tetsuro Kikuchi, Biogeochemistry
Mizuki Matsukawa, Plant Protection
Tomohiro Nishigaki, Soil Science
Andressa C. S. Nakagawa, Crop Science
Miwa Arai, Soil Ecology and Soil Science
Satoshi Ogawa, Agronomy
Yoshiaki Ueda, Plant Physiology and Genetics

Forestry Division

Hiroyasu Oka, Director

Senior Researchers
Naoki Tani, Forest Genetics
Kenzo Tanaka, Forest Ecology and Tree Ecophysiology
Rempei Suwa, Forest Ecology
Masaki Kobayashi, Tree Molecular Biology

Researcher
Kiyosada Kawai, Tree Physiology and Wood Anatomy

Fisheries Division

Tsutomu Miyata, Director

Project Leader
Marcy N. Wilder, Crustacean Biochemistry

Senior Researchers
Shinsuke Morioka, Fish Biology
Toru Shimoda, Marine Chemistry
Isao Tsutsui, Aquaculture
Masaya Toyokawa, Marine Planktology
Tomoyuki Okutsu, Aquatic Animal Physiology
Ryogen Nambu, Benthic Biology
Tatsuya Yurimoto, Aquatic Biology
Bong Jung Kang, Aquatic Animal Physiology

Researcher
Yukio Matsumoto, Aquatic Biology

Tropical Agriculture Research Front

Hide Omae, Director

Project Leaders
Shinsuke Yamanaka, Plant Genetic Resources
Toshihiko Anzai, Irrigation and Drainage

Senior Researchers
Shotaro Ando, Soil Science
Tatsushi Ogata, Pomology
Nobuya Kobayashi, Plant Breeding
Takuma Ishizaki, Plant Molecular Biology
Yoshifumi Terajima, Sugarcane Breeding
Shin-ichi Tsuruta, Molecular Genetics

Researchers
Hiroki Saito, Rice Breeding and Molecular Genetics
Ken Okamoto, Agricultural Engineering
Hiroshi Matsuda, Tropical Pomology
Masakazu Nakayama, Vegetable Crop Science
Hiroo Takaragawa, Crop Science
Takashi Kanda, Soil Science
Kosuke Hamada, Soil Science
Daichi Kuniyoshi, Rice Breeding

Technical Support Office
Kunimasa Kawabe, Head
Hirokazu Ikema, Machine Operator
Masato Shimajiri, Machine Operator
Masakazu Hirata, Machine Operator
Yasuteru Shikina, Machine Operator
Shinji Ogata, Machine Operator
Masashi Takahashi, Machine Operator
Masahide Maetsu, Machine Operator
Yuto Hateruma, Machine Operator

The Japanese Fiscal Year and Miscellaneous Data

The Japanese Fiscal Year and the Annual Report 2021

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) 2021 covers the period from April 1, 2021 through March 31, 2022.

The Annual Report 2021 summarizes the full extent of JIRCAS activities that occurred during this period. The subsequent Annual Report will detail events and programs from April 1, 2022 through March 31, 2023 (FY 2022).

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

Annual Report 2021

(April 2021-March 2022) No.28 (October 2022)

Published by

Japan International Research Center for Agricultural Sciences (JIRCAS)

1-1 Ohwashi, Tsukuba, Ibaraki 305-8686, JAPAN

Tel. +81-29-838-6313

Fax. +81-29-838-6316

Homepage https://www.jircas.go.jp

2022年(令和4年)10月 21日 発行

発行者　国立研究開発法人　国際農林水産業研究センター

理事長　小山　修

〒305-8686　茨城県つくば市大わし1-1

電話：029-838-6313

FAX：029-838-6316

印　刷　松枝印刷株式会社

〒303-0034　茨城県常総市水海道天満町2438

JAPAN INTERNATIONAL RESEARCH CENTER
FOR AGRICULTURAL SCIENCES