ISSN 2759-5846 (Online)

Annual Report 2023 (Apr. 2023– Mar. 2024)

JAPAN INTERNATIONAL RESEARCH CENTER FOR AGRICULTURAL SCIENCES

JIRCAS

Japan International Research Center for Agricultural Sciences

Annual Report 2023

(April 2023-March 2024)

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 2023

Message from the President ---------- 2
Highlights from 2023 ---------- 5

Research Overview

Overview of JIRCAS's Research Structure ---------- 18
Main Research Programs ---------- 21
Program A Environment ---------- 21
Program B Food ---------- 37
Program C Information ---------- 60

Training and Invitation Programs / Information Events

Invitation Programs at JIRCAS ---------- 68
Fellowship Programs at JIRCAS ---------- 73
Workshops ---------- 75

Appendix

Publishing at JIRCAS ---------- 81
Refereed Journal Articles 2023-2024 ---------- 82
Fifth Medium to Long-Term Plan of the Japan International Research Center for Agricultural Sciences ---------- 89
Financial Overview ---------- 93
Members of the External Evaluation Committee ---------- 94
JIRCAS Staff in FY 2023 ---------- 95
The Japanese Fiscal Year and Miscellaneous Data ---------- 98

Message from the President

President
Osamu Koyama
(FY2021-)

Pushing ahead towards sustainable agri-food system transformation

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 between 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 economic 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 the SDGs, to overcome various issues and form a sustainable society by 2030. Many activities are being developed to achieve the goals. In 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, for its part, also declared that it would aim to be carbon neutral by 2050, and so in the same year, it issued a policy approach called the "Strategy for Green Food Systems," aiming to enhance productivity potentials while ensuring the sustainability of agriculture, forestry, fisheries, and food industries through innovation. The Basic Law on Food, Agriculture, and Rural Areas, which is often called the constitution of Japan's agricultural policy, will also be revised in line with this direction for the first time in 25 years.

In parallel with the above, JIRCAS has maintained a solid and long-term corporate philosophy (JIRCAS Vision). It has consistently endeavored to solve food and environmental problems through research and development and made international contributions through science and technology. In April 2021, JIRCAS started the 5th Medium to Long-Term Plan based on the 5th Medium to Long-Term Target as instructed by the government, redefining 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, and to represent 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.

Following a difficult first two-year period in the implementation of the Fifth Medium to Long-Term Plan, which was heavily impacted by the Covid-19 pandemic, research activities at local sites in foreign countries mostly recovered in the third year, FY 2023, thanks to the easing of the pandemic. However, the global food and agriculture situation remained uncertain due to climate change events and conflicts in Ukraine and other regions. Under these circumstances, global food security concerns have been raised in various international fora. As an institution representing Japan, which depends on the international market for about 60% of its food on a calorie basis, JIRCAS had its role defined, and its mission of making an international contribution through science and technology innovation was highlighted further.

Several new research projects were initiated in FY 2023. The "TERRA Africa" project, which aims to establish regenerative agriculture suitable for Africa, was kicked off in Ghana under the overseas cooperation assistance program of the Nippon Foundation. Also, a research proposal on greenhouse gas emission reduction through paddy water management in Cambodia was selected as a new research project for the FY 2023 Science and Technology Research Partnership for Sustainable Development (SATREPS) program. The "Green Asia" project, which aims to promote the transformation towards sustainable food systems in the Asia-Monsoon region by sharing Japanese experience and technologies with areas in the region, continued its rigorous activities together with the Ministry of Agriculture, Forestry and Fisheries of Japan for the second year. Meanwhile, various research results achieved through continuing collaborations have been recognized by local institutions and the private sector for their potential contributions to both food security and sustainable, resilient food systems.

With a rich history of international joint research spanning more than 50 years, our strength lies 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 that you will continue to understand, support, and cooperate with the activities of JIRCAS. We also welcome your frank advice and questions.

June 2024

Osamu Koyama, President

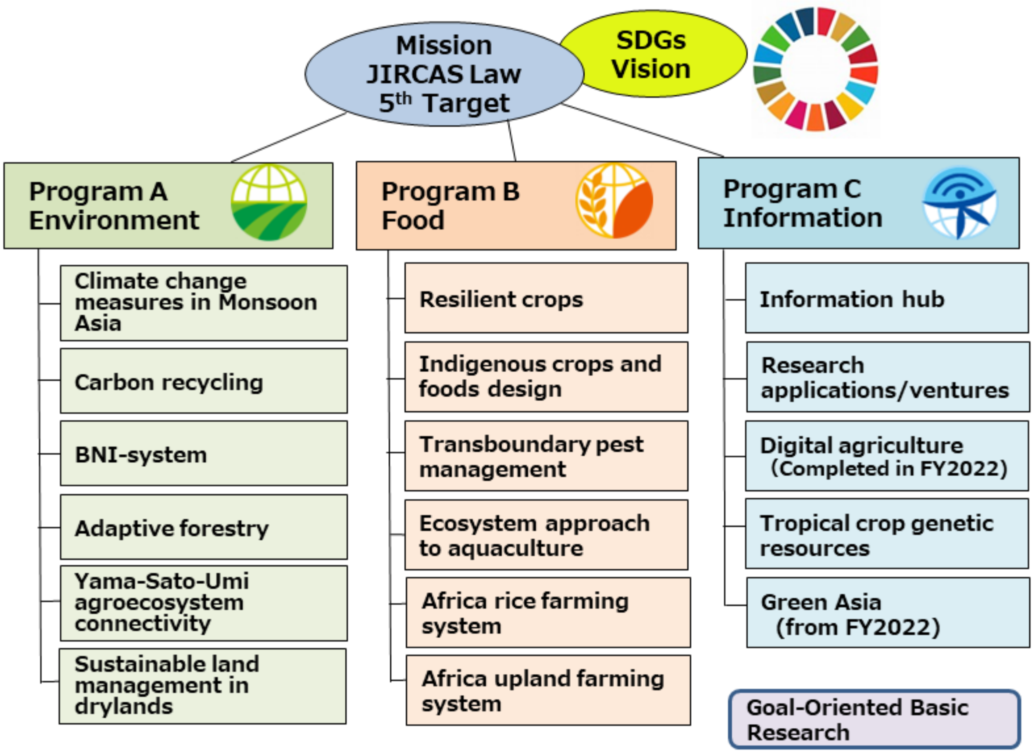


Fig. 1. Program-Project Research Framework (FY2021-2025)

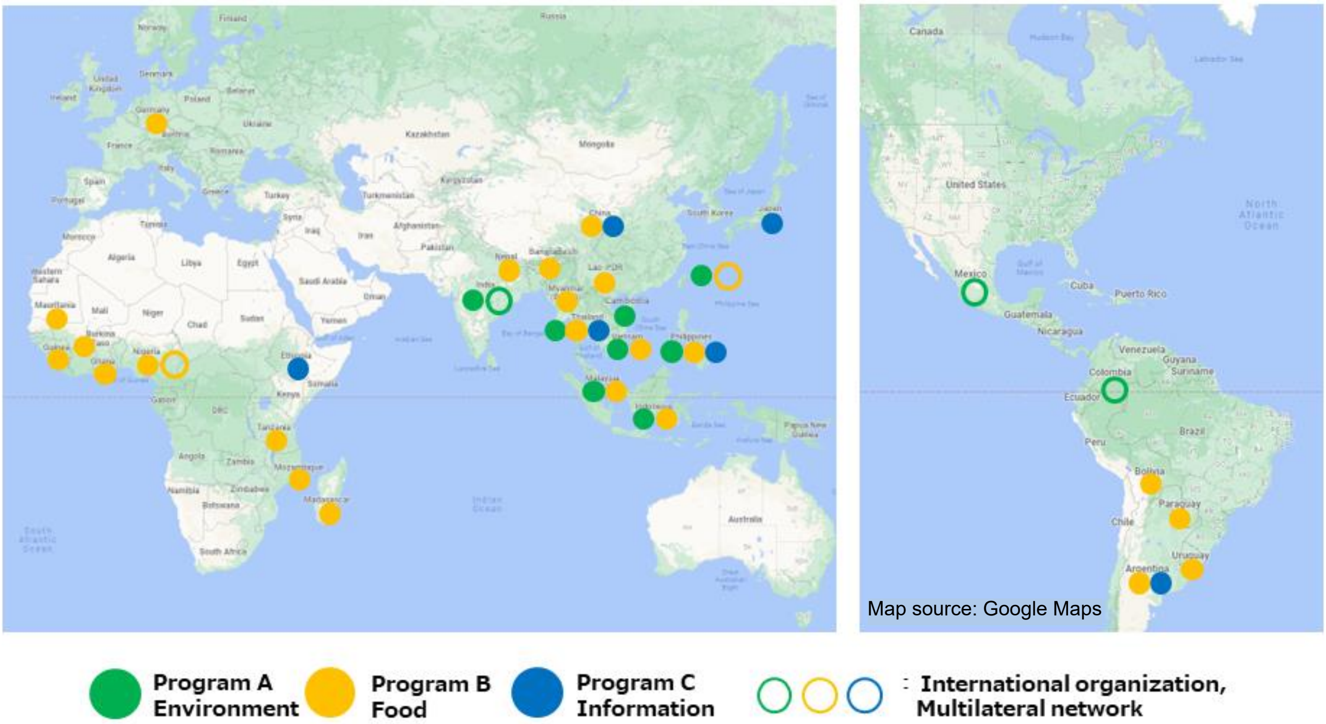


Fig. 2. Locations of activities in the 5th Medium to Long-Term Plan

Highlights from 2023

JIRCAS International Symposium 2023 Report

JIRCAS International Symposium 2023, themed "Innovations to enhance the resilience of tropical forests and sustainability of the forest industry," was held in hybrid format at the U Thant International Conference Hall of the United Nations University in Shibuya, Tokyo, on November 17, 2023. It was held under the auspices of the Ministry of Agriculture, Forestry and Fisheries (MAFF) and the Forestry and Forest Products Research Institute (FFPRI).

In the opening session, JIRCAS President Osamu Koyama stated that the symposium aims to present and discuss the opportunities and challenges of balancing tropical forest resilience and forest industry sustainability. He also mentioned the 50th anniversary of Japan-ASEAN Friendship and Cooperation and the 30th anniversary of JIRCAS's reorganization when the Forestry Division in JIRCAS was structured.

Mr. Zentaro Kosaka, Deputy Director-General of the Forestry Agency, MAFF, spoke on behalf of MAFF about JIRCAS's continued efforts and cooperation in research, technological development, and technical cooperation that contribute to sustainable forest management in tropical regions.

Dr. Tohru Nakashizuka, Director General of FFPRI, gave a welcome address and talked about the history of promoting forest research through the close cooperative relationship between FFPRI and JIRCAS. He also discussed the need to continue this cooperative relationship in order to develop joint research with forest and forestry researchers in tropical countries. Both speakers concluded their speeches with words of hope for the development of research and activities at JIRCAS for the conservation and sustainable use of tropical forests.

There were two keynote speeches. Prof. Kaoru Kitajima, Vice Dean of the Graduate School of Agriculture at Kyoto University, spoke on the topic of "Climate Change, Fire and Forest Resilience," and Dr. Sonya Dewi, Director of Asia Programme at the Center for International Forestry Research and World Agroforestry (CIFOR-ICRAF), spoke about her thoughts on "Global Policy Developments and Initiatives on Tropical Forests and Sustainable Industries."

Session 1, themed "Enhancing Resilience of Tropical Forest Landscapes and Trees" and chaired by Dr. Shoji Noguchi, Director of Forestry Division at JIRCAS, featured Dr. Wan Mohd Shukri Wan Ahmad, Director of the Forestry and Environment Division at Forest Research Institute Malaysia, (FRIM) with his presentation on "Sustainable Forest Management (SFM) and Conservation"; Dr. Naoki Tani, Senior Researcher in the Forestry Division at JIRCAS, with his presentation on "Enhancing Tropical Forest Resilience and Production through Tree Breeding Technology"; and Dr. Motoe Miyamoto, Team Leader in the Department of Forest Policy and Economics at FFPRI, with her presentation on "Deforestation Mechanisms and Sustainable Solutions." Through this session, the participants learned about activities and recommendations for realizing SFM.

Session 2, themed "Improving Industrial Sustainability of Tropical Timber/Non-timber Products" and chaired by Dr. Miyuki Iiyama, Program Director for Information at JIRCAS, featured Dr. Mohammad Na′iem, Professor in the Faculty of Forestry at Gadjah Mada University, with his presentation on "Contributions of Tree Improvement Program to Increase Forest Productivity and Achievement of Indonesian Nationally Determined Contributions (NDCs)"; Dr. Akihiko Kosugi, Project Leader in the Biological Resources and Post-harvest Division at JIRCAS, with his presentation on "Oil Palm Trunk - High Value Technology for Tropical Forest Conservation"; and Dr. Hiromitsu Samejima, Research Manager in the Biodiversity & Forests Area at the Institute for Global Environmental Strategies, Japan, with his presentation on the "Development of Timber and Oil Palm Industries in Southeast Asia and International Policy for Tropical Forest Conservation."

During the panel discussion moderated by Dr. Keiichi Hayashi, Program Director for Environment at JIRCAS, the panelists explored innovations to enhance the resilience of tropical forests and the sustainability of the forest industry and discussed the importance of collaboration between companies and the government, as well as the importance of providing scientific evidence for production sites and certification systems. Professor Kitajima commented on deforestation and the conservation of forest functions from a holistic perspective, confirming the need to consider governance. Dr. Shukri shared information on the role of research institutions in forest management in Malaysia and their contribution to national forest management. Dr. Miyamoto explained the relationship between poverty and deforestation, and the role of Japanese and international research institutions in implementing long-term policies to reduce poverty in developing countries. Dr. Dewi talked about the efforts of international organizations in global trends such as forest certification and the introduction of due diligence. Professor Na′iem presented the root causes and required initiatives to solve the problems related to sustainable forestry, which remain a challenge in Indonesia. Dr. Samejima also highlighted the role and importance of due diligence in conserving forest functionality and the need to ensure that smallholders are not excluded from the supply chain.

In her closing remarks, JIRCAS Vice-President Yukiyo Yamamoto thanked the speakers and participants and summarized the following points:

1. There is no doubt that the survival of human society will be threatened without systems and technologies to properly and sustainably manage the tropical forest resources that cover most of the Earth's land area.
2. In order to achieve this, stakeholders must be aware of the issues related to the compatibility of tropical forests and the forest industry, and use the systems and technologies appropriately.
3. The symposium has not only facilitated dialogue but also provided a valuable opportunity for sharing

essential information and knowledge in this regard.

She extended her special thanks to MAFF and FFPRI for their unwavering support in organizing this event. She also expressed her appreciation to all symposium participants, both on-site and online, as well as everyone involved in the planning and execution of this event for their valuable contributions and participation.

The event was attended by 101 participants on-site and 173 online viewers from 23 countries around the world, including Japan and Southeast Asian nations, demonstrating the high level of interest in the innovations to enhance the resilience of tropical forests and sustainability of the forest industry.

To those unable to attend the event, videos have been posted on the JIRCAS YouTube channel. (In the original language only, no Japanese-English interpretation provided.)

Commemorative photo

The 2023 (The 17th) Japan International Award for Young Agricultural Researchers and Commendation Ceremony

About the Japan Award

The Japan International Award for Young Agricultural Researchers (Japan Award), which began in 2007, is organized and presented by the Ministry of Agriculture, Forestry and Fisheries (MAFF) of Japan to honor young foreign researchers whose outstanding achievements promote research and development of agricultural, forestry, fishery and other related industries in developing regions.

Up to three young researchers under age 40 (as of January 1st, award year) who have shown (1) outstanding performance in research and development in agriculture, forestry, fisheries, or related industries in developing regions and (2) outstanding achievements in research and development that will lead to future technological innovation in agriculture, forestry, fisheries, or related industries in developing regions are invited yearly to Japan to receive certificates of commendation from the Chairman of the Agriculture, Forestry and Fisheries Research Council.

The 2023 (The 17th) Japan Award Ceremony Report

The 2023 (The 17th) Japan Award commendation ceremony was held on November 17 (Friday) in a hybrid format (online and in-person) at the U Thant International Conference Hall of the United Nations University in Tokyo.

On behalf of the organizers, Mr. Kazuyoshi Honkawa, Chairman of the Agriculture, Forestry and Fisheries Research Council (AFFRC) of the Ministry of Agriculture, Forestry and Fisheries, greeted the participants. Dr. Daisuke Kawakami, Deputy Director General for Science, Technology and Innovation of the Cabinet Office of Japan, and Mr. Osamu Kubota, Vice President of the Japan International Cooperation Agency (JICA), gave congratulatory remarks, followed by Dr. Mutsuo Iwamoto, Chairperson of the Selection Committee, who explained the screening process. The certificates of commendation (Chairman's Award) were presented by AFFRC Chairman Honkawa, and the cash incentives (MOTAI-JIRCAS Award) were given by Mr. Osamu Koyama, President of JIRCAS. The 2021 (The 15th) Japan Award winners, who were unable to personally receive their prizes due to the COVID-19 pandemic, were in attendance at the award ceremony.

There was a brief photo session after the ceremony, followed by commemorative lectures of their research achievements by the 2023 winners and a welcome lunch reception to celebrate the event.

The 2023 (The 17th) Japan Award Winners (*Ages are as of January 1, 2023.)

Khalisanni KHALID
(37 years old, Male, Malaysian)
Professional Affiliation: Malaysian Agricultural Research and Development Institute (MARDI)

Research Achievement: Development of Nanofertilizer Using Flexible Nanoparticle Catalysis Technology

Reason for the Award

The awardee made it possible to produce nanofertilizers inexpensively by using flexible nanoparticle catalyst technology, which can reduce the size of colloidal aggregates of conventional fertilizers to nano-size. The developed nanofertilizer has features that can enhance the characteristics of foliar application fertilizer, improve crop productivity, and reduce the amount of fertilizer applied. This technology has already been commercialized and popularized, and the research has been evaluated for its potential for future development in the context of the need for effective utilization of resources.

Avijit GHOSH
(30 years old, Male, Indian)
Professional Affiliation: ICAR-Indian Grassland and Fodder Research Institute (IGFRI)

Research Achievement: Development and Evaluation of Ecofriendly Soil Health Management Strategies for Semi-arid and Sub-humid Region of India

Reason for the Award

The awardee examined the impact of climate change on soil carbon storage by analyzing the thermal and hydrothermal sensitivity of soil organic carbon decomposition in India, and estimating the carbon sequestration capacity of deep soils. In addition, efforts were made to contribute to the coexistence of agricultural production and environmental conservation, such as using rice straw as a natural source of silicon to solubilize native soil phosphorus in order to prevent the incineration of a large amount of rice straw, which is considered to be one of the causes of severe air pollution in India. These research studies have been evaluated for its originality in enabling sustainable land management based on local agricultural methods from a broad perspective.

Martin Paul Jr. TABE-OJONG
(30 years old, Male, Cameroonian)
Professional Affiliation: International Food Policy Research Institute (IFPRI)

Research Achievement: Improving Smallholder Commercialization and Reducing Poverty through the Adoption of Improved Crop Varieties in Africa

Reason for the Award

The awardee demonstrated that the introduction of drought-tolerant legume varieties with high protein content and potential for soil fertility through nitrogen-fixing functions can improve agricultural production and nutrition for smallholder farmers, as well as their farming activities through commercialization, with the goal of transforming existing grain-based agricultural activities in West Africa. The research has been evaluated as a development economics study that provided a model for agricultural innovation among smallholder farmers in West Africa.

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. Memorandums of Understanding (MOUs) have been signed between JIRCAS and its research partners, both domestic and abroad, to implement long-term research collaborations. In FY 2023, JIRCAS implemented considerably more joint research activities than in FY 2022. For example, JIRCAS renewed an MOU with the Food and Agriculture Organization of the United Nations (FAO) to gather and share information on global issues such as food security, undernourishment, and environmental resource management. In recent years, the FAO has selectively engaged with contracting parties to sign MOUs. The extension of the MOU means that the FAO considers JIRCAS as an important partner.

As of March 2024, the number of active MOUs was 148. Based on the work plans elaborated in the respective MOUs, JIRCAS carried out joint research projects with 79 research institutions in 28 countries.

Together with domestic partners, JIRCAS carried out 116 joint research activities in total: 13 with national research and development agencies under the Ministry of Agriculture, Forestry and Fisheries, 9 with independent entities, 9 with public research institutions, 66 with universities, and 16 with private companies. Some of the private companies contributed to the financing of research activities implemented by JIRCAS (worth 13 million JPY).

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 5th 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. 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

Lysimeter experiments at TARF showed that the optimized subsurface irrigation system (OPSIS) supplied sufficient water to the sugarcane root zone and saved irrigation water, and that the experiments confirmed increased sugarcane yields in new plantings (Photo 1). Pipe tests with crop plants conducted in a glasshouse at TARF confirmed the effect of biochar application on nitrate nitrogen (NO_3-N) leaching and crop growth. The effect of sugarcane residue application on crop growth and the potential for reducing chemical fertilizer application on fields with acidic and basic soils at TARF were determined. The determinants of above-ground biomass were elucidated from analyzing mangrove forest structure in Miyara River, Ishigaki Island. Water purification capacity in Ishigaki Island was estimated by surveying "sea lettuce" abundance in the coastal area and through laboratory experiments of nitrogen uptake. Nitrogen load reduction and reduction of chemical fertilizer application were estimated by considering fertilizer management techniques in the calculation of the nitrogen footprint for Ishigaki Island. It was shown that when the amount of basal fertilizer was halved, the nitrogen load and chemical fertilizer input for the entire island were reduced by 3.6% and 5.3%, respectively.

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

We have been conducting genetic and breeding studies to improve rice varieties in tropical countries. One of our main objectives is to enhance rice productivity under unfavorable conditions such as less fertile soils. We have also been developing breeding materials resistant to rice blast disease to reduce pesticide application. Breeding lines with durable blast resistance have been developed through DNA marker selection. These developed breeding lines are shared with national agricultural research institutes in tropical Asian countries such as Bangladesh, Philippines, Vietnam, Indonesia, and Laos through international collaborations (Photo 2). We are also working to improve rice varieties by applying genome editing technologies that can introduce genetic mutations accurately.

Sugarcane research at TARF enables the establishment of essential information and technologies for the effective use of sugarcane-related wild 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* as important genetic resources for sugarcane improvement. A database consisting of 150 accessions of *Erianthus* genetic resources native to Thailand was developed (https://www.jircas.go.jp/ja/database/erianthus), and agronomic data were collected from the second ratoon crop of about 500 accessions of Japanese *S. spontaneum* for database development. Moreover, we are working to develop new breeding materials using wild genetic resources and evaluation methods to select breeding materials that improve sugarcane stress tolerance. In Thailand, the sugarcane variety TPJ04-768, which was developed by interspecific hybridization using wild sugarcane (*S. spontaneum*) under the collaboration between JIRCAS and the Khon Kaen Field Crops Research Center, has been officially named "DOA Khon Kaen 4 (KK4)" and approved as a recommended variety by the Thai government. KK4 produces approximately 1.5 times more bagasse due to its higher fiber content while maintaining a similar sugar yield compared with the currently dominant sugarcane variety KK3 (Photo 3). The commercial use of KK4 promises to increase bioenergy production using bagasse without competing with food production.

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 measures for the warming climate in passion fruit production, the characterization of leaf photosynthesis at high temperatures among various genetic resources of passion fruit was carried out.

Several integrated research activities focusing on a plant factory are being conducted at TARF. The aim of the research activities is to develop technologies for stable year-round production of tomatoes and strawberries in tropical/subtropical regions through collaboration with private companies and the National Agriculture and Food Research Organization (NARO). Research studies are being conducted in collaboration with private companies to boost tomato cultivation in summer and increase strawberry production in subtropical regions (Photo 4). Another activity is the 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.

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 570 accessions of sugarcane and its relatives, 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. In collaboration with NARO and the Okinawa Prefectural Agricultural Research Center, 301 crossing fuzz with 108 combinations were obtained and provided to the domestic breeding program. Furthermore, 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 3rd and 4th selections in the domestic sugarcane breeding programs of NARO and the Okinawa Prefectural Agricultural Research Center.

Photo 1. Lysimeter experiments using OPSIS for sugarcane cultivation at TARF

Photo 2. Characterization of the developed rice breeding lines in a collaborating country

Photo 3. Growth of KK4 at a lower-yielding field in Thailand

Photo 4. Strawberry cultivation using LED lighting and an environmental control system in summer at TARF

Academic Prizes and Awards

Researcher Muraoka and Colleagues Win Best Paper Award at the 11th ASAE International Conference

Dr. Rie Muraoka (Researcher, Social Sciences Division) and her colleagues won the Best Paper Award (3rd Prize) for their research entitled "Sustainable Intensification of Maize Farming in Kenya: Evidence from a Longitudinal Smallholder Survey" presented at the 11th International Conference of the Asian Society of Agricultural Economics (ASAE) held at Aoyama Gakuin University in Tokyo on March 18-20, 2023.

In this paper, the authors empirically analyzed the relationship between land productivity and the determinants of adoption of technologies and methods* that have recently begun to be adopted in densely populated areas of Kenya. The results showed that population pressure on land promotes the adoption of sustainable intensive agriculture and that the adoption of intensive agriculture increases land productivity.

The study showed that promoting sustainable intensive agriculture with the right mix of agricultural inputs available to farmers has the potential to significantly increase food productivity in Africa.

*Sustainable intensive agriculture through the use of high-yielding hybrid maize, chemical fertilizers, organic fertilizers, and mixed cropping of maize and legumes

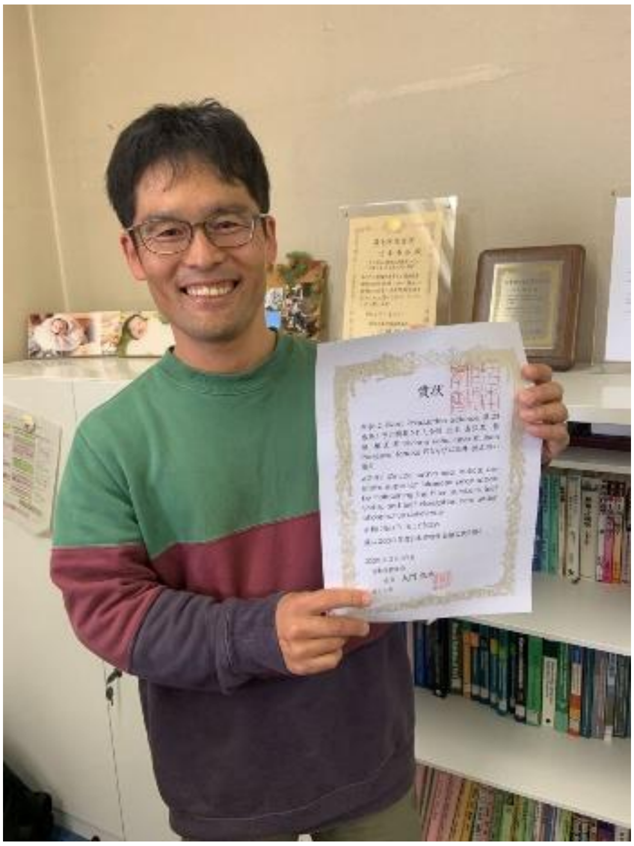
Dr. Rie Muraoka

Project Leader Tsujimoto and Colleagues Win Japanese Society of Crop Science Best Paper Award

Dr. Yasuhiro Tsujimoto, Project Leader of the "Africa Rice Farming System" project, and colleagues from the Crop, Livestock and Environment Division received the 20th Japanese Society of Crop Science Best Paper Award for the paper titled "AZ-97 (*Oryza sativa* ssp. *Indica*) exhibits superior biomass production by maintaining the tiller numbers, leaf width, and leaf elongation rate under phosphorus deficiency."

This award is given to members of the Crop Science Society of Japan who published outstanding papers in the journal *Plant Production Science*. In this paper, Dr. Tsujimoto and colleagues evaluated the morphological characteristics of indica rice AZ-97, which exhibits high performance under highly P-deficient fields in Madagascar, and found that this rice genotype maintained high biomass by increasing tiller number and leaf width even under phosphorus deficiency conditions. Phosphorus-deficient soil is one of the major factors hindering crop production in Madagascar and other tropical countries. The findings of this study are expected to be useful for rice breeding to improve productivity under such phosphorus-deficient conditions.

Yasuhiro Tsujimoto, Mitsukazu Sakata, Viviane Raharinivo, Juan Pariasca Tanaka, Toshiyuki Takai (2021) AZ-97 (*Oryza sativa* ssp. *Indica*) exhibits superior biomass production by maintaining the tiller numbers, leaf width, and leaf elongation rate under phosphorus deficiency.
https://doi.org/10.1080/1343943X.2020.1808026



Dr. Yasuhiro Tsujimoto

Three TARF Staff Members Receive MEXT Award for Creativity

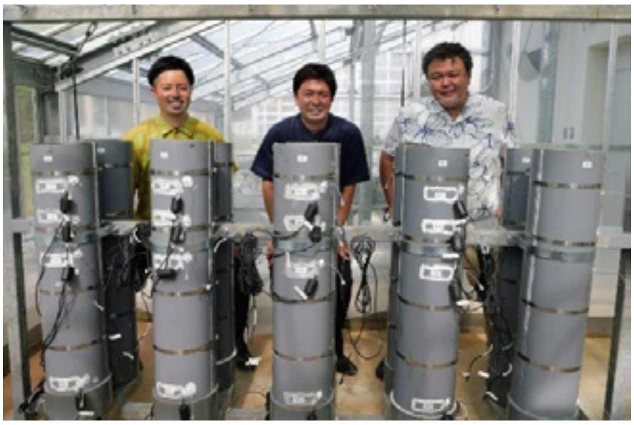
Each year, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) awards the "Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology" to individuals who have made outstanding achievements in research and development and in promoting the understanding of science and technology.

On April 7, 2023, three staff members of the JIRCAS Tropical Agriculture Research Front (TARF) Technical Support Office, namely, Yasuteru Shikina, Masahide Maetsu, and Yuto Hateruma, received the Award for Creativity for their achievement entitled "Invention of a low-cost observation system for solute dynamics in soil." The award is given to those who have contributed to the advancement of technology in their fields through outstanding originality and ingenuity.

The JIRCAS "Yama-Sato-Umi Agroecosystem Connectivity" project is conducting research on the movement of nitrogen in soil with the aim of reducing the environmental burden. Column tests (using cylinders) have been conducted to reproduce agricultural soils, but the conventional method does not allow reuse of cylinders, and retesting requires cost and preparation time. The newly developed system allows both reuse of cylinders and reduction of preparation time (8% of the conventional method), and also allows installation of sensors, which has been difficult in the past.

This achievement is expected to enable more accurate testing and accelerate technology development. JIRCAS will continue to use this system to develop technologies that reduce environmental load.

The three TARF awardees with Director Omae (leftmost)



The developed system for testing

Rural Development Division Director Shindo Receives 2023 JAICABE Fellow Award

On May 13, 2023, Dr. Soji Shindo, Director of Rural Development Division, received the 2023 Japan Association of International Commission of Agricultural and Biosystems Engineering (JAICABE) Fellow Award.

Agricultural engineering is the study of engineering technologies related to agricultural production, including infrastructure, operations, mechanization, and environmental improvement. JAICABE consists of 10 academic societies, including the Japan Society for Bio-Environmental Engineering, the Japanese Society of Agricultural, Biological and Environmental Engineers and Scientists, the Society of Agricultural Meteorology of Japan, the Society of Agricultural Structures Japan, the Japanese Society of Irrigation, Drainage and Rural Engineering, the Japanese Society for Agricultural Informatics, etc.

For FY2023, JAICABE presented the Fellow Award to 23 individuals who have made significant academic and technological developments and ongoing achievements related to agricultural engineering.

Dr. Shindo's achievements include his long-standing efforts to solve agricultural water management problems in developing regions and the International Contribution Award he received in 2013 from the Japan Society of Irrigation, Drainage and Rural Engineering (JSIDRE) for a series of reports on agricultural water policy trends in Egypt and his work on a project to strengthen water user associations. The committee also recognized his contributions to the International Society of Paddy and Water Environment Engineering (PAWEES), an international academic society for the advancement and dissemination of scientific knowledge and technology of paddy-related disciplines with a scope of land, water, and environment.

Dr. Soji Shindo

Project Leader Wilder Receives 2023 Japan Prize of Agricultural Science/ Yomiuri Prize of Agricultural Science

Dr. Marcy Wilder, Project Leader in the Fisheries Division, received the "2023 Japan Prize of Agricultural Science/Yomiuri Prize of Agricultural Science" and delivered a commemorative lecture at the award ceremony on April 5, 2023. This award is overseen by the Association of Japanese Agricultural Scientific Societies

Dr. Wilder has been engaged in basic research on the mechanisms of shrimp reproduction, molting, and osmoregulation with the aim of contributing to a stable shrimp aquaculture industry. The results of this research have already been applied and commercialized to realize recirculating land-based shrimp production that does not impact the natural environment. Dr. Wilder's significant achievements in both the development of Japan's fisheries industry and international contributions have led to the awarding of this prize.

At the award ceremony held at the University of Tokyo's Yayoi Auditorium, Dr. Wilder delivered a commemorative lecture entitled "Physiological and biochemical studies on commercially-important shrimp species and applications to the development of new aquaculture technology." Dr. Wilder, a native of the U.S., first came to Japan on a university orchestra tour to participate in the Tsukuba Expo'85, where she developed a connection with Japan. After receiving her doctoral degree in 1993, Dr. Wilder began her career at JIRCAS in 1994, where she has been a pioneer in the development and implementation of shrimp culture technology.

During the panel discussion with the other six awardees, Dr. Wilder emphasized the importance of agriculture, forestry, and fisheries research and encouraged young researchers, including women, to become more active in STEM - Science, Technology, Engineering, and Mathematics.

Award information (link in Japanese): http://www.ajass.jp/30_10.html

Dr. Marcy Wilder

Senior Researcher Kashiwa Receives "Young Scientist Award" at World Soybean Research Conference

Dr. Takeshi Kashiwa (Senior Researcher, Biological Resources and Post-harvest Division) received the "Young Scientist Award" at the World Soybean Research Conference 11 (WSRC11) held in Vienna, Austria, on June 18-23, 2023, for his presentation on "Genome analysis of the pathogen causing Cercospora leaf blight and purple seed stain of soybean."

This award is given to the presenter of an outstanding presentation at WSRC11, covering a broad range of soybean research, and is specifically intended for researchers 35 years old or younger. In this presentation, Dr. Kashiwa and his colleague reported a detailed genomic analysis and characterization of the pathogen that causes Cercospora leaf blight and purple seed stain in soybean, which are problems in soybean production worldwide. The results of this study are expected to provide basic molecular biological information for research on soybean fungal pathogens, including *Cercospora* spp.

Conference Information : https://www.wsrc11vienna.com/
Award Information : https://www.wsrc11vienna.com/abstract-submission/young-scientist-award/

Dr. Takeshi Kashiwa

Rural Development Division Director Shindo Receives 2023 PAWEES International Award

Dr. Soji Shindo, Director of the Rural Development Division of JIRCAS, was honored with the prestigious International Award of the International Society of Paddy and Water Environment (PAWEES) during the International Conference 2023 held in Busan, Korea, on October 23-25, 2023.

The International Award is presented to individuals who have made outstanding contributions to the advancement of paddy and water environment engineering. Dr. Shindo, who has served as the Managing Editor of *Paddy and Water Environment*, an esteemed academic journal published by the Society since 2020, has played a pivotal role in enhancing the editorial quality of the journal. His noteworthy contributions have been further acknowledged with this award, attributing his expertise and dedication to the editorial work of the journal. In addition to his ongoing editorial efforts, this recognition also stems from his powerful keynote speech on "Climate Change Countermeasures in Rice Paddy Agriculture" delivered at the PAWEES 2021 Taiwan Congress in October 2021. Dr. Shindo's insightful guidelines provided valuable insights for various countries and regions dealing with climate change concerns in rice paddy agriculture.

In addition, Dr. Naoki Horikawa, former Senior Researcher in the Rural Development Division, received the Reviewer Award (Maruyama Prize), which is given to reviewers who have made special contributions to maintaining and improving the quality of the journal *Paddy and Water Environment*.

PAWEES 2023: https://pawees2023.com/
International Award: https://pawees.net/?page_id=35
Reviewer Award: https://pawees.net/?page_id=39

Dr. Soji Shindo

Researcher Iwasaki Receives JSSSPN Best Oral Presentation Award for Young Scientist

Dr. Shinya Iwasaki, Researcher in the Rural Development Division, received the Best Oral Presentation Award for Young Scientists at the annual meeting of the Japanese Society of Soil Science and Plant Nutrition (JSSSPN) held at Ehime University on September 12-14, 2023. The winning presentation was for his research entitled "Effect of tillage method and manure management on soil carbon and physicochemical properties in corn fields in Central Thailand" (Co-authors: Tancharoen Somrutai, Luanmanee Suphakarn, Nobuntou Wanida, and Naruo Matsumoto).

Soil carbon sequestration has attracted attention as a climate change mitigation measure, sequestering atmospheric carbon dioxide in the soil. In the tropics, where low-fertility soils are widespread, soil carbon sequestration is essential for establishing sustainable agriculture because it improves soil fertility and contributes to stable and improved crop yields.

In his award-winning research, Dr. Iwasaki clarified the effects of soil carbon sequestration and crop yield in tropical soils through a combination of tillage/no-tillage, chemical fertilizer application, and organic matter application, and presented a fertilizer management method to maximize soil carbon sequestration.

- List of awardees for the JSSSPN Best Poster Presentation and Best Oral Presentation for Young Scientists
  https://jssspn.jp/info/secretariat/post-250.html

Dr. Shinya Iwasaki

Project Leader Izumi Receives Certificate of Appreciation from Can Tho University, Vietnam

Dr. Taro Izumi, Project Leader of the "Climate Change Measures in Monsoon Asia" project, was honored by Can Tho University (CTU), Vietnam, for his longstanding collaborative research contributions. CTU Vice-President Nguyen Hieu Trung, on behalf of President Ha Thanh Toan, presented the certificate of appreciation at a special ceremony on November 30, 2023.

Dr. Izumi, who began collaborating with CTU in 2008 on climate change adaptation in the agricultural sector, has been leading the joint implementation of the aforementioned climate change project since 2021.

Besides his remarkable research achievements, Dr. Izumi was also recognized by CTU for his contributions to human resource development and for his key role as a liaison between the Japanese private sector and the university.

Commemorative photo

Senior Researcher Sarr and Colleagues Receive Best Presentation Award for Applied Research at SAT Technology Showcase 2024

Dr. Papa Saliou Sarr (Senior Researcher, Crop, Livestock and Environment Division) and his colleagues were awarded the Best Presentation Award for Applied Research for their outstanding research results presented at the SAT Technology Showcase 2024 hosted by the Science Academy of Tsukuba (SAT) on January 25, 2024.

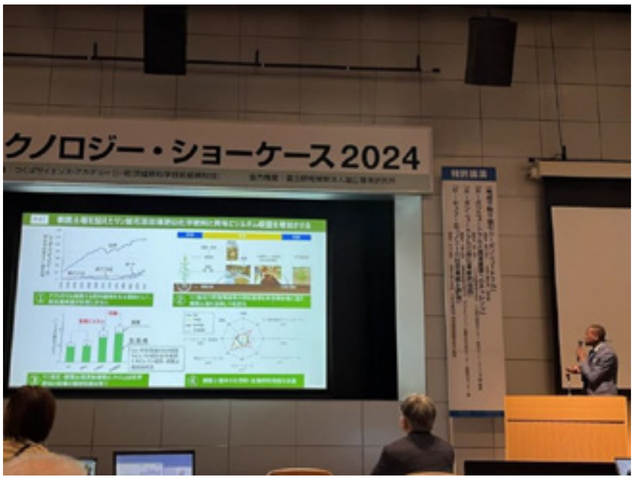
Since 2001, SAT has organized the annual "Technology Showcase" as a platform for interdisciplinary exchange of ideas and technologies among researchers and engineers from Tsukuba City and the Tokyo metropolitan area. This year's event, held at the Tsukuba International Congress Center, featured 93 research presentations from students and public research institutions, including poster displays, one-minute indexing presentations, and a special symposium.

Dr. Sarr presented the research entitled "Phosphate rock-enriched compost with rhizosphere soil increases sorghum yield equivalently to chemical fertilizers," which was conducted in collaboration with Project Leader Satoshi Nakamura, Dr. Shinya Iwasaki, and researchers from the National Institute of Environment and Agricultural Research (INERA), Burkina Faso, under the JICA-JST and SATREPS project "Establishment of the model for fertilizing cultivation promotion using Burkina Faso phosphate rock."

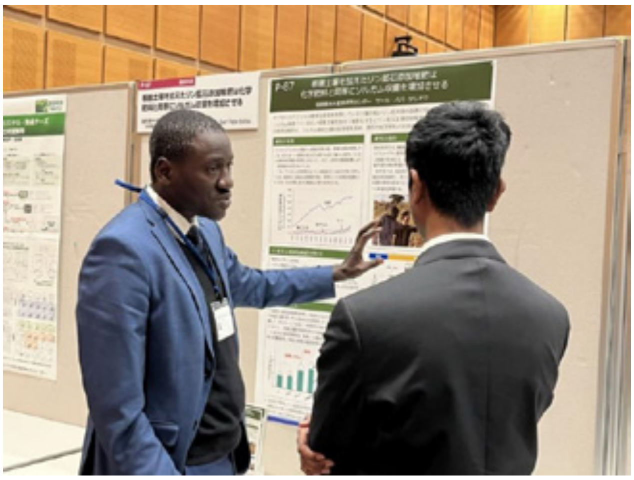
In recognition of the groundbreaking application of the research to industrial technology, the participants voted to award Dr. Sarr and his colleagues the "Best Presentation Award for Applied Research." This award highlights the advanced nature of their work in addressing the challenges associated with the rising cost of chemical fertilizers.

The phosphate rock-enriched compost developed by Dr. Sarr and his team provides a sustainable alternative to chemical fertilizers, which have become increasingly scarce due to recent price increases, by incorporating phosphate rock and rhizosphere soil into sorghum residue. This innovative approach not only improves the biological properties of soils, but also achieves sorghum yields comparable to chemical fertilizers. Importantly, the materials used are locally available, making it a promising new organic fertilizer for improving soil fertility in sub-Saharan Africa.

October 20, 2022 Press Release
Development of Organic Fertilizer Production Technology Using Low-Grade Phosphate Rock



Indexing presentation



Poster presentation and explanation to participants

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 2023 as follows:

1) Research activities for each Research Project were reported in January 2024.
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 2024.
3) A meeting to promote research cooperation in international agriculture, forestry and fisheries was held in late February 2024. The research activities of JIRCAS were reported to government officials from MAFF and specialists from other research institutes under MAFF and from Japan International Cooperation Agency, 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 2024.

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 2024.

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 2023 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)	5

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. Development of soil and crop management technologies to stabilize upland farming systems of African smallholder farmers

■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 (Completed in FY2022)
4. Advancement of tropical crop genetic resources utilization through the development of database, technologies and research networking
5. Accelerating application of agricultural technologies which enhance production potentials and ensure sustainable food systems in the Asia-Monsoon region

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 148 MOUs and JRAs remained in force at the end of FY 2023.

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.

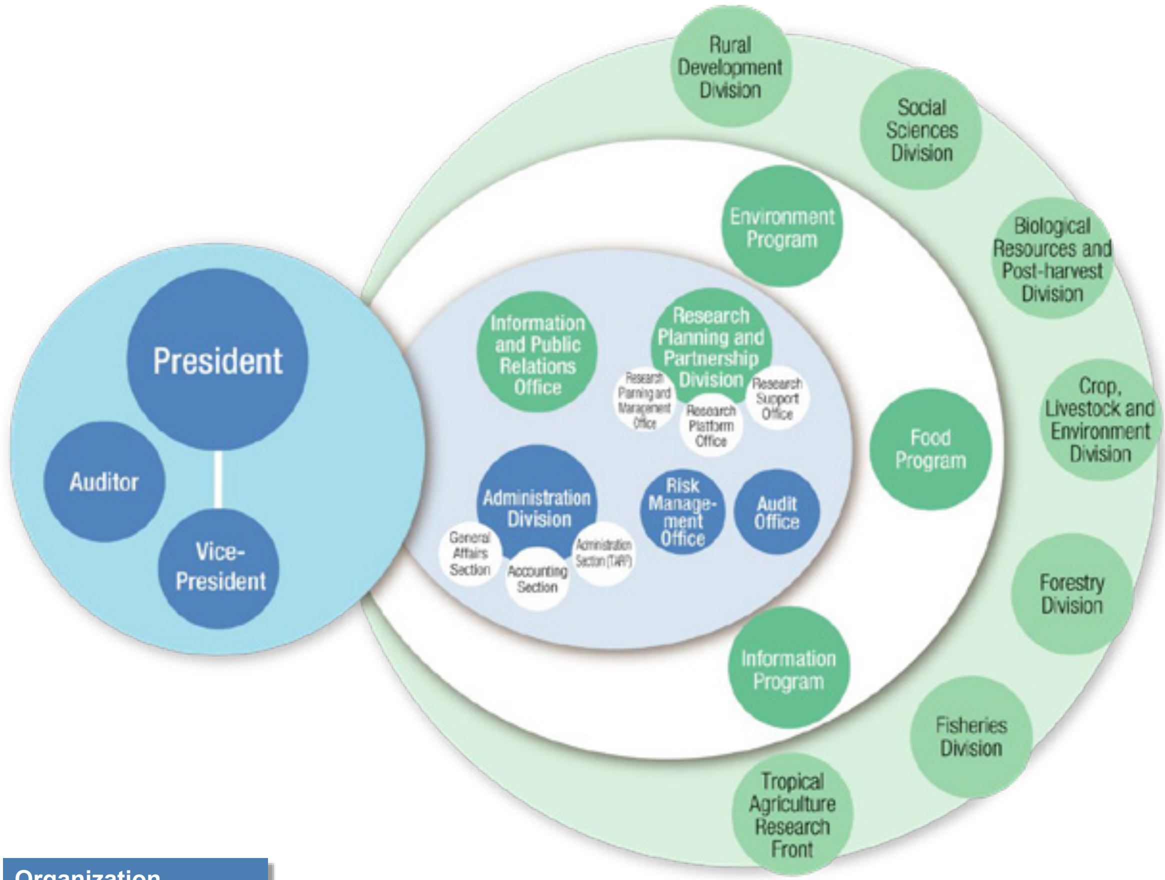
7. Organization of JIRCAS

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]

We used a satellite altimeter and synthetic-aperture radar (SAR) images to monitor flood conditions in Cambodia. Our findings confirmed that floods caused extensive damage in floodplains where paddy rice farming is the main activity, and demonstrated the importance of cultivation management to avoid flooding periods. Our research also confirmed that intermittent irrigation can maintain rice yields comparable to those from continuous flooding. A prototype of a water use management model was developed based on the research results obtained from the Inbanuma survey. We integrated the results of a long-term field experiment in Thailand and demonstrated that the greatest soil carbon storage occurs through a combination of no-tillage and composting, and that improvement of productivity through soil carbon storage with non-tillage is possible. Our findings in the Philippines demonstrate a positive correlation between the carbon use efficiency of soil microbes and the relative abundance of *K*-strategist bacteria, which increases with higher dissolved organic nitrogen and carbon (DON, DOC) levels, suggesting that the application of organic materials that increase DOC and DON is effective for soil carbon sequestration. In vitro trials were initiated in the field for the introduction of cashew nut shell liquid (CNSL) into U.S. herds in collaboration with the Agricultural Research Service of the U.S. Department of Agriculture through a U.S.-Japan bilateral program. We initiated a platform to facilitate effective communication with participating organizations, such as companies, universities, and research institutes that are interested in Joint Crediting Mechanism (JCM) in the agricultural sector. We continued our active cooperation and information dissemination activities with international organizations and the administrative departments of the Ministry of Agriculture, Forestry and Fisheries. Furthermore, we attended the Global Research Alliance-Livestock Research Group (GRA-LRG) annual meeting to demonstrate our country's presence and provided feedback to a Japanese livestock research society through organizing an annual meeting to build consensus and cooperation toward global scale challenges.

[Carbon recycling]

Preliminary results have demonstrated that the application of saccharification bacteria to the soil improves phosphorous solubilization and nitrogen fixation capacity, thereby promoting plant growth. We selected algal strains and optimized the culture method to improve cell density and lipid content of microalgae. We used 16SrRNA gene sequences to identify strains capable of growing in the presence of methane and accumulating high concentrations of polyhydroxybutyrate (PHB). We measured soil GHG fluxes (CO_2, CH_4, and N_2O) in Malaysian palm plantations to show that high GHG emissions to the atmosphere are caused by termite activity and fertilizer application, and to indicate that the decomposition of oil palm residue may be partly responsible for this emission. Furthermore, we discovered a thermophilic anaerobic bacterium, a new species and new genus, which efficiently saccharifies xylan, and developed a co-cultivation method with *Clostridium thermocellum* to boost saccharification performance a few times higher than the sole cultivation method. In addition, we worked closely with a private company to implement our research results for social implementation through a JIRCAS venture company, including the application of research results to a pellet production plant currently under construction in Sarawak, Malaysia, and the operation of a biogas production plant using the technology for highly efficient saccharification of barley lees (intellectual property acquired in FY 2021). We worked for the social implementation of the developed technology through information dissemination to the director general of the Malaysian Oil Palm Board (MOPB) and the undersecretary of the Ministry of Plantation Commodities of Malaysia, which is the competent authority of MOPB and the overseer of the palm oil industry.

[BNI-system]

The multi-location trial in the states of Punjab, Madhya Pradesh, and Bihar, India, using Biological Nitrification Inhibition (BNI)-enabled wheat lines from CIMMYT international varieties such as BNI-Munal and BNI-Borlaug 100 as parent lines, was conducted successfully. Results showed that the BNI-enabled lines with Lr#N-SA performed well under low nitrogen conditions, even in relatively high pH fields that are expected to have less BNI-effect due to the nature of Lr#N-SA. Backcrossing to introduce Lr#N-SA into elite Indian wheat varieties is ongoing, and the BC2F2 population is currently being obtained. A foundation for the next-generation BNI-enabled wheat, using *Leymus mollis*, was established, and a line with a chromosome addition of *L. mollis* was found to be BNI active. Genome-wide association studies (GWAS) for zeanone (a hydrophobic compound with BNI activity) were performed, and the candidate loci for BNI were obtained. A doubled haploid population comprising high- and low-BNI maize lines from CIMMYT maize lines (CMLs) was prepared to analyze BNI-related candidate genes. On-farm field trials were initiated at the Tropical Agriculture Research Front (TARF) to determine the residual BNI effect of *Brachiaria humidicola* when used as a rotation crop with maize. The aim is to develop a BNI modification of the denitrification-decomposition (DNDC) model for the possible *Brachiaria*-maize rotations. At the Centro International de Agricultura Tropical (CIAT), our 20-year-long *Brachiaria humidicola* field trial found a low level of soil nitrate and a continuous effect of BNI in the soil. An ex-ante analysis of the introduction of a possible BNI-enabled sorghum in India showed that the reduction in nitrogen application and consequently LC-GHG emission was lower in the dry season than in the rainy season, despite the introduction of the BNI-enabled sorghum with 30% of soil nitrification inhibition. This indicated the importance of cropping pattern and post-harvest treatment of rainy-season crops. In addition, the identification of the hydrophilic BNI compound “MBOA” from maize was included in the FY 2023 Research Highlights publication and selected as a press release by JIRCAS. JIRCAS spearheaded the introduction of the BNI trait into Japanese elite wheat, in collaboration with national research institutions and with MAFF’s support as part of the “Development of New Varieties for Enhancing Food Security” project under the FY 2022 Supplementary Budget. We also continued our activities under the “Green Asia” project to accelerate the social dissemination of BNI-enabled wheat in Nepal. We also organized a joint coordination committee and a joint technical committee for the “SATREPS BNI-Wheat” project in India. BNI-enabled wheat technology was presented at the G7 Miyazaki Agriculture Ministers Meeting, and we actively contributed in introducing BNI-enabled wheat to G7 agriculture ministers, government officials, and international organizations. We also contributed to the 15th Research Dialogue of the Bonn Climate Change Conference of the UN Framework Convention on Climate Change (UNFCCC), the G20 Technical Workshop in Hyderabad, India, and the 28th Climate Change Conference of the UNFCCC in Dubai, UAE. As a result of these efforts, we have been able to accelerate BNI research and establish an international collaboration on BNI-enabled wheat with the Julius Kühn Institute, Germany, and others. In addition, the Novo Nordisk Foundation, one of the world’s largest philanthropic foundations, is paying attention to BNI-wheat and other crop technologies for further funding opportunities.

[Adaptive forestry]

We conducted a drought experiment with seedlings of four dipterocarp species, which are major timber species in tropical forests. Our study revealed that the soil moisture content at which photosynthetic activity declines to 10% of its maximum was related to leaf-level resistance to wilting. In addition, we were able to estimate temporal and spatial differences in growth based on long-term and site-specific temperature data by using the relationship between temperature and gene expression in two mangrove species (*Kandelia obovata* and *Rhizophora stylosa*) with different temperature responses. For the Dipterocarpaceae, a major timber species from Southeast Asian tropical rainforests, we developed a genomic selection model to predict growth based on genomic information and established a method to select the next generation without evaluation using progeny trials. We measured diameter growth, survival rate, diameter/height relationship, and canopy size for three dipterocarp tree species after 31 years of planting in the Chikus Forest Reserve, Malaysia. We reconstructed a growth prediction model to evaluate growth and mortality of planted trees and different planting methods. We observed soil carbon flux using portable chamber systems in *Shorea leprosula* and *Neobalanocarpus heimii* plantations in the Chikus Forest Reserve and found that soil CO_2 release and soil CH_4 uptake were significantly greater in *N. heimii* plantations than in *S. leprosula* plantations. We completed plant sampling and correction of genotypic data for Indonesian teak, which is one of the four selected tree species. This was done in consultation with key counterpart institutions, allowing us to determine the genetic structure and environmental adaptive genetic variation across the entire natural distribution of teak. In addition, our research revealed that hybrid seedlings between *S. leprosula* and *S. curtisii* from the Dipterocarpaceae family can grow faster than *S. curtisii* and are more drought-tolerant than *S. leprosula*. This finding was published in the FY 2023 Research Highlights. Furthermore, we presented the results of the project’s research on tropical forest resilience at the JIRCAS International Symposium 2023 and organized an international seminar on clonal teak forestry. In collaboration with the Forestry and Forest Products Research Institute and related universities in Japan, we worked towards advancing the social implementation of research results through a research proposal to a large external funding source. This proposal aims to assess the contribution of mangroves, which are important tree species in tropical ecosystems and have captured global interest due to their potential to mitigate greenhouse gas emissions.

[Yama-Sato-Umi agroecosystem connectivity]

We demonstrated the combined effect of tropical fruit trees and mushroom logs, revealing that shading from fast-growing tropical trees reduced soil erosion by 69%. Additionally, the sugarcane variety “Haruno-Ogi,” which was developed using interspecific hybridization, proved more effective in reducing soil runoff than conventional varieties even during ratoon cropping because of its vigorous regeneration after harvest and high leaf area index (LAI) from early growth. We recorded a yield increase in sugarcane production with a 30% reduction in recommended chemical fertilizer dosage by applying residue, such as filter cake and bagasse ash, from sugarcane mills. The optimized subsurface irrigation system (OPSIS) increased sugarcane yields in newly planted fields by supplying sufficient water to the sugarcane root zone, thereby minimizing wastage of irrigation water. We identified the effect of carbonized bagasse application depth on nitrate-nitrogen leaching through a pipe test with upland rice in a glasshouse at the Tropical Agriculture Research Front (TARF) in Ishigaki City. To determine the spatial and seasonal characteristics of river water quality, we conducted hydrologic and water quality surveys during both wet and dry seasons for five rivers in Negros Occidental, Philippines. Using the Soil and Water Assessment Tool+ (SWAT+) hydrological model, we examined calculation conditions for crop cultivation, among others, in the Todoroki River watershed on Ishigaki Island, Japan. We also estimated the effect of reducing nitrogen load and chemical fertilizer application by incorporating fertilizer management technologies into our calculation conditions for nitrogen footprint. In addition, we co-hosted a seminar titled "Towards an Ishigaki Island where water, people, and living things activities coexist in harmony" in Ishigaki City to present our research activities and findings from TARF. Furthermore, we attended the PHILSUTECH Annual National Convention, the biggest conference in the Philippines related to the sugar industry. In this conference, we shared our research findings obtained from both TARF and our project sites in the Philippines.

[Sustainable land management in drylands]

We conducted research on soil moisture dynamics using lysimeters at the Central Soil Salinity Research Institute of India (CSSRI), revealing that soil moisture consumption is large, reaching depths of up to 15 cm below the soil surface. Based on the result of this year-round monitoring, we recommend implementing sub-surface irrigation to a depth of 20 cm. We also conducted a verification test using a lysimeter and confirmed that sub-surface irrigation at 20 cm depth, using water drop tubes, suppressed salt accumulation in the surface layer of farmland and significantly increased crop water productivity. The mechanism of reduced drainage function due to dispersion, which is one of the major problems in sodic soils, was shown to be defined by salt concentration, not salt composition. We also confirmed that if sodic soils encounter saline water with a lower sodium adsorption ratio (SAR) than the saline water used during sodification, the value of the salt concentration that causes dispersion might decrease. A sample survey of farmers in Haryana revealed that approximately 75% of farmers were concerned about soil degradation in the future, emphasizing the need for innovative solutions. One such solution is the adoption of Cut-soiler technology. To promote its use, we held group discussions in rural villages and identified some limiting factors such as youth shunning agriculture and distance to extension organizations (locally known as KVKs). Furthermore, drainage improvement using Cut-soiler has been certified as an effective technology for managing salt-affected soils by the Indian Council of Agricultural Research (ICAR). As part of knowledge dissemination, we conducted lectures on Cut-soiler during a training course organized by the African and Asian Regional Development Organization (AARDO). In addition, we contributed to human resource development by supervising three doctoral students under the collaborative research agreement between JIRCAS and CSSRI.

TOPIC 1

Meta-analysis reveals general rice ratooning ability, and rice ratoon cropping shifts the plant type from panicle weight type to panicle number type

Rice ratooning is a cultivation method that omits seedling raising, puddling, and transplanting and is therefore attracting attention as a low-input and low-cost method. However, it faces the challenge of significantly lower yields compared to conventional double-cropped rice. To address this, many studies have been conducted on the identification of varieties and traits with high ratooning ability. However, due to differences in genetic and environmental factors, there are various results from many studies, making it difficult to understand the ratooning ability of rice.

This report uses statistical analysis of 51 field experiment data collected from 14 countries from 1976 to 2022 to examine the general ratooning ability, the effect of genetic and environmental factors on the ratooning ability of yield-related traits (plant height, number of stems, panicle length, number of spikelets, number of panicles, 1000-grain weight, grain-filling rate, growth period, and grain yield), and the relationship between ratooning ability and yield. In this study, ratooning ability is defined as the growth ratio of the ratoon crop to the main crop (ratoon rate).

The growth period of ratoon rice was 41% shorter than that of the main crop, and the number of spikelets and grain yield were significantly reduced by 48% and 56%, respectively, while the number of stems and panicles increased by only 19% (Fig. 1). This suggests that ratoon rice cultivation can accelerate heading, and the plant architecture shifts from the panicle weight type in the main crop to the panicle number type in the ratoon crop (Fig. 2). The influence of the number of stems in ratoon rice on ratoon rate was more variable and more susceptible to the effects of genetic and environmental factors such as variety and cultivation environment, while the number of spikelets, growth period, and 1000-grain weight were relatively less affected (Fig. 3). Path analysis between ratoon rates of each yield-related trait shows that growth period had a significant direct effect on grain yield, plant height, and panicle length, and that panicle length had a significant direct effect on the number of spikelets (Fig. 4). In other words, the results suggest that the shortening of the growth period of ratoon rice accelerates heading, which restricts the growth of the stem apex and the differentiation of young panicles that determine the number of spikelets, while the number of panicles does not increase significantly, resulting in a decrease in grain yield.

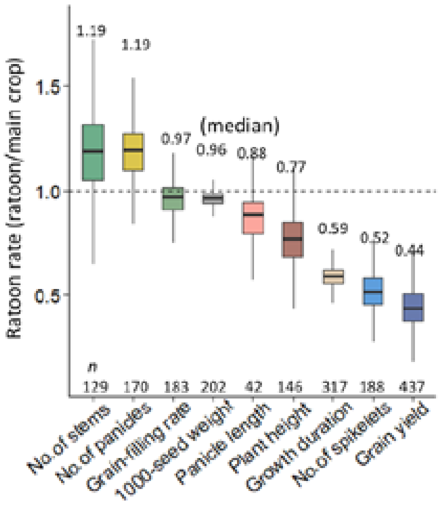


Fig. 1. Ratoon rate (final amount of growth in the ratoon crop relative to that in the main crop) for each yield-related trait

Boxplots show the distribution of the data. *n* indicates the number of data shown in the figure.

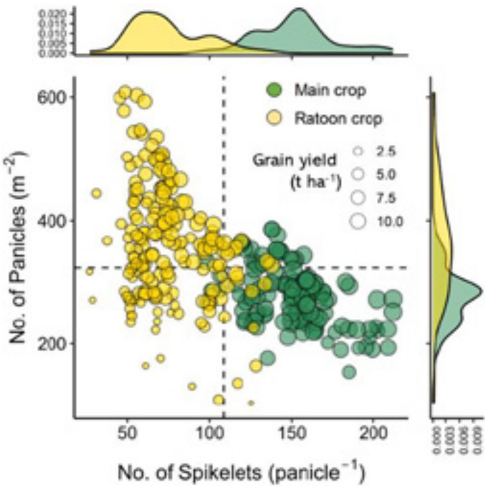


Fig. 2. Relationship between number of panicles and number of spikelets for main and ratoon crops

The number of data *n* = 170.

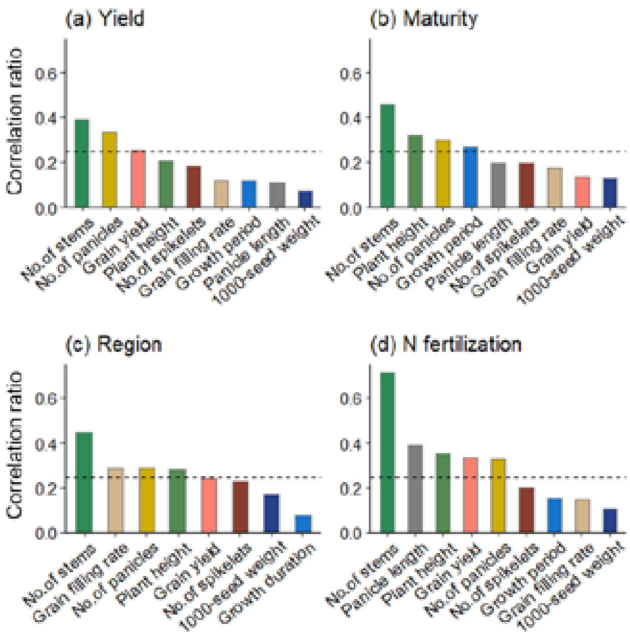


Fig. 3. Effects of differences in genetic and environmental factors such as variety and cultivation condition on the ratoon rate of yield-related traits

Correlation ratio indicates the ratio of the weighed variance of the group means divided by the variance of all samples on ratoon rate. The groups are divided into (a) yield: low (4.0 t ha⁻¹), medium (6.5 t ha⁻¹), high (9.0 t ha⁻¹), (b) maturity: early (110 days), medium (130 days), late (147 days), (c) region: South and Southeast Asia, East Asia, America, Africa, and (d) N fertilization: low (< 100 kg N ha⁻¹), medium (300 kg N ha⁻¹ > N ≥ 100 kg N ha⁻¹), and high (≥ 300 kg N ha⁻¹).

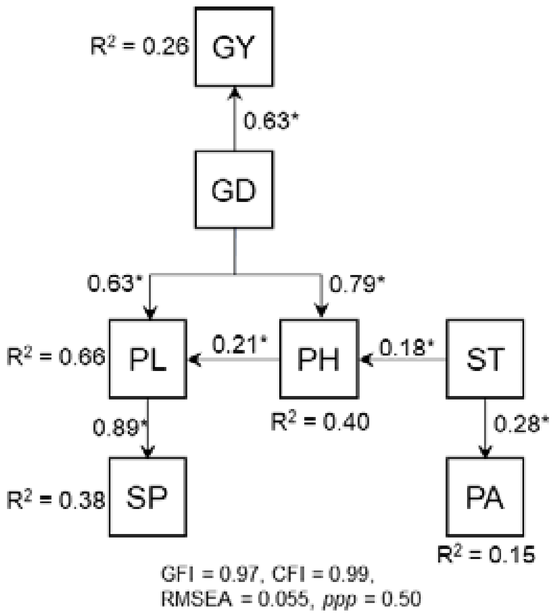


Fig. 4. Path analysis of the influence of features associated with yield on the ratoon rate

GY, grain yield; PH, plant height; ST, stem number; PA, panicle number; SP, spikelet number; PL, panicle length; GD, growth duration; sample size, *n* = 42; *, statistically significant pathways; GFI, goodness of fit index; CFI, comparison fit index; RMSEA, root mean square error of approximation; *ppp*, posterior predictive *p*-value.

Reference

Shiraki et al. (2024) *Agronomy Journal* 116: 504–519. © The Author(s) 2024

The figures were reprinted/modified from Shiraki et al. (2024).

(Shiraki, S. [JIRCAS], Kywae, Thura, Lae, L.M., Thin, M.C., Kyaw, M., Nwe, N., May, T.O., Loon, P.P., Aung, K.T. [DAR])

High-efficiency microbial saccharification with novel xylan-saccharifying bacteria

Lignocellulosic biomass is attracting attention as the world's most abundant renewable resource, and its effective utilization is being sought. However, the development of an efficient and cost-effective technology for biomass saccharification is a challenge, and JIRCAS has developed the "microbial saccharification method," which does not rely on commercial cellulose saccharification enzymes (cellulases), but only on the cultivation of saccharifying microorganisms (see FY2022 Research Highlights: Technology development to saccharify cellulose "only by cultivating microorganisms" without using cellulase enzymes).

Some agricultural waste biomass contains not only cellulose but also a large amount of xylan. Since xylan inhibits the saccharification of cellulase enzyme, it is necessary to search for xylan-saccharifying microorganisms that can be incorporated into microbial saccharification methods and to develop saccharification technology using such microorganisms. We screened microorganisms that efficiently saccharify xylan at 60°C under anaerobic conditions using xylan as the sole carbon source and obtained DA-C8 bacteria. The characteristics of the DA-C8 bacteria isolated in this study are reported.

We have screened microorganisms that efficiently saccharify xylan from Ishigaki Island compost at 60°C under anaerobic conditions using a medium containing xylan as the sole carbon source and obtained DA-C8 bacteria. This bacterium belongs to the same phylogenetic lineage as the known *Xylanibacillus composti*, but based on genetic, chemotaxonomic, and phylogenetic analyses (including digital DNA-DNA hybridization), average amino acid sequence identity values, and major polar lipid composition, a new genus and species, *Insulambacter* and *I. thermoxylanivorax*, were proposed (Fig. 1). *I. thermoxylanivorax* DA-C8 not only can completely saccharify xylan (Fig. 2) but also hemicelluloses other

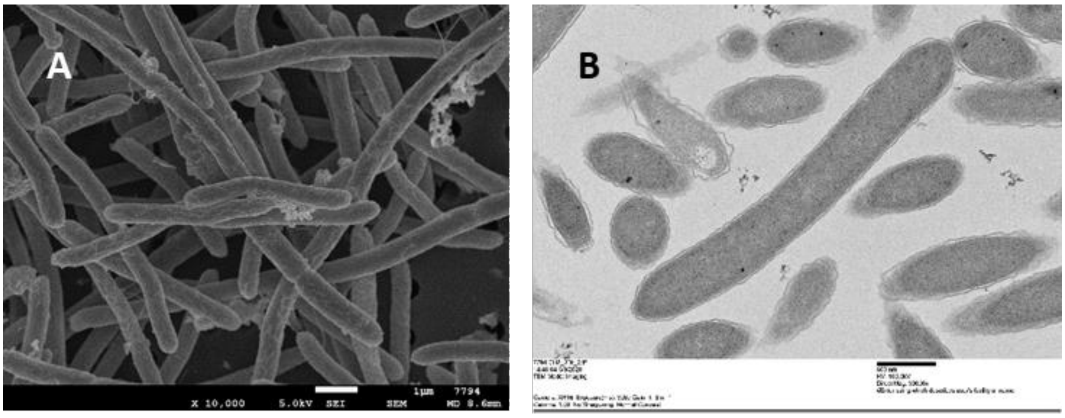


Fig. 1. Cell morphology of *I. thermoxylanivorax* strain DA-C8 cultured in xylose carbon source medium
A. Scanning electron microscopy image of *I. thermoxylanivorax* DA-C8. White scale bar is 1 μm;
B. Transmission electron microscopy image of a thin section of *I. thermoxylanivorax* DA-C8 strain. Black scale bar is 0.4 μm.

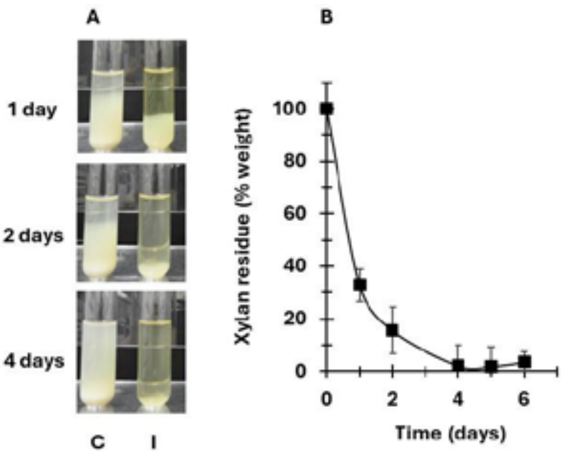


Fig. 2. Xylan saccharification capacity of *I. thermoxylanivorax* DA-C8
A. Xylan saccharification by *I. thermoxylanivorax* DA-C8 in 1% xylan carbon source medium.
Days 1, 2, and 4 after inoculation with *I. thermoxylanivorax* DA-C8. C: uninoculated, I: inoculated with *I. thermoxylanivorax* DA-C8;
B. Residual percentage of xylan over time in 1% xylan carbon source medium.

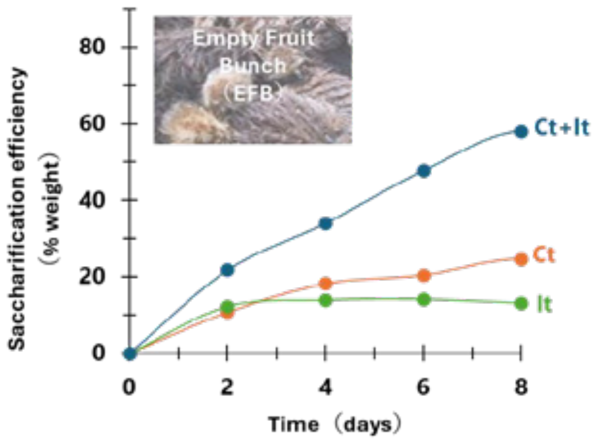


Fig. 3. Microbial saccharification by co-culture of *I. thermoxylanivorax* DA-C8 and *C. thermocellum*
Microbial saccharification was measured in a medium containing 1% EFB fiber. Comparison of saccharification capacity of *C. thermocellum* alone (Ct), *I. thermoxylanivorax* DA-C8 alone (It), and *C. thermocellum* in co-culture with *I. thermoxylanivorax* DA-C8 (Ct+It), which has high cellulose saccharification capacity used in the microbial saccharification method.

than xylan, such as arabinoxylan and galactan. It also grows over a wide temperature (37–60°C; optimum temperature: 55°C) and pH range (4–11; optimum pH: 9). In a microbial saccharification test using oil palm fiber (EFB), which contains relatively high amounts of xylan, the saccharification capacity of *Clostridium thermocellum* alone was 24.7% and 13.2% for *I. thermoxylanivorax* DA-C8, which has a high cellulose saccharification capacity. When *I. thermoxylanivorax* DA-C8 and *C. thermocellum* were co-cultured, the saccharification efficiency was 58.1%, showing an extremely high saccharification efficiency. This is a 2- to 4-fold increase in saccharification efficiency compared to each alone (Fig. 3). *I. thermoxylanivorax* DA-C8 has been deposited as a reference strain at the RIKEN BioResource Center (JCM 34211T) and the German Microbial Cell Culture Collection Center (DSM 111723T) and is available for distribution.

References

1) Chhe et al. (2021) Characterization of a thermophilic facultatively anaerobic bacterium *Paenibacillus* sp. strain DA-C8 that exhibits xylan degradation under anaerobic conditions. *J. Biotechnol*. 342: 64–71. https://doi.org/10.1016/j.jbiotec.2021.10.008 © Elsevier B.V. 2021
2) Chhe et al. (2023) *Int J Syst Evol Microbiol*. 73(3): 005724. © The Author(s) 2023 The figures were reprinted/modified from Chhe et al. (2021) with permission.

(Kosugi, A., Uke, A. [JIRCAS])

TOPIC 3

Waterlogging due to rainfall alters gene expression patterns in the upper stem of oil palm

Palm oil accounts for approximately 36% of global vegetable oil production, making it the most abundant. However, the majority of this production occurs in Southeast Asia, specifically in Indonesia and Malaysia. The geographical concentration of production systems is considered vulnerable to climate change. To reveal the weather factors affecting oil palm (*Elaeis guineensis*), we comprehensively analyzed the gene expression levels of oil palm tissues collected over time (transcriptome analysis). By examining the relationship between meteorological factors and oil palm, we can unravel its physiological responses to environmental conditions. Understanding oil palm's physiological responses to environmental factors can help identify vulnerabilities to climate change and contribute to sustainable oil palm plantation management.

At the research site in Lampung Province, Indonesia, samples were collected from the leaf and stem tissues of oil palm for transcriptome analysis over a time series (Figs. 1 and 2). Sampling was conducted approximately nine times over two years (T1 to T9). Notably, during sampling at T3 and T7, there were rainfall events exceeding 80 mm per day. The gene expression profiles of samples obtained from the oil palm stem tissues at T3 and T7 differed significantly from those at other time points (Fig. 3). However, there was no clear relationship between the gene expression profiles from both tissues and the daily average temperature or cumulative temperature. To investigate the gene expression patterns related to waterlogging, we categorized genes into those associated with waterlogging and those unrelated, based on homology searches with the model plant *Arabidopsis thaliana*. In the trunk tissues, the proportion of genes related to waterlogging showed significant expression variation in

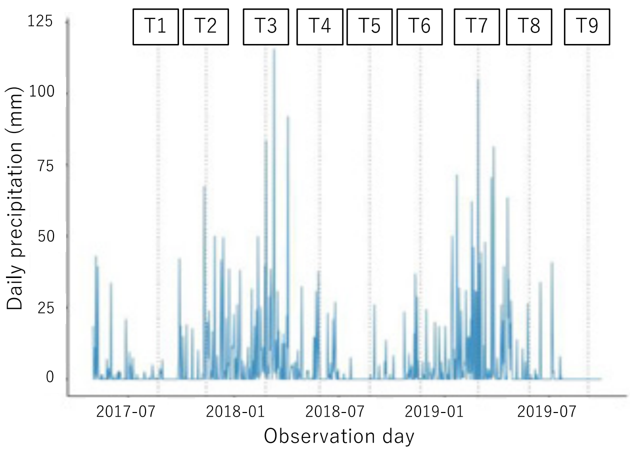


Fig. 1. Daily precipitation at the study site (Lampung Province, Indonesia) during the observation period
T1 to T9 indicate sampling dates for transcriptome analysis.

Fig. 2. Studying and sampling of old palm trunk tissue

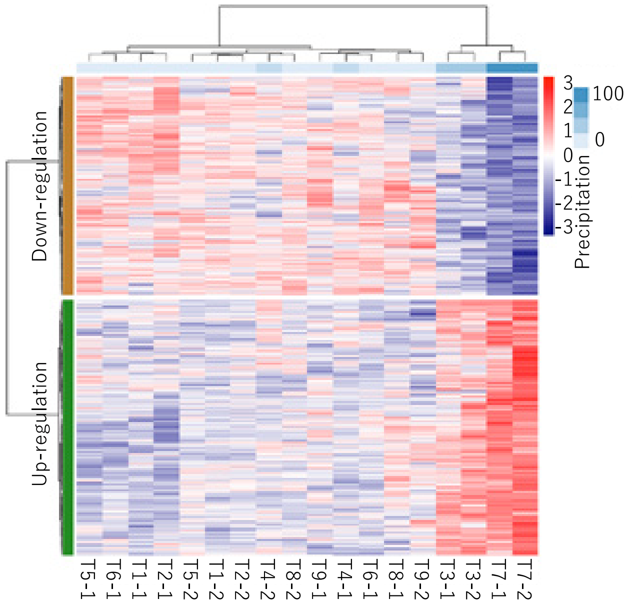


Fig. 3. Heatmap of the gene expression profile of stem
By arranging profiles based on daily precipitation, a heatmap reveals significant differences in gene expression profiles between T3, T7, and other samples with high daily precipitation.

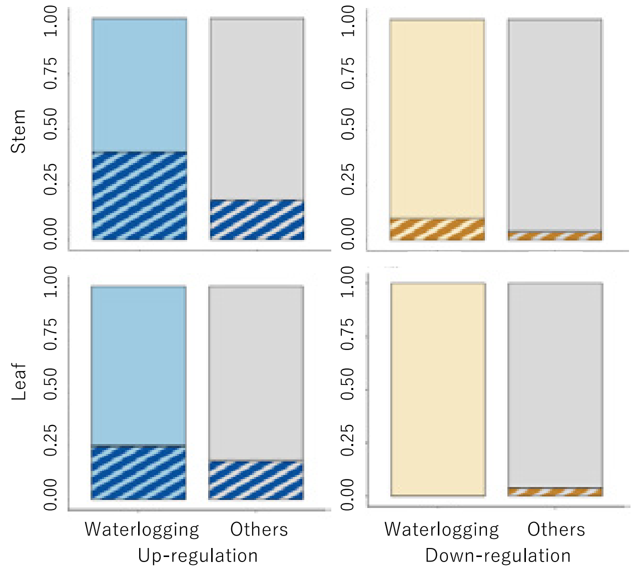


Fig. 4. Proportion of differentially expressed genes in waterlogging-related gene sets and other gene sets during waterlogging
Distinct patterns of gene expression, especially in stem between waterlogging-related genes and other gene sets, were found when investigating the proportion of differentially expressed genes (diagonal in the bars) during waterlogging (T3 and T7).

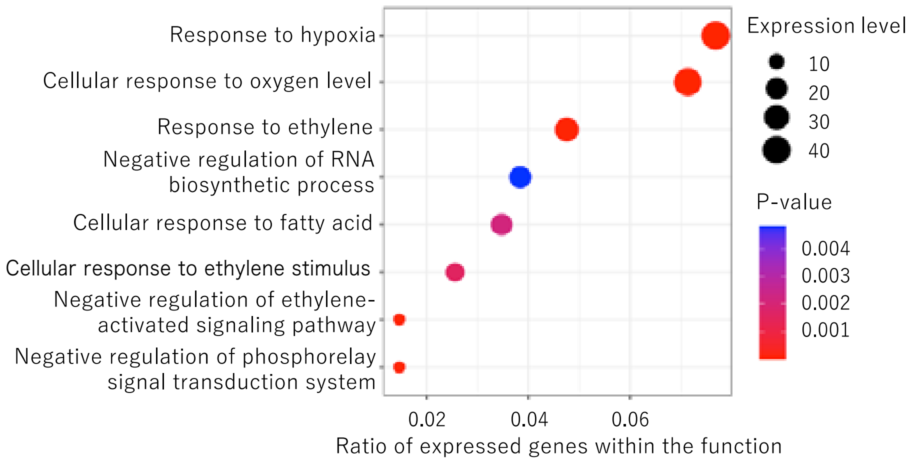


Fig. 5. Functions of genes differentially expressed during waterlogging in stems
We found that significantly differentially expressed genes are primarily associated with low-oxygen response and oxygen levels. Additionally, changes in gene expression related to ethylene response were also observed.

both upregulation and downregulation compared to other gene groups. Conversely, such a trend was not observed in leaf tissues (Fig. 4). The homology search results for *A. thaliana* and oil palm revealed substantial differences in gene expression levels related to low oxygen response and oxygen levels. Additionally, changes in gene expression related to ethylene response were evident, indicating stress responses to waterlogging (Fig. 5). These findings suggest that while mature oil palms exhibit resilience to temperature fluctuations, they are sensitive to stress responses in stem tissues under short-duration, heavy rainfall conditions, highlighting their vulnerability to waterlogging.

Reference

Lim et al. (2023) *Frontiers in Plant Science* 14: 1213496.
© The Author(s) 2023
The figures were modified from Lim et al. (2023).

(Tani, N., Arai, T., Kondo, T., Kosugi, A. [JIRCAS], Irawati, D., Nugroho, S. [UGM], Lim, H. [Univ. of Tsukuba])

Identification of the key biological nitrification inhibition (BNI) compound from maize roots

Specific plants can suppress nitrification in soil by releasing inhibitory natural products from their roots, a chemical-ecological phenomenon called biological nitrification inhibition (BNI). BNI utilization is a useful strategy for solving environmental problems (e.g., water pollution by NO_3; production of the greenhouse gas N_2O) and improving nitrogen uptake while reducing nitrogen losses from agricultural fields. The crucial property for the isolation of BNI compounds is whether their root exudates, extracts, and compounds are water-insoluble (hydrophobic) or water-soluble (hydrophilic). While hydrophobic compounds with lower mobility are retained in the rhizosphere, hydrophilic compounds can move further away from the roots. In a previous study, two major hydrophobic BNI-contributing compounds from the root surface (zeanone and HDMBOA) were identified in maize, together with two analogs of HDMBOA from inside the roots (Fig. 1). Our objective in this study is to identify the chemical structure and function of a hydrophilic BNI-active compound from maize.

The most BNI-active compound in hydrophilic BNI-activity from maize roots was identified as 6-methoxy-2(3*H*)-benzoxazolone (MBOA). MBOA has been detected in several *Poaceae* species such as maize and wheat. MBOA strongly inhibited the growth of *Nitrosomonas europaea* (Fig. 2). In a soil incubation experiment, NO_3 production was suppressed in the presence of MBOA during incubation for 4 days, and BNI-activity declined in parallel with MBOA biodegradation after incubation for 5 days (Fig. 3). Further experiments suggested that two benzoxazinoids, HDMBOA and HDMBOA-β-glucoside, which are chemically and biologically unstable in soil, respectively, could be converted into the more stable BNI-active MBOA in the soil (Fig. 4). Therefore, MBOA is a key component in the BNI-activity of maize.

MBOA is degraded in soil via microbial reaction, while new MBOA can be constantly produced and released by living maize. Hence, maize can stably exhibit BNI activity. The BNI compounds identified in our study are a promising indicator for evaluating BNI capacity among maize species, and can lead to the development of BNI-enhanced maize.

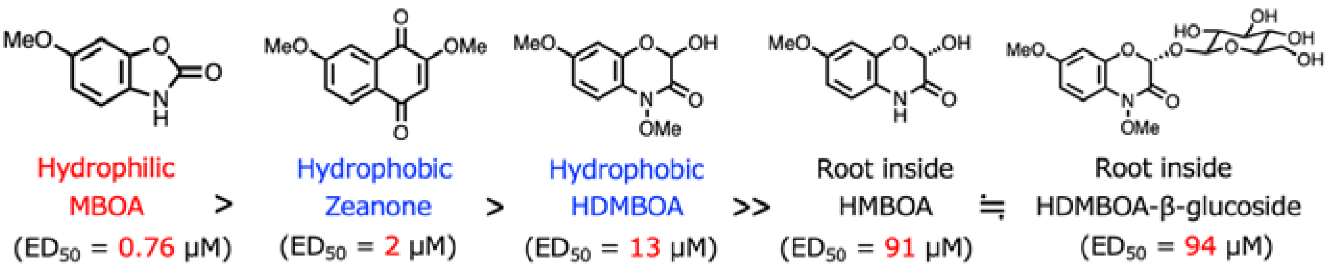


Fig. 1. Structures and BNI activities of identified BNI compounds from maize roots
The values in the parentheses indicate BNI activities. A smaller value means stronger BNI activity.

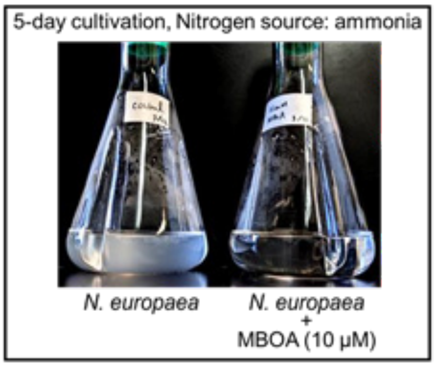


Fig. 2. Effect of MBOA on the growth of *N. europaea*
(Left) *N. europaea* in cloudy medium; (Right) Clear medium caused by suppression of the growth of *N. europaea* in the presence of MBOA.

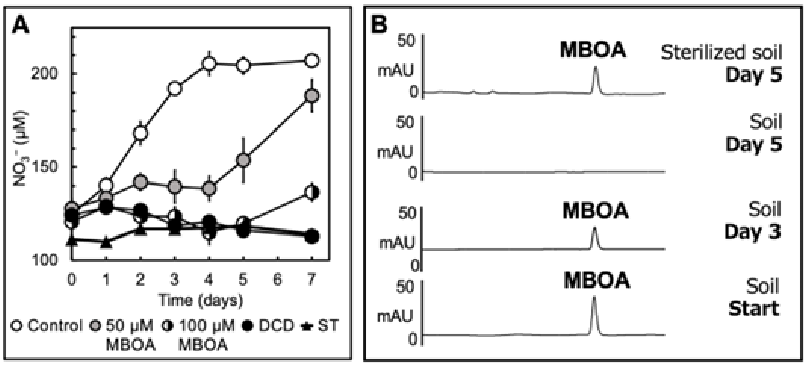


Fig. 3. Effect of MBOA on nitrification and its stability in soil incubation test
Soil was incubated under the presence of MBOA, and the concentrations of NO_3 and MBOA were time-dependently measured. Day 0 (start) means the result 1 hour after application of MBOA. (A) Control: water was used instead of MBOA., DCD: chemical nitrification inhibitor dicyandiamide, ST: sterilized soil. (B) Concentration of MBOA was measured by HPLC.

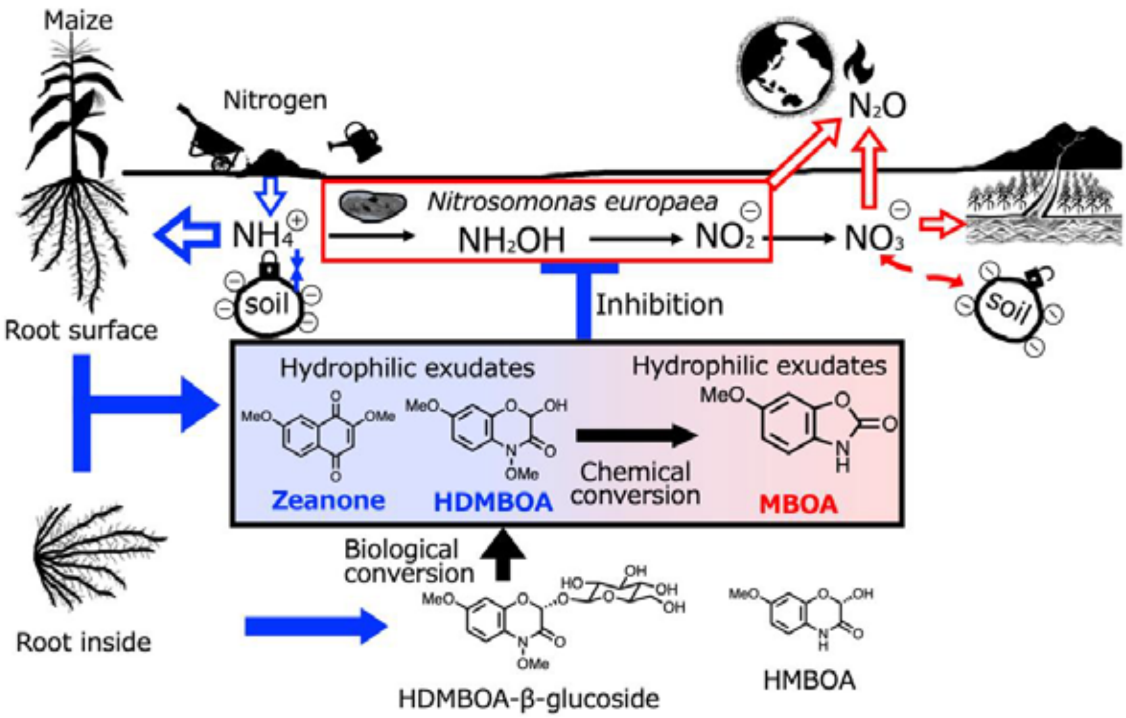


Fig. 4. BNI mechanism of maize
BNI of maize is exhibited by three BNI-active compounds including the key MBOA.

Reference

Otaka, et al. (2023) *Plant Soil* 489: 341-359. © The Author(s) 2023
The figures were reprinted/modified from Otaka et al. (2023).

(Otaka, J., Yoshihashi, T., Subbarao, G.V., MingLi J. [JIRCAS], Ono, H. [NARO])

TOPIC 5

Development of models to predict stem diameter and tree height of *Shorea platyclados* (Dipterocarpaceae) based on genomic information from seedlings

In recent years, rapid advancements in DNA sequencing technology have made it relatively inexpensive to collect genomic information even for woody plants that are close to wild species. However, for woody plants with large individual sizes and long lifespans, evaluating the performance of next generations (known as progeny trial) after breeding superior individuals requires vast land and time for their growth. This becomes a limiting factor in selecting superior individuals. Therefore, attention is now focused on methods that utilize genomic information to predict specific phenotypes. Specifically, if we can predict future phenotypes using genomic information from offspring, it becomes possible to overcome previous limiting factors. In this study, we aimed to develop a genomic selection model for *Shorea macrophylla*, a tree species in the Dipterocarpaceae, which is expected to be intensively planted in Southeast Asian tropical forests.

We established a workflow using a training population of a progeny trial forest with relatively less environmental heterogeneity for genomic selection (GS) model. We collected genomic information and focal phenotypes. Using these data, we corrected the spatial structure of the phenotypes due to environmental heterogeneity, detected important genetic markers by genome-wide association study (GWAS), and established a workflow for developing GS models (Fig. 1). The workflow was implemented using scripts in R and Python, which we have made publicly available. By selecting highly correlated markers based on GWAS results, we achieved usable predictive accuracy using both linear models (6 algorithms) and nonlinear models (6 algorithms). With this model, it becomes possible to select offspring based on genomic information from the training population without the subsequent progeny testing (Table 1). This approach promises to enhance breeding outcomes related to growth. Specifically, when predicting the 7-year diameter growth, we calculated the median of predictive accuracy for 100 randomly generated models using linear and nonlinear methods.

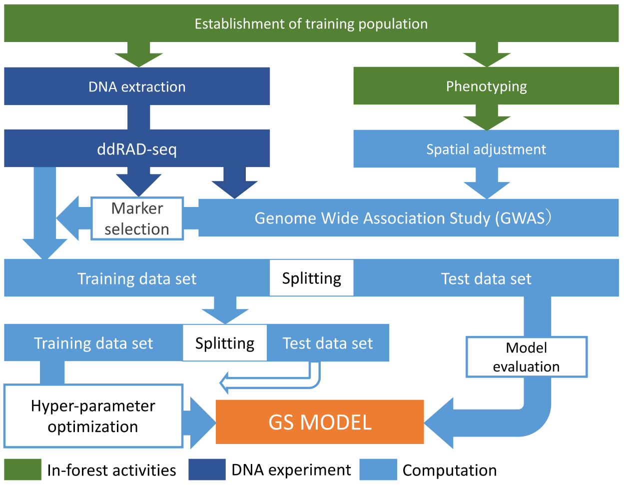


Fig. 1. Workflow for GS model
This script, which includes the calculation process highlighted in light blue, has been publicly released.

Table 1. The maximum predictive ability for diameter growth and tree height

Trait	Number of markers	Maximum predictive ability	Algorithm
D7	48	0.279	BRR
	96	0.342	CNN1D
	192	0.291	CNN1D
	18037	0.440	XGB
H7	48	0.343	XGB
	96	0.427	BayesB
	192	0.354	LGB
	18037	0.297	LGB

D7 and H7 represent diameter growth and tree height in the seventh year of planting, respectively. The maximum predictive accuracy was obtained from 10 trials of 10 training data (total of 100 trials) and using the algorithm when the 48, 96, and 192 markers were selected by GWAS from a total of 18037 markers.

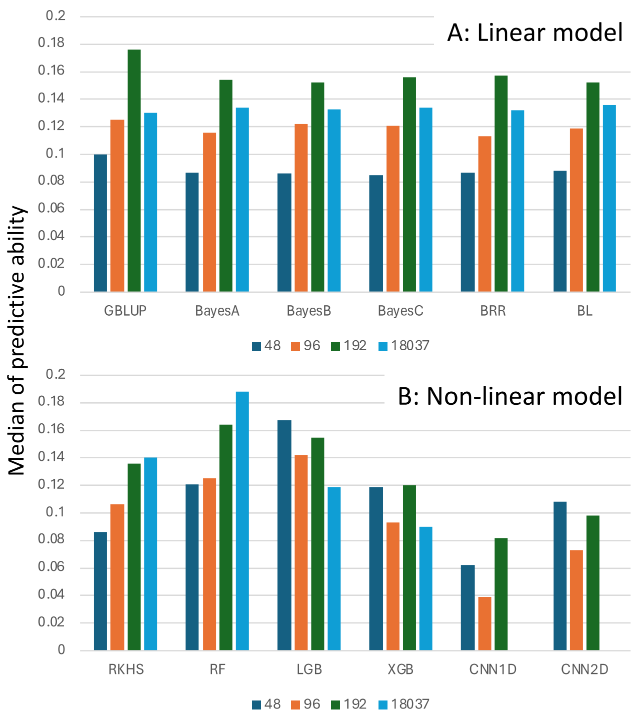


Fig. 2. Median of predictive accuracy of GS models for diameter growth in the 7th year of planting
By GWAS, 48, 96, and 192 DNA markers were selected from a total of 18037 DNA markers, Median was calculated from the 100 replicates for linear algorithms in A and non-linear algorithms in B. Due to the computational burden, CNN1D and CNN2d do not use all markers.

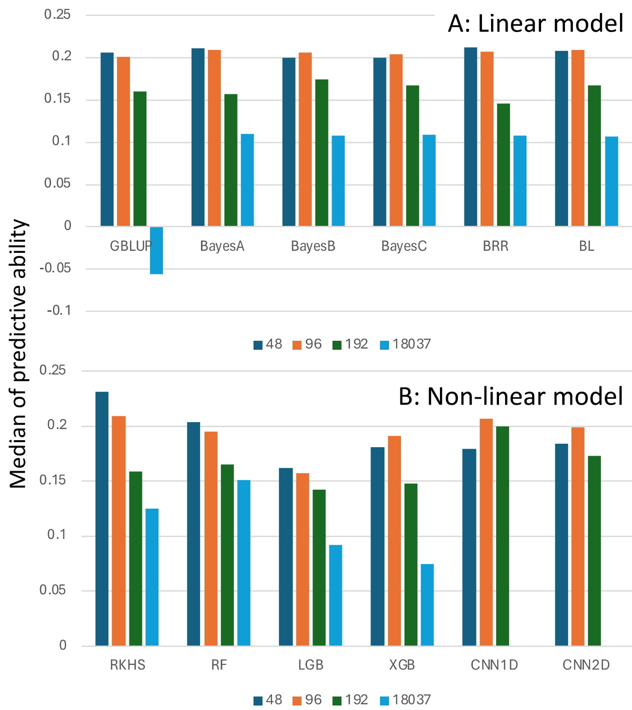


Fig. 3. Median of predictive accuracy of GS models for tree height in the 7th year of planting
See footnote in Fig. 2.

Given that diameter growth results from a combination of primary and secondary growth, the use of nonlinear models, which can account for interactions among numerous genes, yielded higher predictive accuracy (Fig. 2). Conversely, tree height, being only influenced by primary growth, was associated with fewer relevant genes. Therefore, narrowing down the number of associated genes through GWAS led to a more accurate GS model. (Fig. 3)

Reference

Akutsu et al. (2023) *Frontiers in Plant Science* 14: 1241908. © The Author(s) 2023

The figures were modified from Akutsu et al. (2023).

(Tani, N. [JIRCAS], Na'iem, M., Widiyatno, Indrioko, S., Sawitri [UGM], Akutsu, H., Tsumura, Y. [Univ. of Tsukuba])

Drought resilience of interspecific hybrids of the tropical forest trees *Shorea leprosula* and *S. curtisii*

Climate change is predicted to increase drought frequency and intensity in the tropical rainforest regions of Southeast Asia, and there is concern that trees with low drought tolerance will die or grow poorly. The dipterocarp family, which dominates the forests of this region, is important as a timber resource. Among them, *Shorea leprosula* (Fig. 1) is suitable as plantation species due to its fast growth rate, but has the disadvantage of low drought tolerance. *S. curtisii*, on the other hand, grows slowly and takes longer to harvest, but can also be grown on dry ridges. An interspecific hybrid can combine the various characteristics of both parents and be used to create superior crop varieties. However, the characteristics of hybrids in dipterocarp trees are unknown. In this study, we investigated the leaf and branch characteristics associated with drought tolerance in interspecific hybrid seedlings between *S. leprosula* and *S. curtisii* to explore the potential for using hybrids to create varieties with high resilience to climate change.

First, we compared leaf morphology and physiological characteristics. *S. leprosula* had the thinnest leaves but also had the highest proportion of palisade layer with a higher photosynthetic capacity. On the other hand, *S. curtisii* had a thick cuticle and epidermis that protected the leaves from desiccation, but the proportion of the palisade layer was low. Hybrids had leaves with medium characteristics or almost the same as in the parent species (Fig. 2). The photosynthetic capacity of *S. leprosula* was higher than that of *S. curtisii*, consistent with its faster growth rate. The capacity of the hybrid was intermediate between the parental species and is likely to grow faster than *S. curtisii* (Table 1). Second, we compared the pattern in which branches lose their water-permeating function under drought stress, and *S. curtisii* and hybrids were found to be more drought-tolerant than *S. leprosula* (Fig. 3). Finally, we artificially dried the soil and examined changes in leaf drought tolerance. The lower leaf osmotic

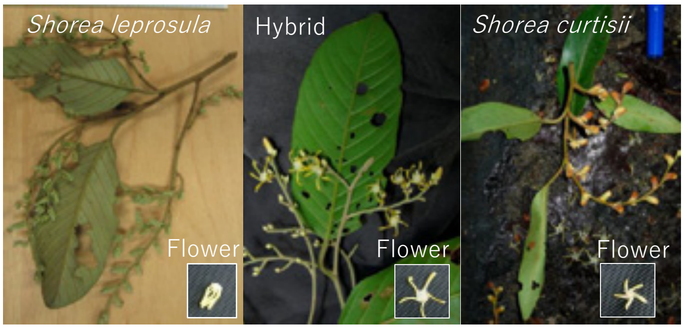


Fig. 1. Flowers and leaves of *S. leprosula* and *S. curtisii* and their hybrid
The petals of *S. leprosula* are closed and twisted, but those of *S. curtisii* are open. Hybrid flowers are open, but the petals are twisted, inheriting the characteristics of both parents.

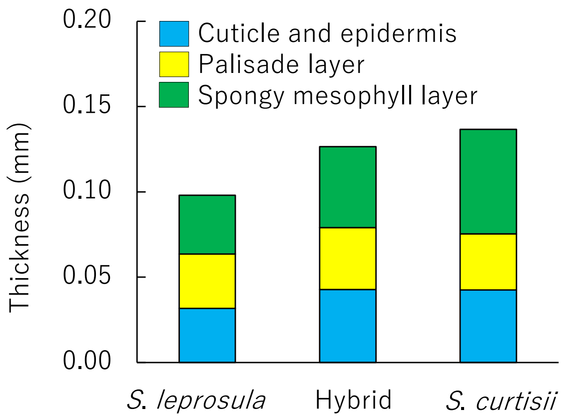


Fig. 2. Thickness of leaf internal tissue
Leaf surfaces with thick epidermis and cuticle significantly suppress water loss, making them more drought- tolerant, whereas those with thick palisade layers contribute to photosynthesis.

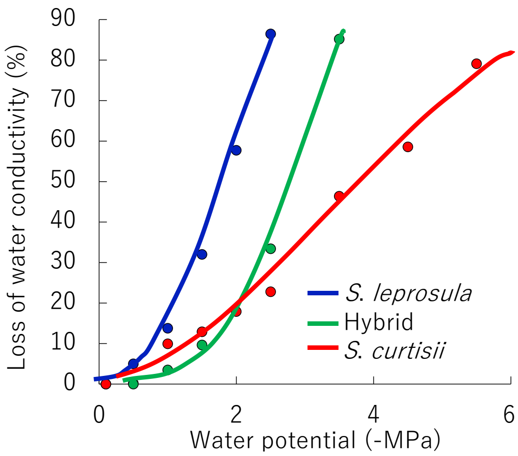


Fig. 3. Branch water conductivity under drought stress
A greater water potential means higher drought stress, which inhibits water flow in the branch. *S. leprosula* easily lost water conductivity under mild drought stress.

Table 1. Leaf photosynthetic rate, osmotic potential, and turgor loss point under drought stress

	Photosynthetic rate (µmol m^{-2} s^{-1})	Osmotic potential (MPa)	Turgor loss point (MPa)
S. leprosula	3.16a	-1.18a	-1.33a
Hybrid	2.44ab	-1.40b	-1.53b
S. curtisii	2.09b	-1.54b	-1.72c

Lower turgor loss point means that the leaves are more resistant to wilting and more drought-tolerant. Different alphabets indicate statistically significant differences.

potential in hybrids and *S. curtisii* indicated that they had a greater ability for osmotic regulation under drought conditions than *S. leprosula*. When drought tolerance was assessed by leaf wilting point (water potential at loss of turgor pressure), the leaves of *S. leprosula* wilted easily, but the hybrids and *S. curtisii* did not wilt easily and had high drought tolerance (Table 1).

Overall, it was clear that the leaves and branches of the hybrid are more drought-tolerant than *S. leprosula*. This suggests that hybrids can be used to create varieties with high drought resilience, helping tropical forestry adapt to climate change.

Reference

Kenzo et al. (2023) *Forest Ecology and Management* 548: 121388. © Elsevier B.V. 2023

(Tanaka, K. [JIRCAS], Ichie, T., Norichika, Y. [Kochi Univ.], Kamiya, K. [Ehime Univ.], Inoue, Y. [FFPRI], Ngo, K. M., Lum, S. K. Y. [Nanyang Tech. Univ.])

TOPIC 7

The difference in biochar application depths affects nitrate leaching and water budget

The Haber–Bosch process enables humanity to produce nitrogen fertilizer, allowing the population to grow by increasing food production. However, the global nitrogen cycle is disturbed beyond the planetary boundary. Nitrogen applied as fertilizer often leaches from farmland in nitrate form, moving into the groundwater, rivers, and other water bodies and polluting the surrounding environment. Therefore, mitigating nitrogen leaching is urgently required. Biochar has been applied to farmlands to mitigate leaching while storing carbon. The effect of biochar application differs depending on the application depth; however, the effect of the application depth remains unclear. This study aimed to evaluate the effects of the biochar application depth on nitrogen leaching and soil water conditions.

We conducted a pipe experiment with no plant using bagasse biochar (800 °C) with four treatments: no biochar application (control), surface application (0−5 cm), plow layer application (0−30 cm), and subsurface application (25−30 cm). The experiment was conducted in a glass room. The amount of applied biochar was the same among the treatments (10 t ha^{-1}). Biochar content rates (expressed as weight ratios) in the biochar amendment layer were 1.57% for surface/subsurface application and 0.26% for plow layer application. Surface irrigation was conducted every two or three days, and powdered fertilizer was applied monthly. We measured the amount of drainage and nitrate leaching during the experiment (Fig. 1). The results showed that the drainage and nitrate leaching amounts differed depending on biochar application depths (Fig. 2). Nitrate leaching tended to be reduced by surface application, whereas drainage and leaching were reduced by plow layer application. Subsurface application did not alter drainage and leaching. We estimated the water budget for each treatment (Table 1). Compared with the control, soil evaporation tended to reduce under surface application, whereas it tended to increase under plow layer application.

Our study indicated that, although the same amount of biochar was applied, the effect of biochar application differs depending on the application depth. Surface and plow layer applications reduced nitrate leaching; the change in soil moisture conditions might induce these differences. Choosing a proper biochar application depth could contribute to mitigating nitrate leaching and possibly reducing nitrogen fertilizer use.

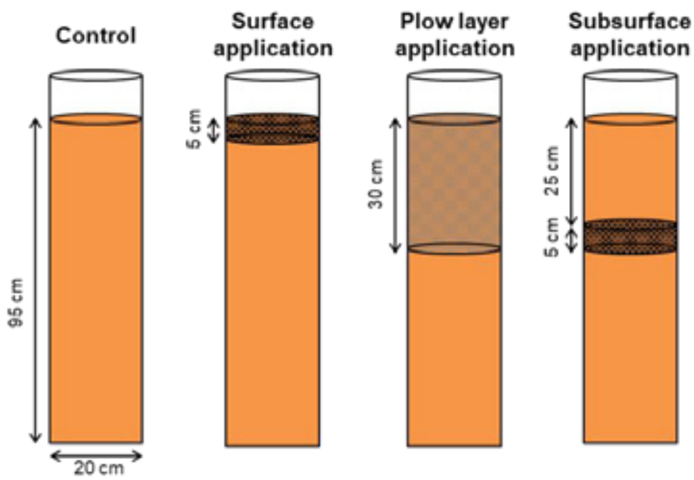


Fig. 1. Pipe experiment
The pipe experiment was conducted from August to November in a glass room. We applied four treatments with five replicates. The soil bulk density was set to 1.25 g cm^{-3}.

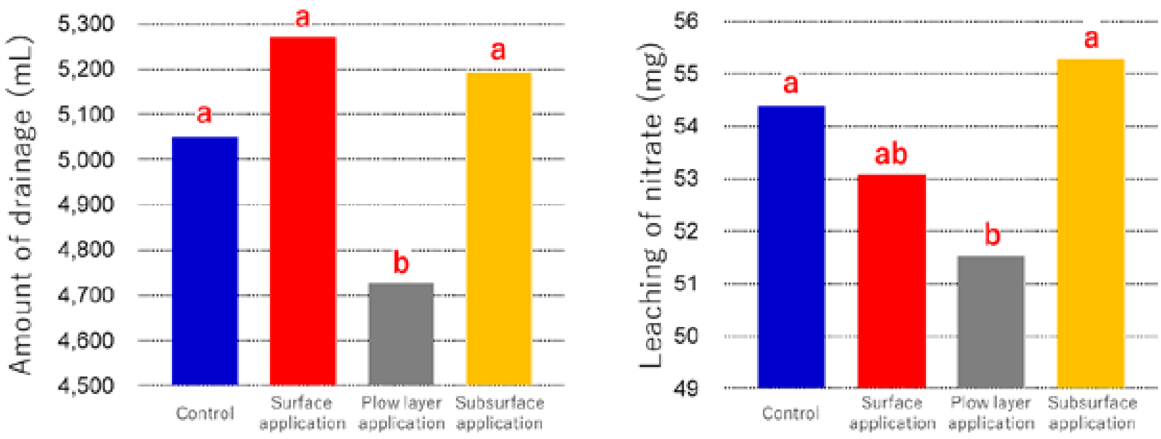


Fig. 2. Cumulative amount of drainage (left) and nitrate (right)
Letters indicate significant difference ($p < 0.005$).

Table 1. Water budget within the pipes

	Control	Surface application	Plow layer application	Subsurface application
Irrigation (mL)		14,850		
Evaporation (mL)	8,960	8,754	9,389	9,149
Water in the pipe (mL)	6,977	7,175	6,860	6,964
Drainage (mL)	5,049 [a]	5,269 [a]	4,726 [b]	5,194 [a]

Water in the pipe was calculated by multiplying sensor values (n=2) at depths of 10, 20, 35, and 80 cm by soil layer volumes. Evaporation was calculated using the amount of irrigation, drainage, and water in the pipe. Letters show significant difference ($p < 0.05$).

Reference

Hamada K, Nakamura S, Kanda T, Takahashi M. (2023) Effects of biochar application depth on nitrate leaching and soil water conditions. *Environmental Technology*. https://doi.org/10.1080/09593330.2023.2283403.

(Hamada, K., Nakamura, S., Kanda, T. [JIRCAS])

TOPIC 8

Unraveling the factors influencing spatiotemporal variations in riverine dissolved organic matter and iron through a machine learning approach

Dissolved organic matter (DOM) serves vital functions in aquatic ecosystems, such as regulating light availability in the water column and providing energy and nutrients to microorganisms, while excessive loading of light-absorbing colored DOM reduces light penetration, inhibiting photosynthesis by primary producers (e.g., phytoplankton, seaweeds). DOM also serves as an organic ligand for iron, an essential micronutrient for primary producers, and increases its availability. Based on the result of periodic water quality monitoring in the rivers of Ishigaki Island, a tropical island of Japan, the factors influencing spatiotemporal variations in the concentrations of riverine DOM and its components were identified by analyzing their relationships with catchment properties (e.g., land use, soil type) and seasonality (e.g., water temperature). Furthermore, the impact of the molecular composition of DOM on the concentration of dissolved iron (DFe) was assessed. The random forest (RF) machine learning algorithm was employed for the analyses because of its flexibility in handling non-parametric datasets and non-linear relationships, and its ability to measure the importance of predictor variables.

The RF models using catchment properties and water temperature as predictor variables accurately predicted

Table 1. Importance of the predictor variables in the random forest (RF) models for dissolved organic carbon (DOC) and three humic-like components (C1 ~ C3)

	Variable	DOC	C1	C2	C3
	Water temperature	**16.1**	**20.8**	**21.3**	**17.5**
Land use	Upland fields	10.8	9.1	11.2	10.0
	Pastures	11.2	8.8	11.5	9.9
	Paddy fields	9.7	7.5	9.3	8.1
	Forests	14.1	11.1	13.2	11.9
	Livestock barns	7.0	8.0	7.2	8.2
Soil	Haplic Acrisols (Chromic)	11.9	11.1	11.3	10.9
	Haplic Cambisols	12.3	9.9	12.4	10.2
	Haplic Acrisols	12.7	8.9	8.3	8.6
	Haplic Cambisols (Eutric)	8.1	7.0	6.3	6.1
	Haplic Regosols (Calcaric)	7.7	6.7	6.2	5.8
	Gleyic Fluvisols	**16.1**	**22.2**	**16.8**	**21.4**
	Population density	11.7	9.6	8.9	8.6

(%) ~ 25, ~ 20, ~ 15, ~ 10

C1: Derived from terrestrial material by photochemical degradation

C2: Produced during microbial degradation of organic matter

C3: Produced during breakdown of lignin (e.g., syringaldehyde)

Importance was measured as the increase in mean squared error (MSE; in %) that occurred when the fitted model was run with the randomly permuted variable of interest. The greater the value, the more important the variable. Values greater than 15% are shown in white bold letters.

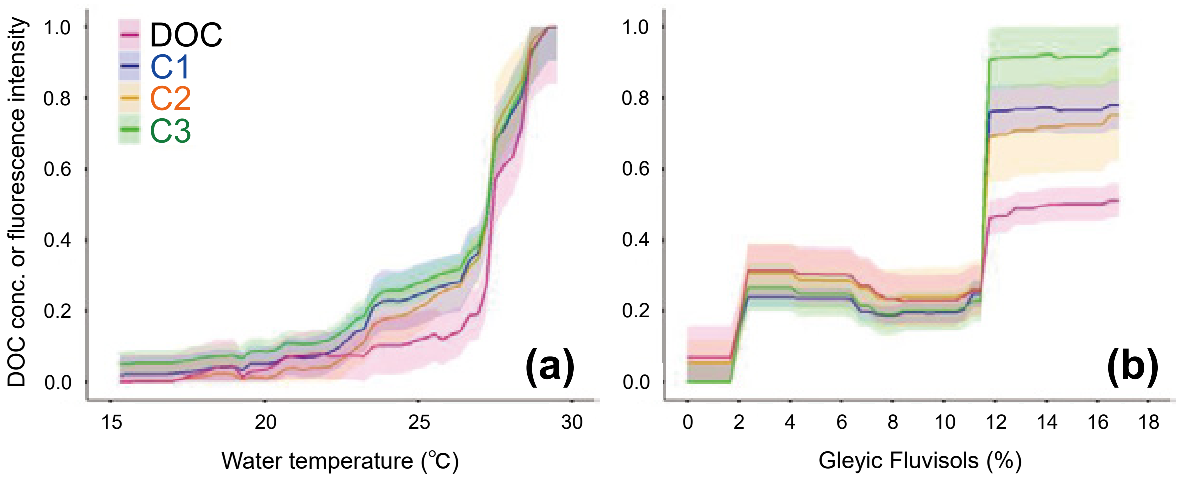


Fig. 1. Partial dependence plots (PDPs) of DOC and humic-like components on (a) water temperature and (b) areal share of Gleyic Fluvisols in the catchment
Solid lines and shaded areas represent the mean partial dependence and its standard deviation, respectively, for 15 RF models generated through three repetitions of five-fold cross-validation. The *y*-axes are scaled to a difference between the maximum and minimum values of each DOM parameter that is common in both panels.

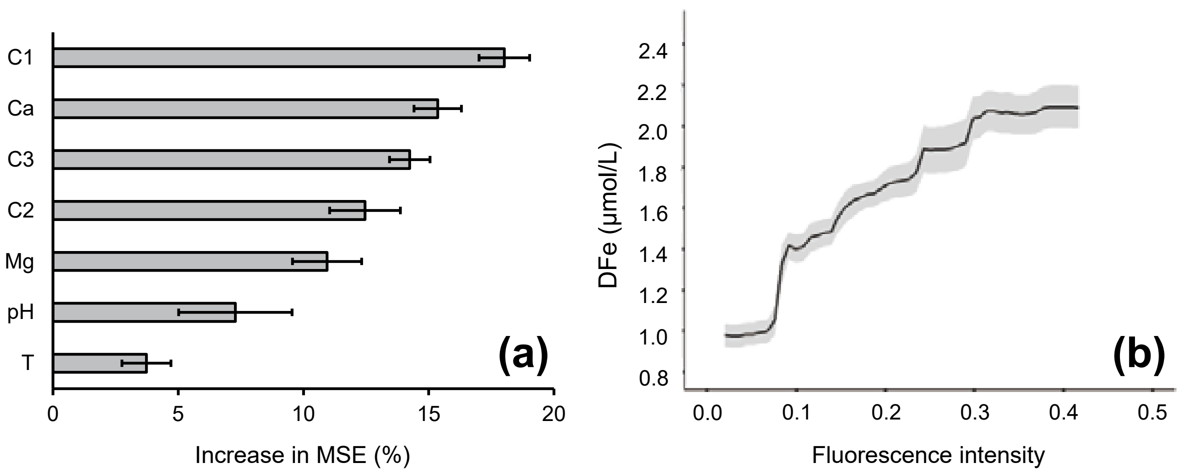


Fig. 2. (a) Importance of the predictor variables in the RF models for dissolved iron (DFe) and (b) PDP of DFe on a humic-like component (C1)
The bars and error bars in 'panel a' represent the mean value and standard deviation, respectively, for 15 RF models from three repetitions of five-fold cross-validation. T denotes water temperature.

the concentration of dissolved organic carbon (DOC) and the abundance of three humic-like components (C1 ~ C3) identified by fluorescence excitation-emission matrix coupled with parallel factor analysis (EEM-PARAFAC). Water temperature and areal share of poorly-drained lowland soil (Gleyic Fluvisols) were identified as the most important predictor variables for DOC and the humic-like components (Table 1) and positively influenced these DOM parameters (Fig. 1). This result indicates that the concentrations of DOC and humic-like components exhibit clear seasonal variations with their maxima in summer and that the poorly-drained lowland soil serves as the major source of riverine DOM (particularly humic-like components) in the studied catchments. The RF model for DFe using the abundance of EEM-PARAFAC components and other parameters relevant to iron solubility (e.g., water temperature, pH, concentrations of Ca^{2+} and Mg^{2+}) as predictor variables also explained a large portion of the variation in DFe concentration. A humic-like component derived from terrestrial material (C1) was the most important predictor variable and had a positive relation to DFe concentration (Fig. 2), emphasizing its significance as an organic ligand for iron.

The results obtained in this study improve our understanding of the spatiotemporal variability of terrestrial DOM and iron loadings and their impacts on tropical coastal ecosystems of high ecological and economic importance.

Reference

Kikuchi, T., Anzai, T., Ouchi, T. (2023) Assessing spatiotemporal variability in the concentration and composition of dissolved organic matter and its impact on iron solubility in tropical freshwater systems through a machine learning approach. *Science of the Total Environment* 904: 166892. © Elsevier B.V.

Table and figures reprinted/modified from Kikuchi et al. (2023) with permission.

(Kikuchi, T., Anzai, T. [JIRCAS])

TOPIC 9

Visualizing the mitigation effect of nitrogen load and chemical fertilizer use, and resource recycling using the food nitrogen footprint concept

The recent price hikes in fertilizers, feeds, and food threaten the global food system, people's livelihoods, and food security. This unstable global situation seriously affects small islands because they heavily rely on importing food and chemical fertilizers to sustain food supply and production. Chemical fertilizer is essential for crop production. However, inefficient use of fertilizers causes considerable loss of reactive nitrogen (Nr) to the environment through volatilization, leaching, and run-off. This phenomenon pollutes the atmosphere, groundwater, and surface water bodies, damaging the environment. To reduce the release of Nr into the environment, we should minimize the use of chemical fertilizers and promote the efficient reuse of regional resources, such as livestock manure. Farmers alone cannot improve nitrogen flow in the food system. The cooperation of consumers, the main driving force of nitrogen flow in the food system, is also essential. The nitrogen footprint is a simple quantitative indicator of the reality and problems of the nitrogen cycle and is useful for sharing results among stakeholders, including consumers. In this study, we aimed to evaluate the present nitrogen flow in the food system of Ishigaki Island, located in the subtropical zone of Japan, and propose a measure to improve it based on the nitrogen

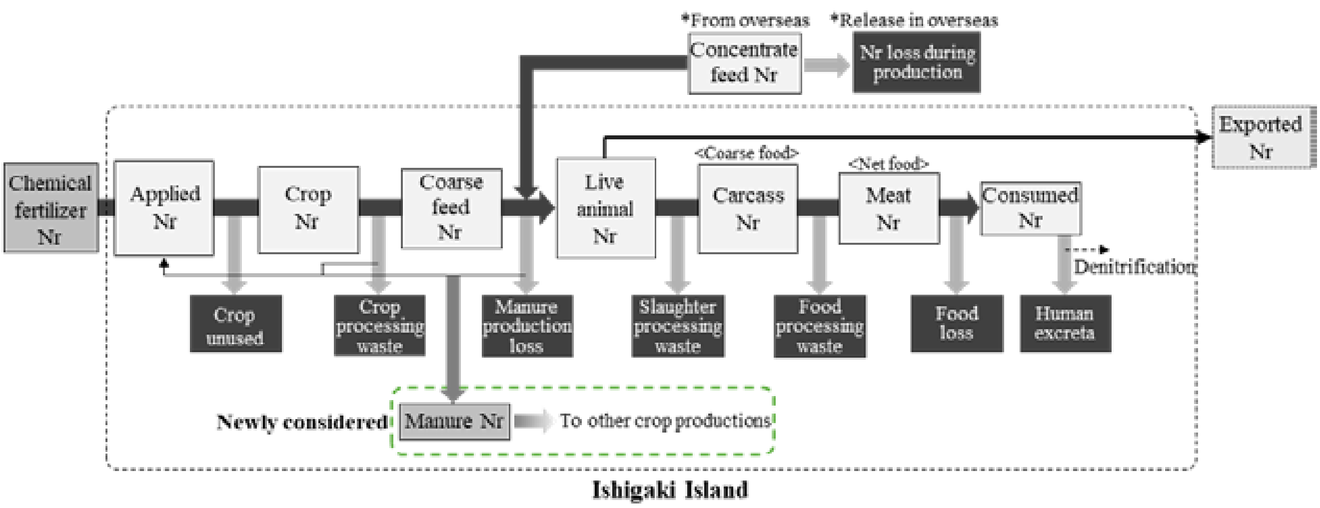


Fig. 1. Schematic for calculating nitrogen flow in livestock production
Nr represents reactive nitrogen. The present study newly considered manure distribution to other crop production.

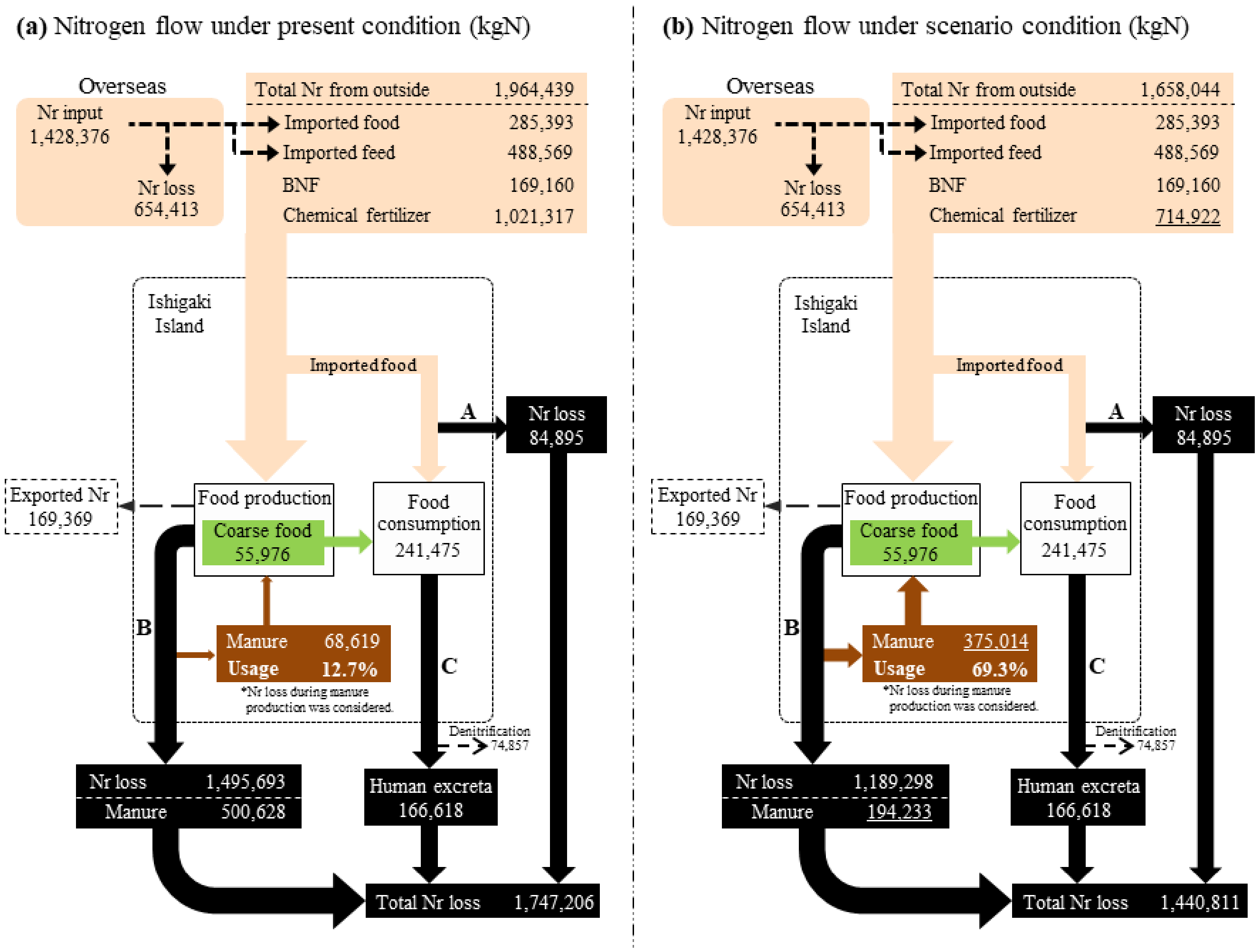


Fig. 2. Nitrogen flow under the (a) present and (b) scenario conditions
Nr is reactive nitrogen, BNF is biological nitrogen fixation, and 'denitrification' is the removed Nr by denitrification from human excreta during sewage treatment. The underlined values indicate differences between the present and scenario conditions. Arrows A–C represent food processing waste and food loss of imported coarse food (A), all Nr losses excluding human excreta in the food system (B), and human excreta after food consumption (C).

footprint concept.

We calculated Nr loss under the present condition of Ishigaki Island using statistical data (Figs. 1 and 2a). It aimed to assess the nitrogen load of the island's entire food system, including imported food and feed and exported food. The study also explored scenarios for achieving a 30% reduction in chemical fertilizer use, a goal of the Sustainable Food Systems Strategy, MIDORI, by maximizing the use of livestock manure on farmland. The results showed that by utilizing 70% of cattle manure on farmland, Nr inputs to crop production could be maintained even with a 30% reduction in chemical fertilizer use, ultimately reducing total Nr loss on Ishigaki Island by 18% (Fig. 2b).

The food nitrogen footprint applied in this study holds promise for similar tropical and subtropical island regions. It aligns with the United Nations Sustainable Development Goals (SDGs) and the Sustainable Food Systems Strategy, MIDORI. It is expected to aid in the development of strategies to address the recent volatility in chemical fertilizer prices.

Reference

Hamada et al. (2023) *Environmental Research Letters* 18: 075010. © The Author(s) 2023
The figures were reprinted/modified from Hamada et al. (2023).

(Hamada, K., Oka, N. [JIRCAS], Eguchi, S., Hirano, N., Asada, K. [NARO])

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 remains 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 information and communication technology (ICT) and the Internet of Things (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 the 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 2023. Regarding rice, we found that early-morning flowering lines have superior nitrogen utilization efficiency. Through comprehensive measurement of metabolites, we identified candidate substances important for phosphorus utilization. For soybean, we generated a breeding line that integrates the salt tolerance gene *Ncl* and root length QTL (quantitative trait loci). We created a list of gene candidates that contribute to the pathogenicity of the soybean fungal pathogen, *Cercospora kikuchii.* For quinoa, we identified a group of genes associated with the sodium accumulation response over time among lines representing the population. Bolivian germplasm seeds and data were collected. The entire genome sequence of a quinoa-derived microbial strain that has plant growth-promoting effects was decoded. In addition, we developed a crop drought stress evaluation system in the field using ridges, and elucidated a new drought stress response mechanism in plants. We also predicted nitrate ion absorption by plants using a mathematical model. We have discovered a wild soybean gene that increases protein content without decreasing lipid content.

[Indigenous crops and foods design]

For design-oriented crop breeding and food processing of indigenous resources to create new and diversified demands, we focused on the following research in FY 2023. We analyzed the sequences of key genes for flavonoid biosynthesis in black and white rice, which are representative of domestic and Lao rice. From the results, we suggested that functional rice breeding utilizing variation in this gene is effective for domestically produced white rice and some Laotian white rice varieties. In order to develop a method for producing lactic acid-fermented amazake that suppresses the growth of *Staphylococcus aureus*, a food-poisoning bacterium, that is suitable for the environment of Southeast Asia, we used the heat-resistant lactic acid bacteria that we had discovered to ferment lactic acid at 45°C. As a result, we confirmed that *S. aureus* was killed under these conditions. Ultraviolet (UV) radiation is stronger, and the temperature is lower in mountainous areas than in flatlands. We have revealed that genes involved in the accumulation of substances such as taxifolin respond to UVB and low temperatures. Furthermore, we found that it is possible to achieve both productivity and quality in black rice by optimizing phosphorus fertilizer management. In addition, with the cooperation of the Wakasa Bay Energy Research Center, which we started collaborating with in 2023, we are the first in the world to demonstrate that black rice grown in mountainous areas has a higher active oxygen scavenging ability than black rice grown in flatlands. Furthermore, as a result of evaluating the starch properties of Laotian rice genetic resources cultivated for three years in the Fukui Prefecture Agricultural Experimental Field, we found a strain that does not become hard even when cooled and is less prone to senescence. These are used in domestic multipurpose rice breeding. We also developed a labor-saving, high-yield cultivation method for yam and clarified the effects of mixed cultivation with cowpea.

[Transboundary pest management]

For the development of an environment-friendly management system against transboundary plant pests based on ecological characteristics, we focused on the following research in FY 2023. We revealed that desert locusts are able to mass spawn without damaging the eggs because of information obtained from the sensory hairs on their ovipositors. Furthermore, we developed a method to quantify pesticide application efficiency using water-sensitive paper in Mauritania. We have established a simple pesticide susceptibility monitoring method for the rice planthoppers. We evaluated the side effects of insecticides on the natural enemies of fall armyworm in Thailand and found insecticides that have a high possibility of being used in combination with the natural enemies. In order to develop efficient pesticide application technology, we conducted a demonstration test in collaboration with two private companies at a baby corn field in Thailand. The results showed that aerial spraying of insecticides containing high-functionality adjuvants using unmanned helicopters may increase yields compared to conventional methods. We analyzed corn supply and demand trends in Myanmar, Thailand, Laos, Cambodia, Vietnam, and other countries located in the lower Mekong River basin. As a result, we found that the spread of fall armyworm and its current control may have a limited impact on supply and demand. We also conducted a management analysis of corn-producing farmers in Thailand. The results confirmed that current pest control methods are too costly and that the direction of technological development aimed at reducing the amount of pesticides used and increasing the efficiency of spraying is correct. In addition, we have published a test method for international comparison of the test results using the simple test method for insecticide susceptibility of fall armyworm developed up to last year. In addition to joint research institutes in Thailand and the National Agriculture and Food Research Organization (NARO), the Royal Agricultural University of Cambodia is also scheduled to participate in the international comparison. We elucidated the behavior of desert locusts to avoid cannibalism during molting.

[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 2023. Based on continuous observation of the environment at major oyster farms in Malaysia, we inferred that the cause of mass mortality of small oyster seedlings was an oxygen-deficient environment and poor feeding, and worked to develop an intermediate growing device to solve these problems. As a result, we found that aeration counteracted oxygen deficiency and promoted shell elongation, and that the function of upwelling water improved feeding efficiency. We succeeded in developing a simple intermediate growing device by using inexpensive materials that are easily available in rural areas. We elucidated the life history, such as mature size and growth of high-grade freshwater shrimp in Thailand. Through tests conducted in Thailand, we have confirmed that dried seaweed feed has the same red coloring effect on shrimp as fresh seaweed feed. We conducted growth and survival experiments using our developed intermediate rearing technology for sea cucumber that combines a floating method and a bottom method at three locations with different environmental conditions (Igan and two locations around Panobolon Island) in the Philippines. As a result, we found that a high survival rate of the sea cucumber can be achieved by releasing the intermediate seedling during periods of high water temperature, and that the survival rate varies depending on the bottom topography (location) even if the water quality is almost the same. We have significantly improved the survival rate (from a few percent to about 40 percent) by applying the intermediate rearing technology we developed. Based on the prototype system dynamics (SD) model, we formulated a scenario for aquaculture, including the scale of sea cucumber aquaculture and risk management, and proposed it to a collaborative research institution.

[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 2023. We improved the spatio-temporal variation prediction model for estimating flooded area in the rice fields of Tanzania, and estimated the initial water use based on the model for estimating flooded area and time in the target area. We showed that by introducing the root length locus *qRL6.1* and the paddy number locus *SPIKE* into NERICA4 and NERICA1, it is possible to improve upland rice yield in environments where water shortage occurs during the ripening stage. We have accumulated nutritional data for the core collection of vegetable amaranth. We also found that in Madagascar, P-dipping has a large yield-increasing effect when seedlings with ca. 4.5 to 6.5 leaves (including primary leaf) are used. We have promoted the spread of P-dipping and found that this technology has a large yield-increasing effect when used with shallow-rooted rice, but shallow-rooted rice has a small nitrogen response. We showed that the inoculation of *Ct* fungi after mycelial cultivation significantly increased the yield of Komatsuna in phosphorus-deficient soils along with the increases in the abundance of microorganisms in the rhizosphere, including *Ct* fungi and phosphorus-dissolving bacteria. Among the wild relatives of cowpea, we found that lines that maintain the plant phosphorus concentration under phosphorus deficiency grow less, but have excellent drought stress tolerance. We showed that increasing production of milk and dairy products significantly improved the stunting of children (< 5 years old) over time among rice farmers in the central highlands of Madagascar. In addition, we have developed and released a new upland rice variety in Madagascar. We showed that P-dipping is effective in various field environments, including flood damage and nitrogen fertilization. The quantitative locus *MP3*, which increases panicle number, was utilized for breeding. We have published a simple method for estimating the phosphorus-fixation capacity of soils based on the air-dry moisture contents, which can be used for phosphorus fertilization diagnosis. In collaboration with many rice researchers in Japan and overseas, we have developed a model and app "HOJO" that quickly and easily estimates rice yield from digital images of rice canopy at maturity. Our approach leverages machine-learning techniques and uses data collected by JIRCAS. Additionally, we provided a lot of information necessary for machine learning. This method is expected to be used in a wide range of fields, including understanding rice production in developing regions, which has been difficult to survey, selecting optimal cultivation methods, selecting superior lines, and formulating policies. Currently, we are using this app to evaluate IRRI's genetic resources with the support of Google.

[Africa upland farming system]

For technology development to facilitate farmers' decision-making and boost sustainable upland farming systems in Africa, we focused on the following research in FY 2023. In northern Ghana, we conducted crop cultivation trials in experimental fields and confirmed that maize yields can be increased through intercropping with cowpea and relay cropping of maize and cowpea. We elucidated the effectiveness of rhizobial inoculation in soybean cultivation and investigated the influence of tillage methods on crop yield. Furthermore, we initiated trials and surveys in farmers' fields using newly designed research methodologies for agricultural planning. We selected a livestock feed preparation method suitable for small-scale farmers and developed a model (prototype) for estimating the amount of water for field irrigation using reservoirs. In Burkina Faso, we showed that the fallow band system could be more effective when combined with minimal fertilization. To assess the impact of soil erosion, we conducted a topsoil stripping test (i.e., to remove the topsoil) and found that cowpeas are susceptible to yield reduction due to soil erosion. Additionally, through a field workshop, we obtained technical evaluations from farmers regarding the improved soil conservation techniques. We showed that the yield response of crops to soil type differed depending on the climate zone, and that the yield response was influenced by differences in early growth. Using new cultivation data, we refined the yield prediction model for each crop. We clarified the adoption status of intensive agricultural techniques in northern Ghana. Also, we investigated the dissemination status of soil conservation techniques in Burkina Faso and collected relevant data. In addition, we compiled and published results regarding the estimation of the impact of climate change on cowpea cultivation in the Sudan Savanna. The irrigation suitability of reservoir beneficiary areas in northern Ghana was estimated. We also summarized and published results on the differential response of sorghum to fertilization between Plinthosols with a shallow functional layer and other soil types, as well as the effects of fertilization and sowing density on cowpea yield in the dominant soil types of the Sudan Savanna.

TOPIC 1

A QTL allele from wild soybean enhances protein content without reducing the oil content

Soybean, which contains approximately 40% protein and 20% oil, is one of the most important sources of protein and oil for human consumption, providing over 71% of the world's plant-based protein and more than 29% of the oil. Generally, soybean protein content shows a negative correlation with oil content, making it difficult to develop varieties with high protein and oil content. Therefore, it is necessary to identify new genes involved in soybean protein and oil content. Wild soybean, the ancestor of cultivated soybean, possesses higher seed protein content than cultivated varieties. Therefore, wild soybean is a valuable genetic resource that could enhance the protein content of cultivated varieties.

To identify the genes responsible for increasing protein content in wild soybean, a population comprising 113 BC_4F_6 chromosome segment substitution lines (CSSL) was developed from a cross between soybean cultivar 'Jackson' and wild soybean accession JWS156-1. The CSSL population was cultivated in field conditions for 3 years (2018, 2019, and 2020), and the seeds harvested from each line were analyzed for protein and oil contents using the Infratec NOVA instrument (Fig. 1). Additionally, quantitative trait locus (QTL) analysis was performed using 243 SSR markers. As a result, we identified 12 QTLs on eight chromosomes associated with seed protein, oil, and protein + oil contents. Among them, the wild soybean allele of protein QTL *qPro19* located on chromosome 19 (Fig. 2) was confirmed to increase protein content without reducing oil content in soybean seeds. To validate the effect of *qPro19*, near-isogenic lines (NILs) for *qPro19* were developed. Analysis of protein and oil contents showed that the wild soybean type NIL exhibited higher protein content compared to the cultivated soybean type NIL, but there was no significant difference in oil content. Furthermore, BC_4 line T-678, which introduced the *qPro19* allele of wild soybean into another soybean variety, 'Tachiyutaka,' showed enhanced seed protein content without reducing the seed oil content (Fig. 3).

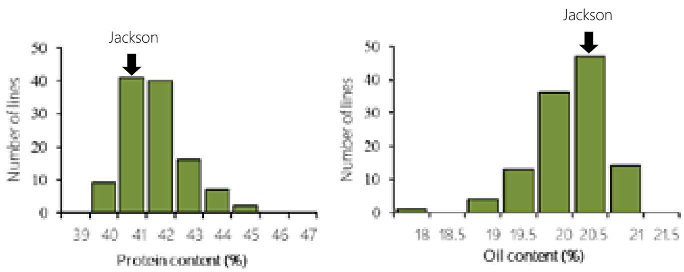


Fig. 1. Frequency distribution of seed protein content (L) and oil content (R) in the wild soybean CSSL population
The protein content and oil content represent the average values over three years from 2018 to 2020. Arrows indicate the observed values for 'Jackson.'

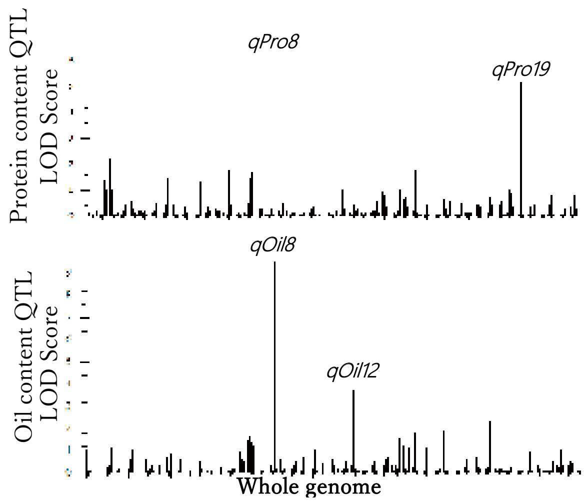


Fig. 2. QTL analysis results of protein content and oil content in the wild soybean CSSL population
QTLs were detected based on the average values over three years. *qPro19* detected on chr 19 is the focus of this study. *qPro8* and *qOil8* detected on chr 8 are previously reported for protein and oil contents. *qOil12* is a minor QTL for oil content. LOD value: A statistical estimate of whether a trait is linked to a certain locus.

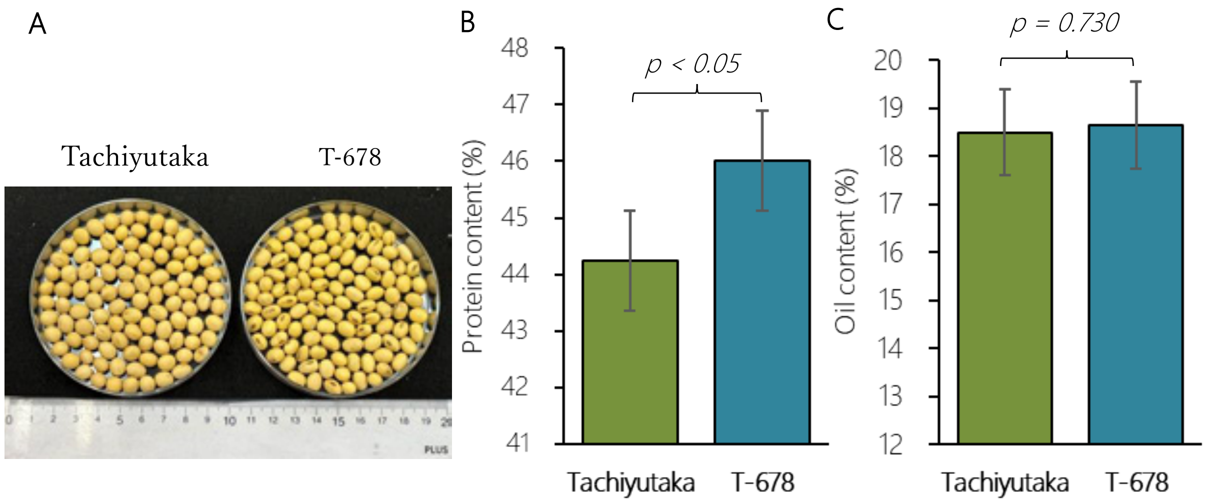


Fig. 3. The allele effect of *qPro19* in a BC_4F_6 backcrossing line T-678
(A) Appearance of 'Tachiyutaka' and T-678 seeds, (B) Protein content, and (C) Oil content. Error bar means standard deviation.

The wild soybean allele of the protein content QTL *qPro19* identified in this study can be utilized as genetic material for developing soybean varieties with high levels of both protein and oil content, as well as for improving protein content in specific soybean varieties.

Reference

Park et al. (2023) *Plant Genetic Resources* 21: 409–417.

(Park, C., Xu, D. [JIRCAS])

TOPIC 2

Development of the drought stress experimental system in the field with ridges

The frequency and damage of droughts have been increasing in recent years, threatening the world's food supply. To develop drought-tolerant crops, many drought studies have been conducted, mainly in the laboratory, and the drought stress response mechanisms of plants have been elucidated at the molecular level. On the other hand, it has been pointed out that the drought stress response of plants in the field differs in some respects from the response mechanisms that have been elucidated in the laboratory, and there are still many unknowns. In the development of drought-tolerant crops, it is essential to conduct drought tolerance tests and elucidate the drought

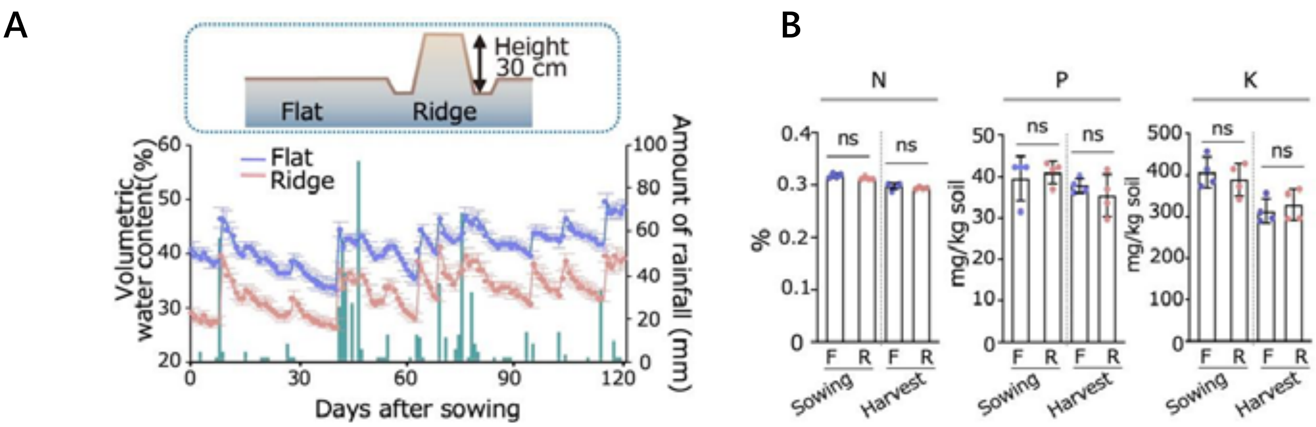


Fig. 1. Soil moisture variability and soil nutrient composition in the field drought stress experimental system with ridges
(A) Time course of soil VWC in the flats (no ridges) and 30-cm high ridges during soybean-growing season. A 30-cm-long soil moisture sensor (TDR) and a temperature sensor were inserted in each test plot, and data were recorded over time by a data logger. n = 4, error bars indicate SD. Green bars indicate precipitation. (B) Nutrient contents of soil in flats and ridges at soybean sowing and harvesting times. n = 4, error bars indicate SD, and ns indicates no significant difference (Student's t-test).

response mechanisms of plants in the field, but it is not easy to reproduce a constant drought environment in the field where the environment fluctuates irregularly.

To overcome the various problems associated with drought trials in the field, we focused on "ridges." During 6 years of trials, we showed that the volumetric water content (VWC) in ridges (ridge height, 30 cm) was consistently lower than that in the flats (Fig. 1A). We also demonstrated that there was no significant difference in the contents of nutrients, nitrogen (N), phosphorus (P), and potassium (K) between the flats and ridges, both at the beginning and at the end of the soybean growing season (Fig.1B). We compared soybean growth in this system. The aboveground biomass of plants grown on ridges was clearly reduced compared with that of plants grown on flats; consequently, the yield of soybean grown on ridges was also reduced compared with that of soybean grown on flats (Fig. 2). The negative effect of ridges on plant growth and yield was complemented by irrigation, indicating that the reduction in plant growth on the ridges was mainly due to lack of water (Fig. 3). Together, these observations demonstrate that ridges are a valuable tool for inducing conditions that mimic mild drought stress in the field.

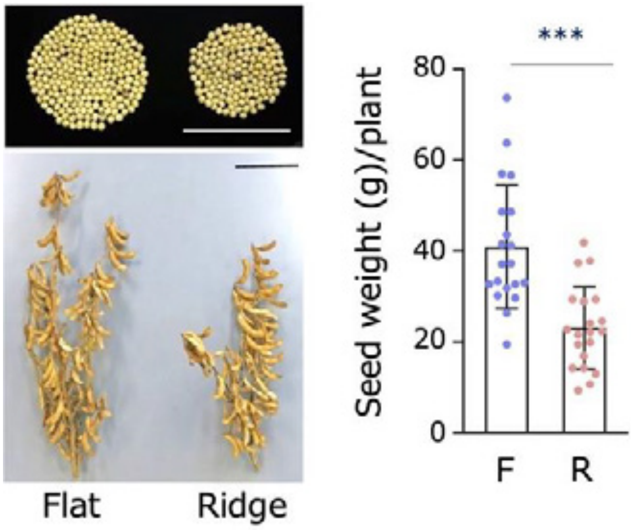


Fig. 2. Soybean growth in the field drought stress experimental system with ridges
Morphology and yield at harvest of soybean grown in this drought stress experimental system. The left side shows the flats (F), and the right side shows the ridges (R). Bars indicate 10 cm in the pictures. n = 20, error bars are SD, and asterisks indicate significant differences (***$p < 0.001$, Student's *t*-test).

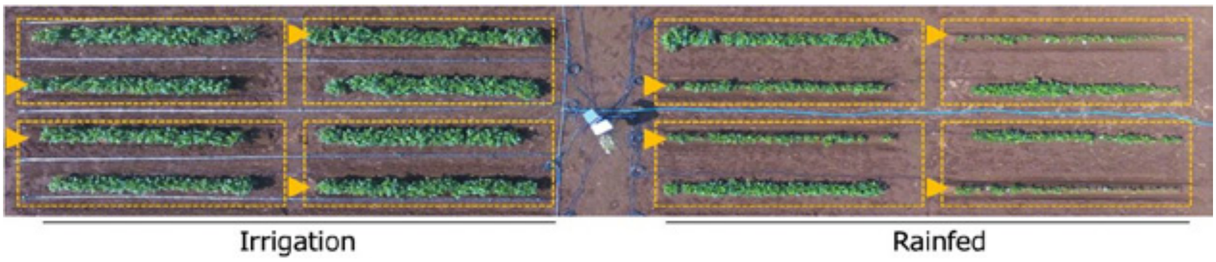


Fig. 3. Irrigation treatment for the field drought stress experimental system with ridges
Growth of soybean about 7 weeks after sowing, taken aerially by drone. Ridges are indicated by yellow arrows. The two rows surrounded by dotted lines indicate one replication including the flat and ridge areas, for a total of four replications of the trial. On the right is the rainfed area (no watering) and on the left is the test area that was irrigated to the same test design as the rainfed area on the right (irrigated area). The white box in the center contains the data loggers connected to the soil moisture sensors inserted in each row.

Although the height and width of the ridges need to be considered depending on the target plants, soil type, and desired level of drought stress, the developed drought stress experimental system is applicable to fields in various regions of the world and is expected to facilitate the selection and production of drought-tolerant lines.

Reference

Nagatoshi et al. (2023) *Nature Communications* 14: 5047. © The Author(s) 2023.

The figures were reprinted/modified from Nagatoshi et al. (2023).

(Nagatoshi, Y., Kobayashi, Y., Fujii, K., Baba, J., Fujita, Y., Ikazaki, K., Oya, T. [JIRCAS])

TOPIC 3

Novel drought stress response mechanisms in plants

Drought is the most serious environmental stress that threatens crop growth and survival. Even a mild drought with no leaf wilting can significantly reduce crop growth and have a profound impact on yields. Therefore, early detection of such "invisible droughts" and appropriate measures such as irrigation are important for stable crop production. However, the response of crops to "invisible drought" in the field and its mechanisms have not been well understood. In this study, using a drought stress evaluation system with ridges we developed, we elucidated the plant response to the "invisible drought" that occurs in the field and its physiological significance through detailed analysis in the laboratory and using model plants.

To understand the plant response to the "invisible drought" that occurs in the field, we conducted RNA sequencing analysis using the leaves of soybean grown on flats and those grown on ridges. The data showed that a battery of phosphate starvation response (PSR) genes was up-regulated under mild drought conditions (Fig. 1). By elemental analysis of the leaves, it was demonstrated that mild drought stress reduces levels of inorganic phosphate (Pi) among the three primary macronutrients, N, P, and K, in plants in the field. In addition, we showed that the expression of PSR genes is induced in a soil water-dependent manner during the initial phase of drought stress in soybean grown in pots with controlled soil water contents. Furthermore, as drought stress intensifies, the expression of abscisic acid (ABA) response genes is induced (Fig. 2). Not only in soybean but also in *Arabidopsis thaliana*, the expression of PSR genes is induced in the early phase of drought stress before the expression of ABA response genes is induced, suggesting that the newly found phenomenon is universal in plants. In PSR-deficient *Arabidopsis* mutant plants, growth is significantly suppressed by mild drought stress compared to wild-type plants, suggesting that induction of PSR gene expression under mild drought stress plays an important role in maintaining growth during water stress (Fig. 3).

Phosphate content and expression of PSR genes are

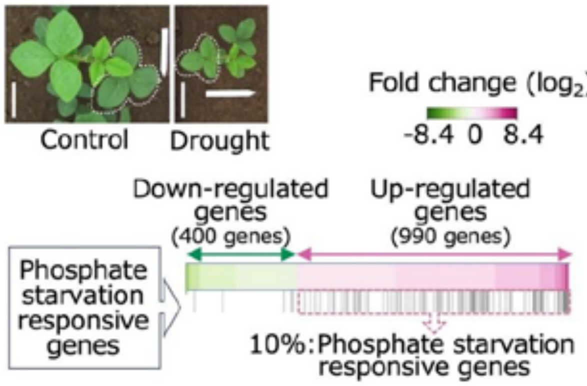


Fig. 1. Induction of PSR genes in soybean leaves under mild drought conditions in the field
Transcriptome analysis of soybean grown in a drought stress evaluation system using ridges in the field. The second leaf of soybean at 31 days after sowing (dotted line in the photo) was used for RNA-seq analysis. Bars in the photo represent 10 cm.

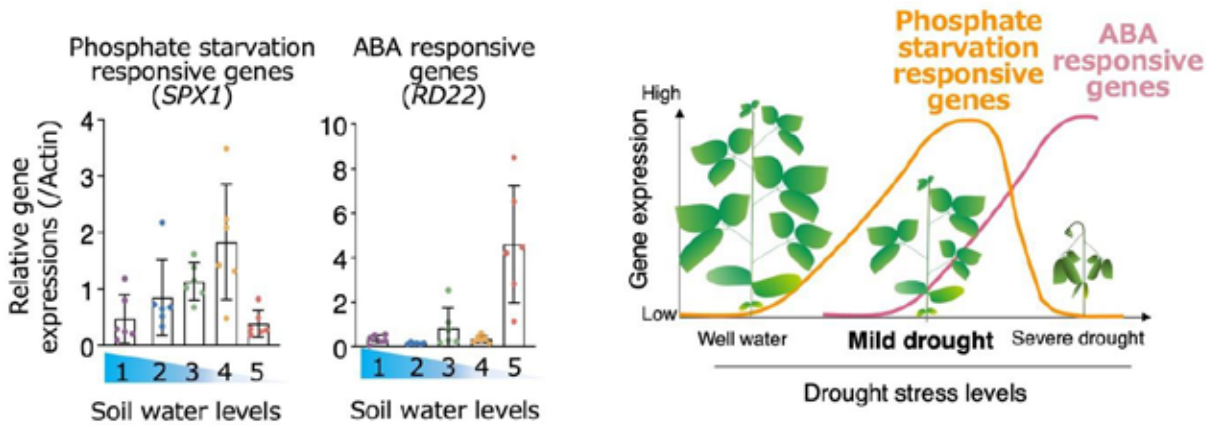


Fig. 2. Expression of PSR genes and ABA-responsive genes induced in a soil water-dependent manner during mild drought
(A) Gene expression analysis of soybean grown in a greenhouse under controlled soil water levels in pots (levels 1-5; higher values indicate less water and greater degree of drought). n = 6, error bars = SD. (B) Model diagram of a newly presented plant drought stress response.

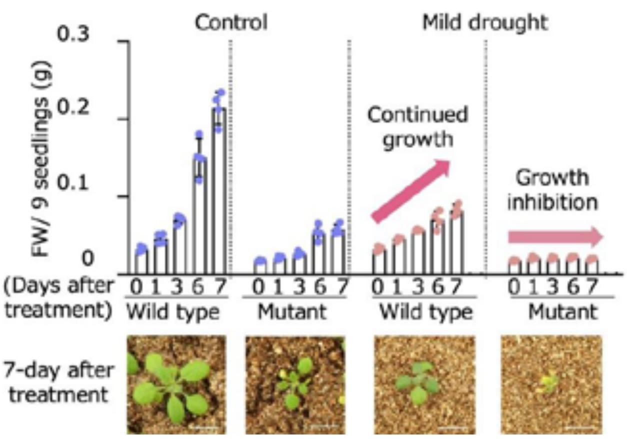


Fig. 3. Drought stress response of *Arabidopsis* PSR-deficit mutants
Growth changes in drought stress-treated *Arabidopsis* wild-type plants and PSR-deficit mutants in which the PSR genes are not induced. Aboveground biomass is shown at 1, 3, 6, and 7 days after drought stress treatment (after water supply to the growing pots was stopped). Bars in the pictures represent 1 cm. n = 4. Error bars indicate SD.

expected to contribute to the development of plant water sensors as early indicators of "invisible drought," but it is necessary to consider the possibility that environmental conditions other than soil moisture may also affect the induction of phosphate deficiency responses.

Reference

Nagatoshi et al. (2023) *Nature Communications* 14: 5047.

The figures were reprinted/modified from Nagatoshi et al. (2023).

(Nagatoshi, Y., Kobayashi, Y., Fujii, K., Baba, J., Fujita, Y., Ikazaki, K., Oya, T. [JIRCAS], Mizuno, N., Yasui, Y. [Kyoto Univ.], Sugita, Y. [Nagoya Univ.], Takebayashi, Y., Kojima M. [RIKEN], Sakakibara H., [RIKEN & Nagoya Univ.], Kobayashi, I. N., Tanoi, K. [Univ. of Tokyo]., Ogiso-Tanaka, E., Ishimoto, M. [NARO])

Mathematical modeling is an effective approach in predicting the temporary expression pattern of the nitrate transporter gene *NRT2.1*

Nitrogen (N), a constituent of many biomolecules such as nucleic acids and proteins, is an indispensable element for plants. Among the major forms of N, nitrate is prevalent under oxidative environments and its availability is closely related to plant growth. However, excessive nitrate uptake leads to increased energy use and reduced pathogen resistance. Thus, plants fine-tune nitrate uptake by regulating the expression of the gene encoding a major nitrate transporter, *NRT2*. Although it is important to manipulate the expression of *NRT2* to modify N use, intuitively understanding key components for such a modification is difficult, especially when the gene is under a complex regulation. For designing plants with optimized N use and increased resilience, it is important to quantitatively understand the changes in the response caused by changes in the regulatory pattern. This study aimed at elucidating important regulatory factors for *NRT2* by comprehensively analyzing its regulatory system via mathematical modeling.

Temporary changes in the expression of Arabidopsis *NRT2.1* (a member of the *NRT2* family) were fitted to an ordinary differential equation to determine coefficients, and a mathematical model describing the temporary expression pattern of *NRT2.1* and other related molecules was developed (Fig. 1). The model predicted that the absence of negative regulation of *NRT2.1* by NIGT1, a transcriptional repressor, decreases the stability of *NRT2.1* expression under a wide range of activity of NLP, which induces the expression of *NRT2.1* and *NIGT1* genes in the presence of nitrate (Fig. 2). This hypothesis was further validated experimentally using mutant plants lacking the regulatory pathway from NIGT1 to *NRT2.1*; the expression of *NRT2.1* was stable under a wide range of nitrate concentrations in the wild-type plants, whereas the expression of *NRT2.1* was greatly affected by nitrate concentrations in the mutant plants (Fig. 3).

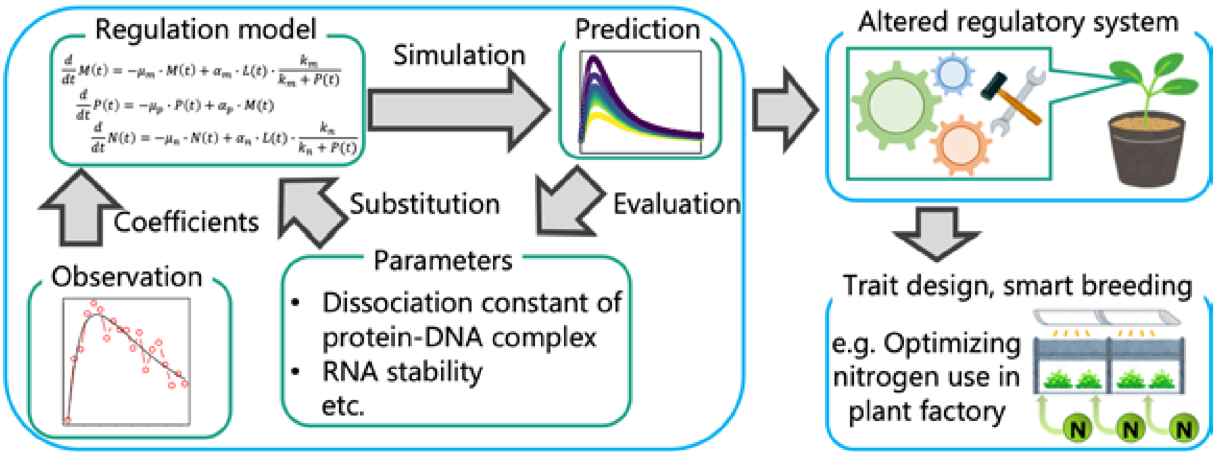


Fig. 1. Concept diagram of the development and use of a mathematical model
Coefficients obtained from experimental data are used to construct the regulation model. The effect of each parameter on the response pattern is evaluated by simulations. The results of simulation shall be used to alter regulatory systems and design crops conferred with a desirable trait.

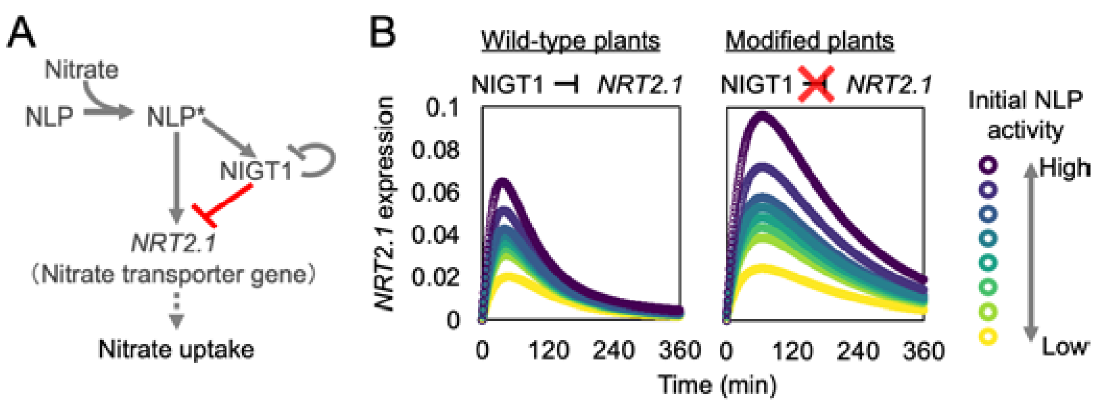


Fig. 2. Regulatory systems involved in nitrate use and prediction of their behavior
(A) Regulatory system involved in nitrate use. Arrow and T sign indicate promotive and suppressive effects, respectively. NLP* indicates activated NLP protein in the presence of nitrate. (B) Predicting the temporary expression pattern of *NRT2.1* in wild-type plants (left panel) and modified plants (right panel) lacking NIGT1 regulation (red sign in A).

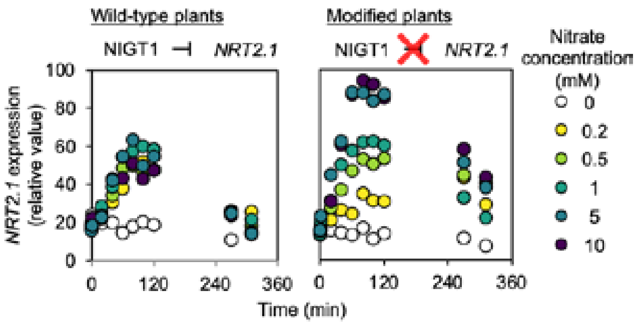


Fig. 3. Experimental validation of the simulation result
Experimentally determined expression levels of *NRT2.1* in the presence of different nitrate concentrations are shown for wild-type plants (left panel) and modified plants (right panel) lacking NIGT1 regulation.

The quantitative description of the temporary response pattern related to N use provides clues on which regulatory component should be altered for a certain desired response. Since a similar regulatory pattern of *NRT2* is conserved in other plant species including rice, this mathematical modeling is likely to be effective in other plant species. This approach is also applicable to other traits and other plant species, especially when the trait is under a complex regulation. This approach is useful for designing plants with favorable traits and accelerating smart breeding. Further understanding of molecular mechanisms and the expansion of more fundamental data will be helpful to accelerate the applicability of this approach.

Reference

Ueda and Yanagisawa (2023) *Plant Physiology* 193: 2865–2879. © The Author(s) 2023
The figures were reprinted/modified from Ueda and Yanagisawa (2023).

(Ueda, Y. [JIRCAS], Yanagisawa, S. [Univ. of Tokyo])

TOPIC 5

Optimum phosphorus fertilizer management can balance productivity and quality of black rice

The Southeast Asian region has a rich tradition of utilizing black rice for its medicinal properties. Black rice pericarp contains various secondary metabolites such as anthocyanins, which are known for their antioxidant effects including restoring liver function and preventing dementia. In tropical areas such as Laos, where black rice is commonly consumed, soils typically lack phosphorus (P), an essential nutrient for crops. Therefore, external P supply is crucial to boosting productivity. However, with rising fertilizer costs and the adoption of labor-saving rice cultivation techniques, it is vital to determine the optimal P fertilization levels. Additionally, understanding the impact of P fertilization on flavonoid accumulation, which contributes to antioxidant properties, is necessary. This study aims to conduct pot trials using P-deficient soil to evaluate how soil P availability affects black rice yield and flavonoid content, which serves as an indicator of antioxidant capacity. The goal is to identify the optimal P fertilization strategy to balance productivity and quality in black rice cultivation.

Pot trials conducted on volcanic soils with limited P availability revealed that P fertilization enhances yield up to a certain point but becomes excessive beyond 250 mg

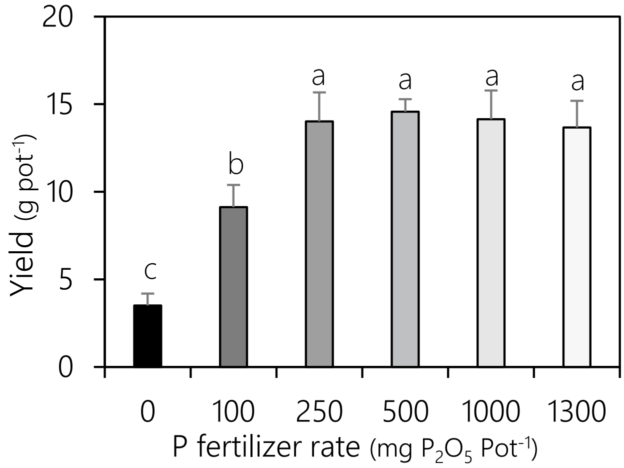


Fig. 1. Yield increases with P application.
Black rice "Asamurasaki" was grown under pot conditions with different amounts of P application rates. Different alphabets indicate significantly different at 5% level (Tukey method, n=5). Error bars in the figure indicate standard deviation.

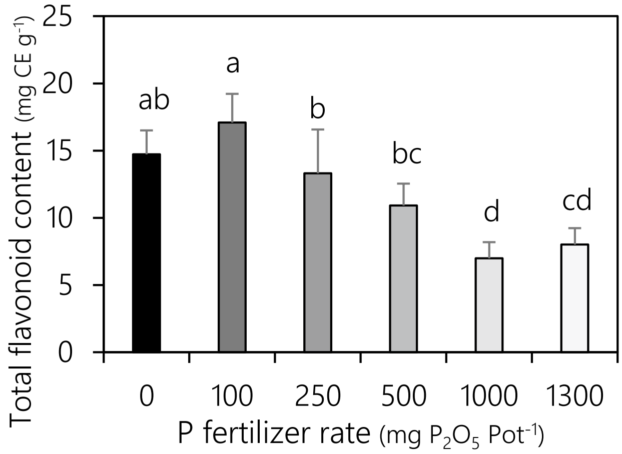


Fig. 2. Total flavonoid content decreases with P application.
Different alphabets indicate significantly different at 5% level (Tukey method, n=5). Error bars in the figure indicate standard deviation.

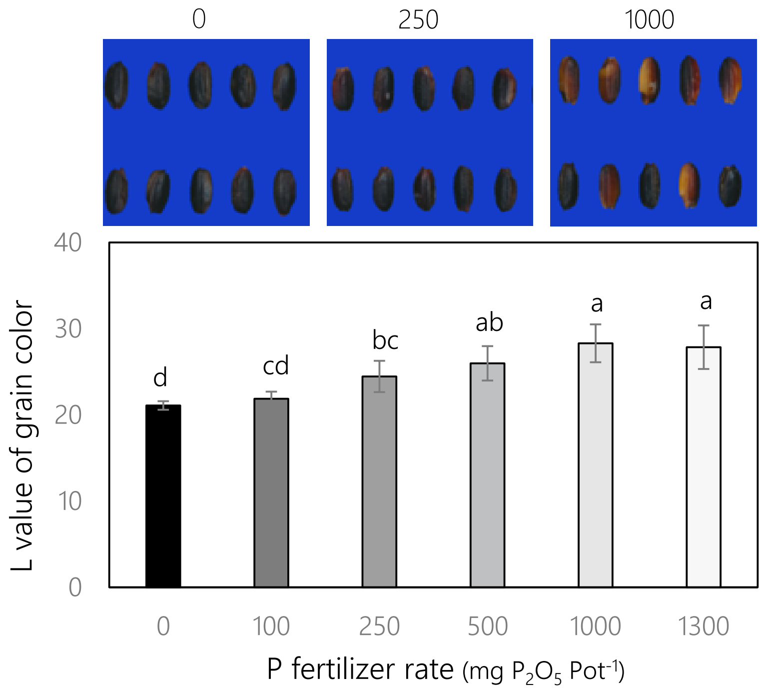


Fig. 3. Lightness of grain color increases with P application.
L value (indicator of lightness) of grain surface was measured with GIE-Lab method.
L value close to 100 shows white color and close to 0 shows black color.
Different alphabets indicate significantly different at 5% level (Tukey method, n=5). Error bars in the figure indicate standard deviation.

P_2O_5 pot^{-1} (Fig. 1). Exceeding this threshold not only fails to further increase yield but also reduces flavonoid content (Fig. 2) and affects the rice's appearance by lightening its color (Fig. 3). Therefore, P fertilization beyond 250 mg P_2O_5 pot^{-1} compromises both flavonoid accumulation and appearance traits.

These findings underscore the importance of careful P fertilization management in P-deficient soils. While it boosts black rice yield, excessive fertilization negatively impacts flavonoid content and appearance quality. Thus, adopting proper P fertilizer management practices is essential for producing high-value black rice that maintains a balance between productivity, functionality, and appearance quality. This knowledge can guide cultivation practices tailored to diverse soil conditions in different regions.

Reference

Oo, et al. (2023) *Frontiers in Sustainable Food Systems* 7: 1200453. © The Authors 2023
The figures were reprinted/modified from Oo et al. (2023).

(Oo, A.Z., Asai, H., Kawamura, K., Takai, T., Tanaka, J.P., Marui, J., Saito, H. [JIRCAS], Kawamura, K. [OUVAM], Win, K.T. [NARO]

TOPIC 6

A simple bioassay method for international comparison of insecticide susceptibility of the fall armyworm, *Spodoptera frugiperda* (J.E. Smith)

The fall armyworm (FAW), *Spodoptera frugiperda*, was a native pest in the Americas (Fig. 1). However, FAW has recently invaded Africa and Asia and is rapidly expanding its distribution. This insect is a polyphagous pest and prefers maize. Due to the frequent use of certain inexpensive and easily available insecticides, resistance development is a concern in Asia. Because of the long-distance migration ability of FAW, if a strain develops resistance to insecticides in one country, it is likely to spread rapidly to neighboring countries. Therefore, it is essential to conduct insecticide susceptibility monitoring using the same methods and share the results to manage insecticide resistance development. For this purpose, we developed a simple insecticide susceptibility testing method using relatively easily available materials to monitor the insecticide susceptibility of FAW in Southeast Asia, including developing regions.

This method can easily evaluate insecticide susceptibility, in contrast to existing methods such as molecular biology techniques and topical application. It consisted of the following procedures: collecting test

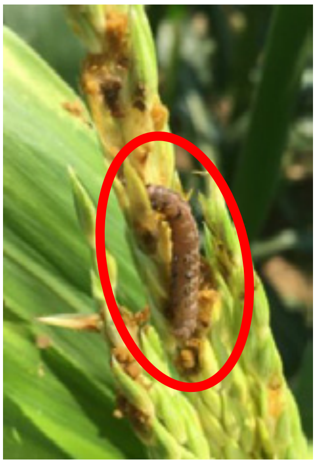


Fig. 1. Fall armyworm larva feeding on maize

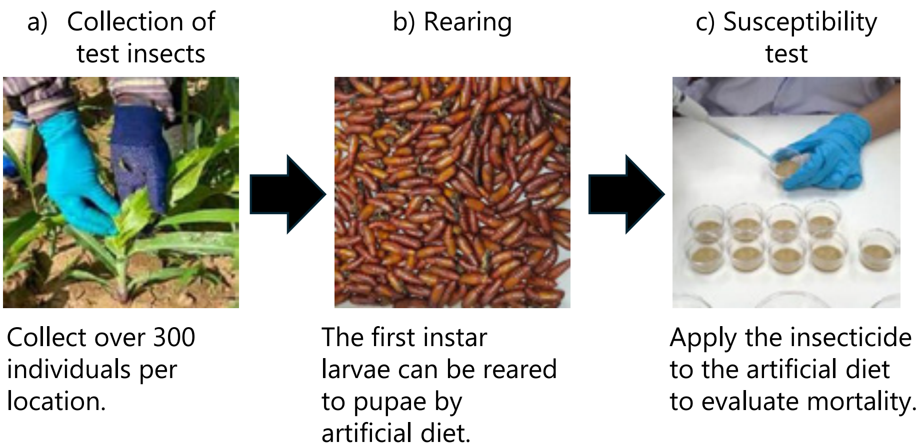


Fig. 2. Summary of the simple insecticide susceptibility test method

Table 1. Composition of the artificial diet

	Ingredients	Quantity
Fraction A	Agar powder	25g
	Reverse osmosis water	800ml
Fraction B	Formalin	4ml
	Yeast	20g
	Methyl paraben	5g
	Sorbic acid	3g
	Mungbean powder	240g
	Reverse osmosis water	800ml
Fraction C	Ascorbic acid (Vitamin C)	5g
	Vitamin stock[1)]	40ml

1) Vitamin stock contains 5 mg biotin, 2.5 g thiamine (vitamin B1), 1.5 g pyridoxine (vitamin B6), 3 g riboflavin (vitamin B2), 20mg cyanocobalamin (vitamin B12), 3 g D-Pantothenic acid hemicalcium salt, 10 g choline chloride, 2.5 g folic acid, 5 g inositol, 6 g nicotinic acid, distilled water 1,000 ml

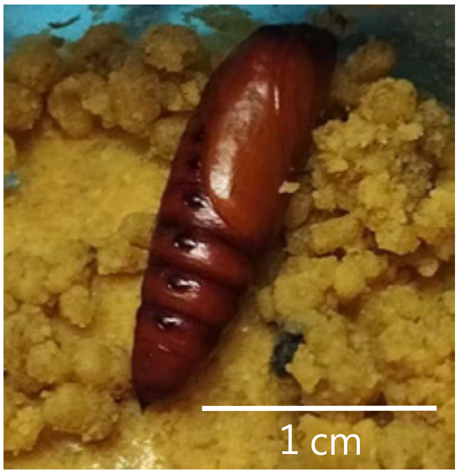


Fig. 3. FAW pupa reared by artificial diet

Table 2. Results of insecticide susceptibility test of several populations in Thailand

Insecticides	Collected year (Location)	LC50 (mg/L)[1)]
Emamectin benzoate 1.92% EC	2019 (Kanchanaburi)	0.014 (0.013–0.016)
	2019 (Tak)	0.015 (0.013–0.018)
	2021 (Suphan Buri)	0.017 (0.014–0.025)
	2021 (Lop Buri)	0.029 (0.023–0.039)
	2022 (Loei)	0.027 (0.021–0.036)
Indoxacarb 15% EC	2019 (Kanchanaburi)	1.526 (0.982–2.048)
	2019 (Tak)	1.877 (1.402–2.337)
	2021 (Lop Buri)	5.259 (3.554–9.019)
	2022 (Sa Kaeo)	7.530 (5.772–10.645)
	2022 (Loei)	10.466 (7.909–15.650)
Chlorfenapyr 10% SC	2019 (Kanchanaburi)	2.086 (1.268–3.450)
	2019 (Tak)	2.049 (1.243–3.360)
	2021 (Lop Buri)	7.056 (6.120–8.122)
	2022 (Sa Kaeo)	7.733 (6.714–8.915)
	2022 (Loei)	8.874 (7.669–10.284)

insects, rearing them with an artificial diet made from relatively easily available materials, and susceptibility testing (Fig. 2). The artificial diet was composed of three fractions (Table 1). By feeding this artificial diet, 1st instar larvae could be raised to pupae (Fig. 3). We conducted diet-overlay bioassays using the 3rd instar larvae within three generations after collection to assess susceptibility. We applied 200 µl of insecticide serially diluted to any multiple using distilled water to 5 ml of artificial feed. After drying, ten 3rd instar larvae were introduced, and the number of dead individuals was counted 72 hours later. From the results obtained, the LC50 value was calculated. We evaluated the susceptibility of the insecticides that are applied in Southeast Asian countries to several FAW populations collected in Thailand using the developed method. The results suggested that the susceptibility of several insecticides decreased over time (Table 2).

The developed method showed enough accuracy and can be used for international comparison to develop resistance management measures. In Thailand, the susceptibility of FAW to several insecticides has decreased. Therefore, there is an urgent need to develop alternative control methods against FAW. The survival rate of 1st and 2nd instar larvae when fed an artificial diet was lower than when fed fresh maize leaves. Thus, fresh leaves are suitable for feeding the young larvae if it is necessary to examine a lot of insecticides in the same period.

Reference

Thirawut et al. (2023) *CABI Agriculture and Bioscience* 4: 19. © The Author(s) 2023
https://doi.org/10.1186/s43170-023-00160-8
Figures and tables reprinted/modified from Thirawut et al. (2023).

(Kobori, K. [JIRCAS], Thirawut, S., Sutjaritthammajariyangkun, W., Rukkasikorn, A.Punyawattoe, P., Noonart, U. [Department of Agriculture, Thailand])

TOPIC 7

A quantitative locus, *MP3*, which increases panicle number, enhances grain yield under an elevated atmospheric CO_2 environment

The atmospheric concentration of CO_2, one of the greenhouse gases, is projected to reach 430 – 1,000 ppm by the end of this century, increasing the average global temperature by 1.0 – 5.7°C above pre-industrial levels (1850~1900). While the increase in temperature will have a negative effect on crop productivity in some regions, the increase in atmospheric CO_2 concentration will have a positive effect on plant photosynthesis. Therefore, crops with sufficient spikelets to store increased photosynthetic assimilates are expected to contribute to increased yield, and the utilization of such crops under high CO_2 concentrations may lead to sustainable crop production under climate change. We have previously shown that a quantitative locus, *MP3* (*MORE PANICLES 3*), found in the temperate *japonica* rice cultivar Koshihikari, promotes tillering and increases panicle number in the high-yielding *indica* cultivar Takanari. The purpose of this study is to identify the causal gene of *MP3* by map-based cloning, clarify the rice groups in which *MP3* is effective, and verify that increased panicle number due to *MP3* contributes to increased grain yield under an elevated atmospheric CO_2 environment.

We can see the results of map-based cloning in Fig. 1. The causal gene of *MP3* is *OsTB1* (*TEOSINTE BRANCHED1*) located on chromosome 3, and there are three sequence differences in the gene between Koshihikari and Takanari. Classifying rice cultivar groups based on the sequence differences, 74% of temperate *japonica* cultivars and 10% of tropical *japonica* cultivars have the same sequence as Koshihikari (Koshihikari type). On the other hand, 60% of the *indica* cultivars have the same sequence as Takanari (Takanari type) (Fig. 2). Then,

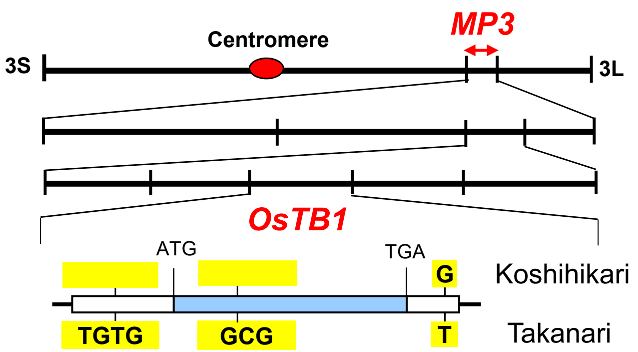


Fig. 1. Map-based cloning of *MP3*
Sequence differences exist in the three locations highlighted in yellow. Blank yellow indicates that the corresponding sequence is deleted.

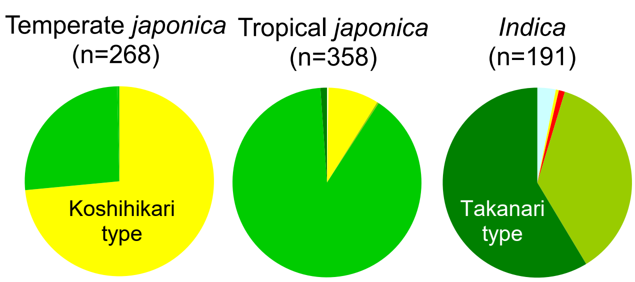


Fig. 2. Type of *MP3* among temperate *japonica*, tropical *japonica*, and *indica*
n means the number of cultivars.

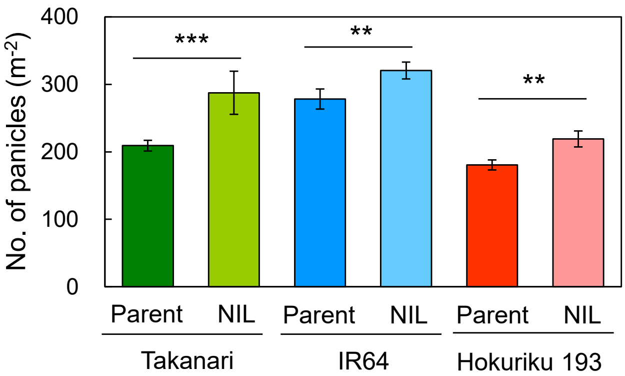


Fig. 3. Comparisons of panicle number between the parental cultivars and its near-isogenic lines (NILs)
*** and ** show significance at 0.1% and 1% levels, respectively.

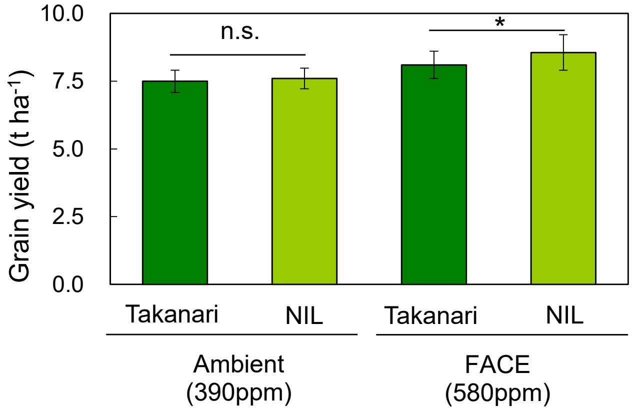


Fig. 4. Comparisons of grain yield between Takanari and its NIL grown in ambient CO_2 and open-air CO_2 enrichment (FACE) conditions
n.s. and * show non-significance and significance at 5% levels, respectively.

near-isogenic lines (NILs) carrying the Koshihikari *MP3* in the high-yielding *indica* cultivars, IR64 and Hokuriku 193, also increase panicle number by 20 – 30% compared to the parental cultivars as in the case of Takanari (Fig. 3). Interestingly, Takanari-NIL enhances grain yield by 6% compared to Takanari under open-air CO_2 enrichment (FACE, 580 ppm CO_2 in the air), whereas it does not under ambient condition (390 ppm CO_2 in the air) (Fig. 4).

Since *indica* cultivars are grown on more than 80% of the world's rice cropping areas, the Koshihikari *MP3* is expected to be widely used in rice breeding in Japan and abroad to address climate change accompanied by rising atmospheric CO_2 levels. However, it should be noted that the effect of *MP3* on panicle number and grain yield under high-temperature conditions needs to be verified in the future.

Reference

Takai et al. (2023) *The Plant Journal* 114: 729–742. © The Author(s) 2023

The figures were reprinted/modified from Takai et al. (2023).

(Takai, T., Tsujimoto, Y., Asai, H., Kawamura, K., Maruyama, K., Ishizaki, T., Kobayashi, N. [JIRCAS], Taniguchi, Y., Takahashi, M., Hirose, S., Hara, N., Sanoh-Arai, Y., Hori, K., Fukuoka, S., Sakai, H., Tokida, T., Usui, Y., Kondo, M., Hasegawa, T., Uga, Y. [NARO], Akashi, H., Ito, J., Tsuji, H. [Yokohama City Univ.], Mochida, K. [RIKEN], Yamamoto, E. [Meiji Univ.], Nagasaki, H. [Kazusa DNA], Nakamura, H. [Taiyo Keiki])

TOPIC 8

Weakening of gene function of OsTB1 by genome editing improves rice productivity under phosphorus deficiency

Tillering is an important trait that determines shoot architecture and yield in rice. Many genes are involved in tillering in rice, and among them, rice *TEOSINTE BRANCHED1* (*OsTB1*) is a key gene that suppresses tillering. On the other hand, phosphorus, a soil nutrient, is one of the most important environmental factors involved in tillering. Phosphorus deficiency leads to reduced tiller number and is a major constraint on rice production in sub-Saharan Africa. In this study, we generate mutants for *OsTB1* using the CRISPR/Cas9 system in X265, which is a major rice cultivar in Madagascar, and then investigate tillering and productivity under phosphorus deficiency in the resultant mutants.

The CRISPR/Cas9 system has generated two types of mutant lines: an in-frame mutant line with 30-bp deletion (#29418) and a frameshift mutant line with 1-bp insertion (#29430) (Fig. 1). The in-frame mutant line #29418 has 1.2 times more tillers than the background cultivar X265 (WT, standing for wild type) at just before heading stage (Fig. 1). On the other hand, the frameshift mutant line #29430 produces 3.4 times more tillers than WT (Fig. 1). This means that OsTB1 weakens its tillering suppression function through the in-frame mutation, while the frameshift mutation loses its tillering suppression function. The expression level of the *OsTB1* gene in #29418 is comparable to that of WT (Fig. 2). The *OsGT1* gene, which is directly regulated by OsTB1 to suppress tillering, is down-regulated in #29430 (Fig. 2). The expression level of *OsGT1* in #29418 is intermediate between those of WT and #29430 (Fig. 2), revealing that the modified OsTB1 expressed in the in-frame mutant line #29418 has a moderate function in the regulation of *OsGT1*. The grain yield of #29418 under phosphorus deficiency is higher than that of WT under low phosphorus application levels: #29418 has approximately 40% higher

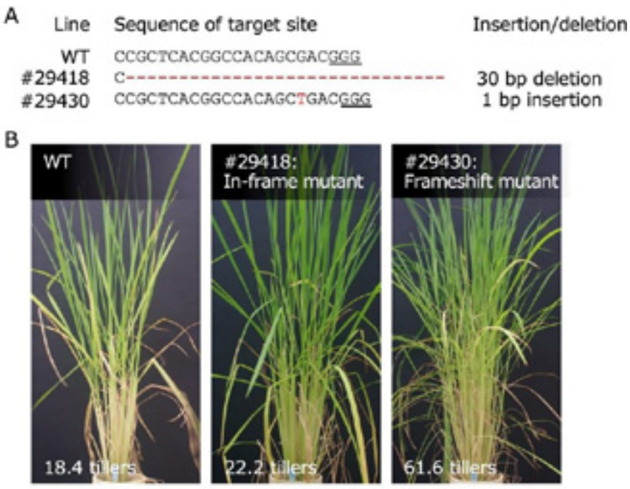


Fig. 1. Generation of mutants for *OsTB1* by genome editing
(A) DNA sequences of mutated *OsTB1* generated by CRISPR/Cas9. Underlines in the target sequences indicate PAM. A red letter indicates an inserted nucleotide. Red dashes indicate deleted nucleotides.
(B) Plants of WT (left), #29418 (in-frame mutant; center), and #29430 (frameshift mutant) at just before heading stage. The mean tiller numbers of each line are indicated at the bottom of pictures.

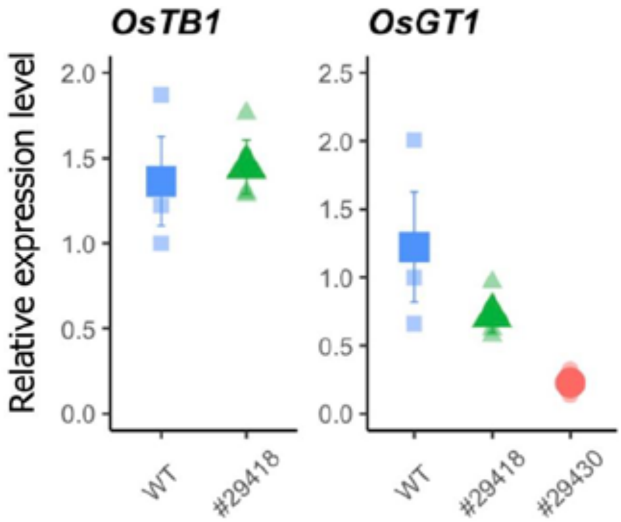


Fig. 2. Expression analysis of *OsTB1* and *OsGT1*
Expression levels in the basal node region of 21-day-old plants are quantified by qRT-PCR. *OsGT1* is a gene that OsTB1 directly binds to its promoter to induce its expression. Each large symbol represents the mean from three biological replications, and each small symbol represents the observed raw value for each replication. #29418, in-frame mutant; #29430, frameshift mutant.

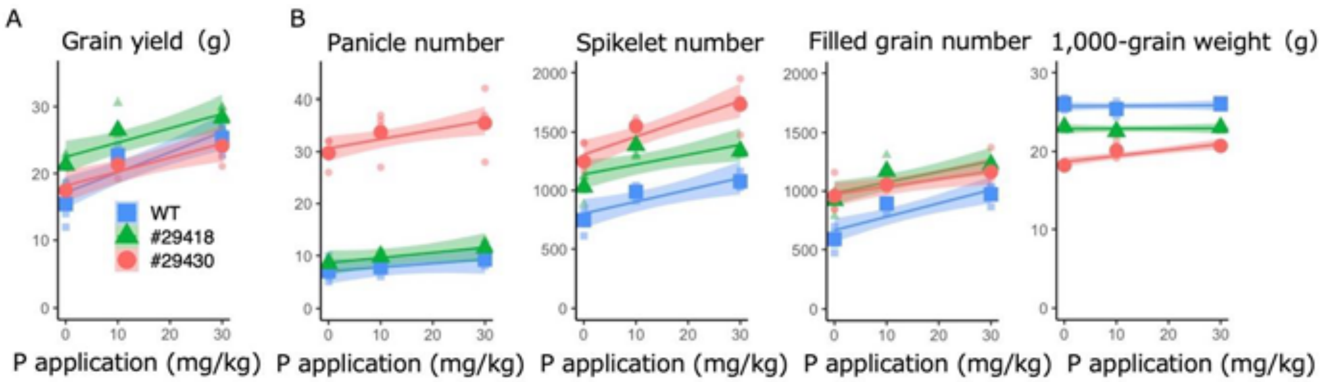


Fig. 3. Grain yield and yield components of mutants for *OsTB1* under different phosphorus (P) applications
#29418 (in-frame mutant), #29430 (frameshift mutant), and WT (X265) were grown in soil supplemented with 0, 10, or 30 mg/kg of P until the mature stage. (A) Grain yield per plant. (B) Yield components of the in-frame mutant line (#29418) and non-mutated X265 (WT). Each large symbol represents the mean from four replications, and each small symbol represents the observed raw value for each replication. Predictions and 95% confidence intervals by ANCOVA are indicated respectively with lines and shading.

grain yield than WT under 0 mg/kg phosphorus application (Fig. 3A). The number of panicles, spikelets, and filled grains of #29418 was higher than those of WT, and the 1,000-grain weight was lower than that of WT (Fig. 3B). The gain in filled grain numbers more than compensates for the reduced 1,000-grain weight. On the other hand, the frameshift mutant line #29430 has more filled grains than WT, but it does not improve yields because the gain in filled grain numbers does not compensate for its decreased 1,000-grain weight.

Our study demonstrates that genome editing of OsTB1 can modify tillering in rice and suggests that the breeding of rice cultivars that have a moderately higher number of tillers may effectively improve rice productivity in areas suffering from phosphorus deficiency.

Reference

Ishizaki et al. (2023) *Plant Science* 330: 111627. © The Author(s) 2023
The figures were reprinted/modified from Ishizaki et al. (2023).

(Ishizaki, T., Ueda, Y., Takai, T., Tsujimoto, Y., Maruyama, K. [JIRCAS])

A simple method for estimating phosphorus (P) retention capacity in paddy soils based on soil moisture content: An effective approach for P fertilization diagnosis

Soils possess the inherent ability to adsorb phosphorus (P), known as P retention capacity. When this capacity is high, the effectiveness of P fertilizer application diminishes. This issue is particularly pertinent in sub-Saharan African (SSA) farmlands, where soil P content is low and farmers have limited access to fertilizers. Effective application of P fertilizers becomes crucial to increasing crop yields in such contexts. Understanding the variability of soil P retention capacity, even among neighboring fields, is essential before fertilizer application. However, analyzing soil P retention capacity typically involves hazardous reagents and expensive equipment, making widespread implementation challenging especially in SSA research institutions with insufficient analytical facilities. In a previous study, we found a significant correlation between the active aluminum content, which determines soil P retention capacity, and the moisture content of air-dried soil in neutral to acidic soils. Yet, the instability of moisture content due to changes in humidity during air drying caused measurement errors. Hence, this study aimed to develop a method to estimate soil P retention capacity accurately and easily by employing saturated salt solution as a moisture conditioning agent to regulate soil moisture content.

The study examined 306 surface soil samples from lowland rice fields in Madagascar, representing diverse soil properties with soil P retention capacity ranging from 10.1% to 96.1%. The results demonstrate that P retention capacity can be accurately estimated based on soil moisture content (Fig. 1). Soil moisture content was measured based on the weight changes before and after exposure to saturated salt solution for one week, which requires no chemical analysis (Fig. 2). By placing saturated salt solution (wherein at least 36 g of sodium chloride is dissolved in 100 g of water) as a moisture conditioning agent inside a closed container for soil placement, regardless of variations in the initial dryness before placement and the relative humidity outside the closed container, soil moisture content can be measured with high reproducibility (Fig. 3).These findings provide practical utility for agricultural extension officers to identify fields responsive to P fertilization with low P retention capacity, facilitating prioritized P fertilizer application for optimal crop yield. While this method is applicable to common lowland rice fields in tropical and subtropical regions, caution is advised for soils with high pH and exchangeable cation content, necessitating thorough validation before implementation.

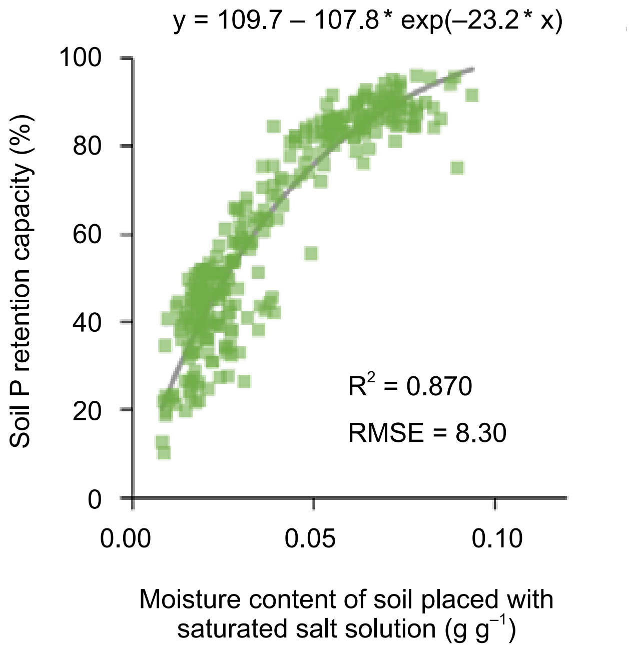


Fig. 1. Relationship between moisture content and P retention capacity of soils placed with saturated salt solution
Coefficient of determination (R^2): It indicates how closely the predicted values match the actual values, with a value closer to 1 indicating higher accuracy.
Root Mean Square Error (RMSE): It represents the average square root of the squared differences between predicted values and actual values, indicating that smaller values suggest a model with lower error.

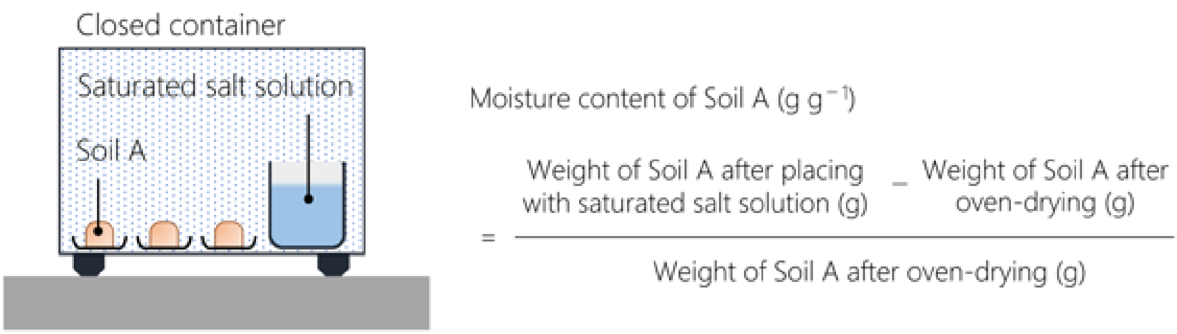


Fig. 2. Overview of placing soil with saturated salt solution in a closed container and the formula for calculating soil moisture content
Saturated salt solution (saturated sodium chloride (NaCl) solution) is used as a moisture conditioning agent. Saturated NaCl solution is known to maintain relative humidity nearly constant within the range of room temperature with minimal influence from temperature. When using approximately one cup of soil (about 200 g), weight is measured using an electronic balance capable of measuring up to 0.1 g.

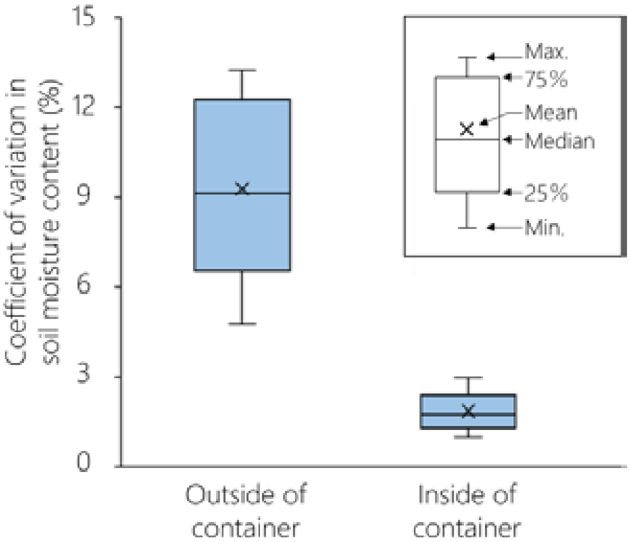


Fig. 3. The coefficient of variation of soil moisture content after placing various soils outside and inside of closed container under different relative humidity conditions
A box plot of the coefficient of variation of soil moisture content after one week of placement of various soils (n = 20, P retention capacity 19.6–94.1%) outside and inside of a closed container at relative humidities of 41%, 52%, and 64% (all at 20°C).

Reference

Nishigaki et al. (2023) *Soil Science and Plant Nutrition* 69: 337–345.

(Nishigaki, T., Tsujimoto, Y. [JIRCAS], Andriamananjara, A., Rakotonindrina, H. [Univ. of Antananarivo])

TOPIC 10

Localized phosphorus application via P-dipping is effective in avoiding flooding damage for lowland rice production

To achieve higher production with minimal environmental impact in sub-Saharan Africa (SSA), it is crucial to make technical transitions from low-input to nutrient-use-efficient production systems. P-dipping, a localized phosphorus (P) application on seedling roots, is a potential approach to enable such a transition for lowland rice production. However, empirical evidence on the effectiveness of this approach in smallholders' heterogeneous field conditions is lacking. Therefore, 18 on-farm trials were implemented by applying three P application treatments (zero P; P broadcast at 13.1 kg P ha^{-1}; P-dipping at 13.1 kg P ha^{-1}) with and without N top-dressing (60 kg N ha^{-1}) under a range of topographic, edaphic, and climatic conditions in the highlands of Madagascar.

The P-dipping method had greater yields, exceeding by 1.1 t ha^{-1} vs. zero P and by 0.5 t ha^{-1} vs. P broadcast on average under the non-N-applied condition. The yield advantage of P-dipping was enlarged with N application, and thus, the effect of N on grain yield was greater in P-dipping than in zero P or P broadcast (Fig. 1). The P-dipping effect was increased when the fields had erratic water levels after transplanting, which was associated with vigorous initial growth and avoidance of submergence stress (Fig. 2). Multiple regression analysis detected that

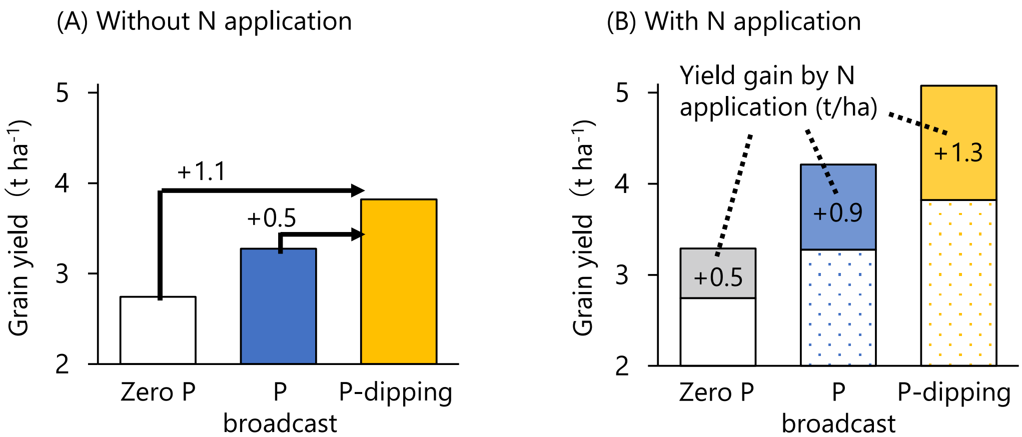


Fig. 1. Yield gain by P-dipping without N (A) and with N application (B)

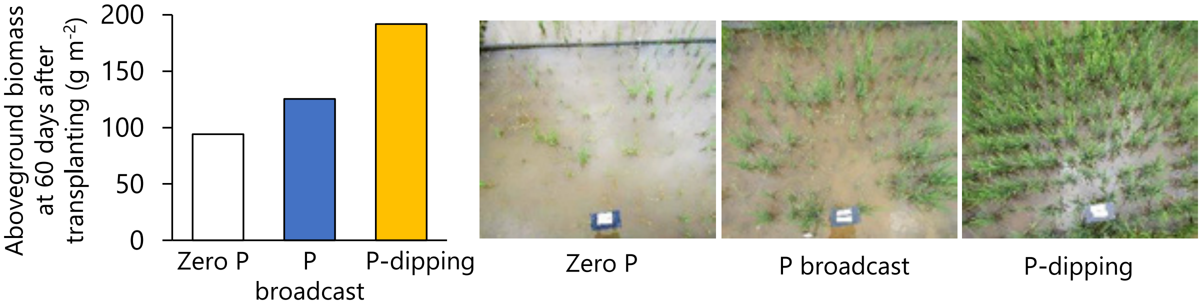


Fig. 2. Effect of P-dipping on the aboveground biomass at 60 days after transplanting and on submergence stress avoidance

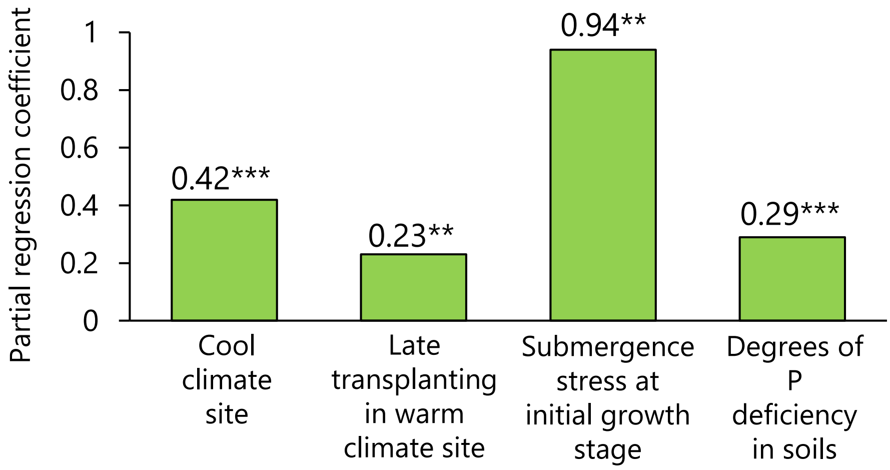


Fig. 3. Determinant factors with their partial regression coefficients for the field-to-field variations in the P-dipping effect on rice yield

the effect of P-dipping on grain yield was prominent not only in fields with initial submergence stress but also in fields at high elevation/cool climate site and late-transplanted fields at low elevation/warm climate site where P-dipping alleviated late-season low-temperature stress by shortening days to heading (Fig. 3). This study revealed that the effect of P-dipping is consistent in various P-deficient soils and is enhanced by combining with N topdressing and when fields are prone to late-season cold stress or early-season submergence stress. The results of this study show that P-dipping has the potential to improve fertilizer use efficiency and help farmers cope with frequent flooding. The technology is expected to contribute to stable and sustainable rice production in sub-Saharan Africa as its use expands.

Reference

Oo et al. (2023) Localized phosphorus application via P-dipping doubles applied P use efficiency and avoids weather-induced stresses for rice production on P-deficient lowlands. *European Journal of Agronomy* 149: 126901. © Elsevier B.V. 2023

The figures were reprinted/modified from Oo et al. (2023) with permission.

(Oo, A.Z., Tsujimoto, Y. [JIRCAS], Rakotoarison, N. [FOFIFA], Andranary, B. [University of Antananarivo])

TOPIC 11

Localized phosphorus application via P-dipping is most effective in increasing lowland rice yields when combined with seedlings at 4.5˜6.5 leaf age

P-dipping refers to the placement of phosphorus (P) fertilizer at the root system during transplanting of rice by adhering P-enriched slurry to the seedling roots. This approach is beneficial for smallholder farmers in sub-Saharan Africa who apply small amounts of P to highly P-fixing soils. This study aimed to identify the optimum seedling age for maximizing the impact of P-dipping. Pot experiments revealed that the adhered amounts of slurry to the roots with P-dipping increased in a sigmoidal pattern against seedling age along with the increases in the root mass (Fig. 1). Correspondingly, the effect of P-dipping on the initial biomass was enlarged with older seedlings in a sigmoidal pattern, increasing slowly during the young seedling age (<4.5 leaves), sharply during the intermediate seedling age, and plateauing during the old seedling age (>6.5 leaves) (Fig. 2). Combining P-dipping with much older seedlings at 8 leaves resulted in severe transplanting shock and plant death.

On-farm trials on 90 fields demonstrated a significant interaction between seedling age and P treatment on grain yield under a range of growing conditions in the central highlands of Madagascar. The highest yield gains over the control from P-dipping were observed in seedlings with intermediate age (4.5~6.5 leaves), followed by old (>6.5 leaves) and young (<4.5 leaves) seedlings at 1.0 t ha^{-1}, 0.7 t ha^{-1}, and 0.6 t ha^{-1}, respectively (Table 1). These results suggested that vigorous and intermediate seedlings with higher slurry adherence than young seedlings and a lower risk of transplanting shock than old seedlings benefited most from P-dipping (Fig. 3). This finding provides smallholder farmers with practical knowledge on how to apply P-dipping more efficiently for achieving improved P management for sustainable rice production. It should be noted that the optimal seedling status and root development for P-dipping can be affected not only by the leaf age but also by the growth conditions in the nursery bed, e.g., sowing density, temperature, water management, light intensity, soil fertility, fertilizer management, and varieties.

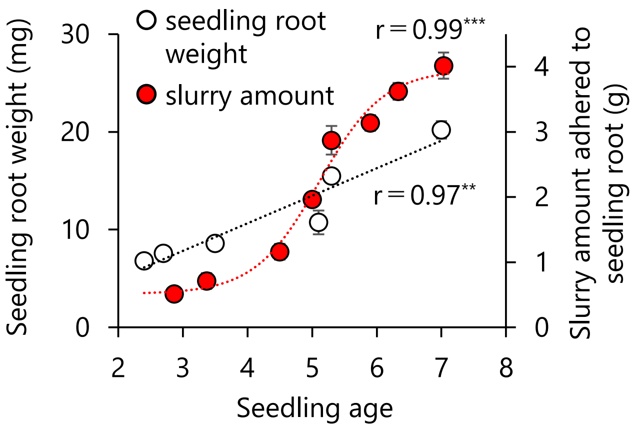


Fig. 1. Relationship between seedling age and (A) root weight and (B) slurry amount adhered to root
Seedlings were raised in a growth chamber at 25°C /15°C day/night temperature and at 20,000 lx.

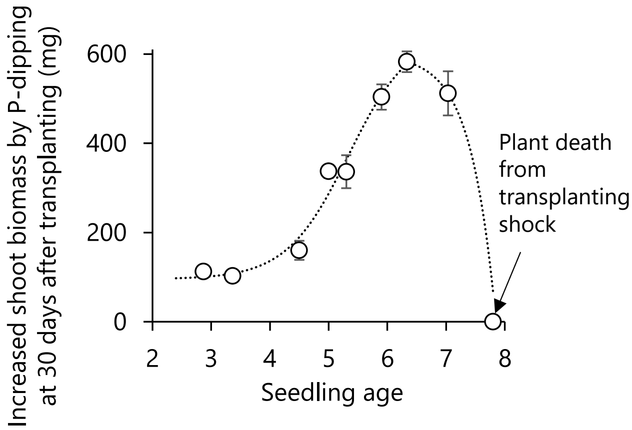


Fig. 2. Effect of P-dipping on initial biomass production using different seedling ages
Plants were grown in a growth chamber at 25°C/15°C day/night temperature and at 20,000 lx.

Table 1. Variations in P-dipping effect among farmers' fields using different seedling ages in Madagascar

Seedling age at transplant	Number of days in nursery (standard deviation)	Number of farmer fields	P-dipping	Grain yield (t ha^{-1})	Yield gain by P-dipping (t ha^{-1})
< 4.5	26 (6)	36	No	2.9 b	-
			Yes	3.5 a	0.6 b
4.5~6.5	47 (6)	37	No	3.0 b	-
			Yes	4.0 a	1.0 a†
> 6.5	58 (7)	17	No	2.3 c	
			Yes	3.0 b	0.7 ab†

Means with different alphabets indicate significant differences by Tukey's HSD test. †P=0.09. Apart from the P treatments, farmers used their own preferred varieties and management practices in the establishment of seedlings and transplanting patterns.

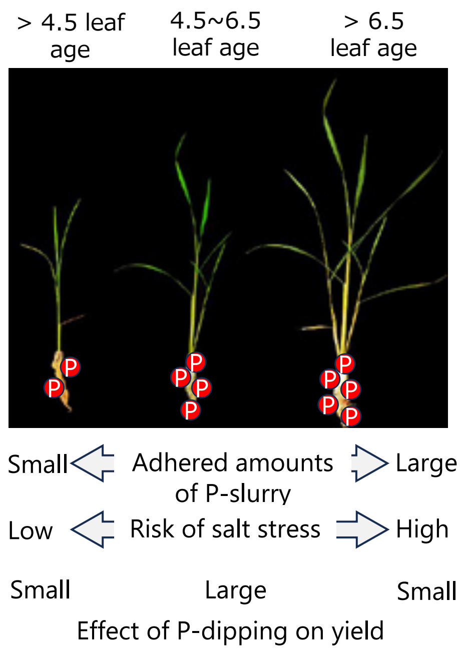


Fig. 3. Diagram on the interaction of P-dipping and seedling age

Reference

Rakotoarisoa et al. (2023) *Crop and Environment* 2: 202-208. © The Author(s) 2023
The figures were reprinted/modified from Rakotoarisoa et al. (2023).

(Tsujimoto, Y., Oo, A.Z. [JIRCAS], Rakotoarison, N. [FOFIFA], Tashiro T., Kano, M., Ehara, H. [Nagoya University])

TOPIC *12*

Unique fertilizer response of sorghum on Plinthosols with thin effective soil depth

Increasing agricultural productivity is essential to meet the rapidly increasing demand for food in Sub-Saharan Africa (SSA). According to statistics from the FAO, while the population of the region tripled between 1980 and 2020, the productivity per unit area of sorghum, the main grain of semi-arid regions in SSA, increased by only 20% and remains stagnant. To address this problem, West Africa is currently redeveloping its cultivation guidelines, which take account of agro-ecological zones reflecting climate, but not soil type differences. However, a special soil type called Plinthosols, in which the effective soil depth (ESD) is less than 50 cm, is widely distributed in the semi-arid regions of West Africa. Because these soils have lower water-holding capacity than other soil types, the response of sorghum to fertilizer application may differ on the Plinthosols.

Therefore, this study aims to determine the differences in fertilizer response of sorghum on three dominant soil types in semi-arid West Africa: Lixisol (LX), which has a thick ESD of about 100 cm and high water-holding capacity; Plinthosol (PT), which has an ESD of about 50 cm; and Plinthosol (PX), which has an ESD of about 25 cm (Fig. 1).

In a year with 21% (1.3 times the standard deviation) less rainfall than the average year, yields are not reduced in LX, but are reduced in PT and PX (Table 1A). This indicates that lack of soil moisture can limit yield in any of the Plinthosols, suggesting that the optimal sorghum variety (e.g., earlier maturing) and sowing density (e.g., more sparsely planted) may be different in Plinthosols than in Lixisols. The optimal nitrogen (N) application rate for sorghum is 74 kgN ha^{-1} in LX and PT but 37 kgN ha^{-1} in PX. The reason for this probably is that the PX with 25-cm ESD has a very limited water-holding capacity and is unable to meet the increased water requirements that accompany the vigorous growth of sorghum with fertilizer application. Since the fertilizer response of sorghum varies greatly among LX, PT, and PX, it is necessary to distinguish between LX, PT, and PX and consider optimal fertilizer amounts, varieties, and seeding densities in the guidelines currently being redeveloped for cultivation in West Africa. This would pave the way for the development

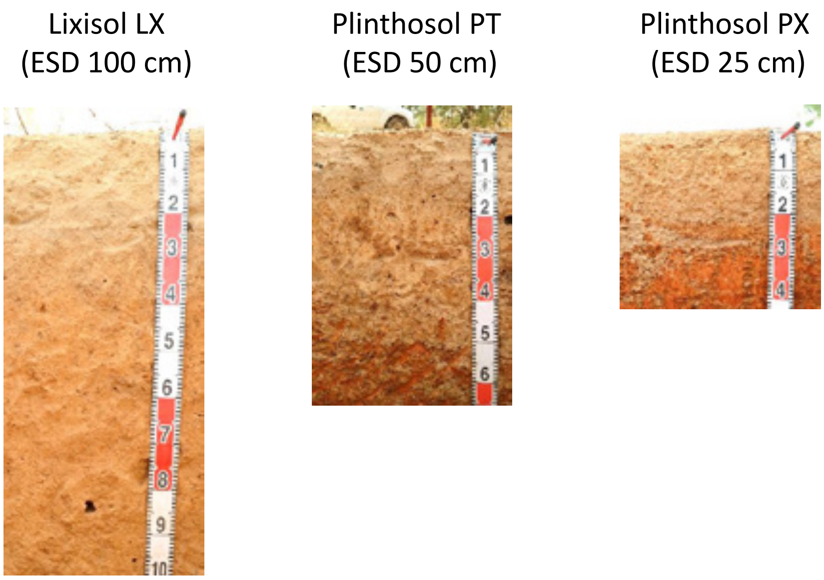


Fig. 1. Soil profiles of the three dominant soil types in the semi-arid West Africa
In PT and PX, an iron hardpan called petroplinthite, which does not allow crop roots to elongate, appears at a depth of about 50 cm and 25 cm, respectively, so the sorghum can only use the water in the soil layer above the iron hardpan.

Table 1. Effects of rainfall amount and fertilization on sorghum yield (kg/ha) in each soil type

	Soil Type		
	Lixisol LX (ESD[1] 100 cm)	Plinthosol PT (ESD 50 cm)	Plinthosol PX (ESD 50 cm)
A: Rainfall amount	ns[2]	*	**
B: Nitrogen application rate[3]			
0 kg/ha	522 (52)c	325 (60)c	287 (71)b
37 kg/ha	1040 (121)b	520 (144)bc	800 (79)a
74 kg/ha	1534 (120)a	971 (107)a	808 (105)a
111 kg/ha	1596 (142)a	784 (101)ab	780 (116)a

Results of a 2-year experiment (average and low rainfall years) in central Burkina Faso, where the geology, topography, and soils are representative of semi-arid West Africa. [1] Effective soil depth. [2] Statistical analysis. ns: not significant ($p > 0.05$), * $p < 0.05$, ** $p < 0.01$; Numbers in brackets are standard errors. Different alphabets indicate that sorghum yields differed significantly ($p < 0.05$) among the same soil type with different nitrogen application rates. [3] Nitrogen was simultaneously applied with phosphorus (23 kg P_2O_5/ha) and potassium (14 kg/ha).

of tailor-made cultivation guidelines that will allow farmers to maximize fertilizer application efficiency. Finally, we would like to mention that soil types can be easily determined by ground-penetrating radar in semi-arid West Africa. (For more information, refer to Research Highlight A04 in FY 2018, "Ground-penetrating radar can predict the soil depth at which the petroplinthic horizon starts in the Sudan Savanna, West Africa").

References

Ikazaki et al. (2023) *Soil Science and Plant Nutrition* 70: 114–122. © The Author(s) 2023

Iseki et al. (2021) *Field Crop Research* 261: 108012. © The Author(s) 2020

Figure and table reprinted/modified from Iseki et al. (2021) and Ikazaki et al. (2023), respectively.

(Ikazaki, K., Nagumo, F. [JIRCAS], Simporé, S., Barro, A. [INERA])

TOPIC 13

Boosting cowpea grain yield in Plinthosols through fertilization and high plant density

Cowpea cultivation is widespread in the semi-arid regions of West Africa (Sudan Savanna) due to its drought tolerance. Cowpea serves as an important protein source for local farmers; however, due to low soil fertility, the yield per unit area is approximately one-fourth of that in Asia and the United States. The simplest way to increase yield in low-nutrient soils is through fertilization. However, due to high fertilizer costs and limited yield increase even with fertilization, most farmers in the region do not use much fertilizer for cowpea cultivation. Additionally, to compensate for low growth due to limited nutrients, increasing planting density is also considered, but the recommended planting density set over 50 years ago in the region remains unchanged.

Two dominant soil types play a significant role in agricultural productivity in the Sudan Savanna: Lixisols and Plinthosols. Lixisols are relatively fertile with high water retention, but they are prone to waterlogging after rainfall. Plinthosols have low fertility and water retention, with a higher risk of nutrient leaching after rainfall. The objective is to clarify the effects of fertilization and high plant density on these two different soil types to explore cultivation strategies to increase cowpea yields.

The effect of fertilization on yield was approximately 1.4 times higher in Plinthosols compared to Lixisols on average (Fig. 1). This difference is attributed to the high water retention in Lixisols, leading to a temporary

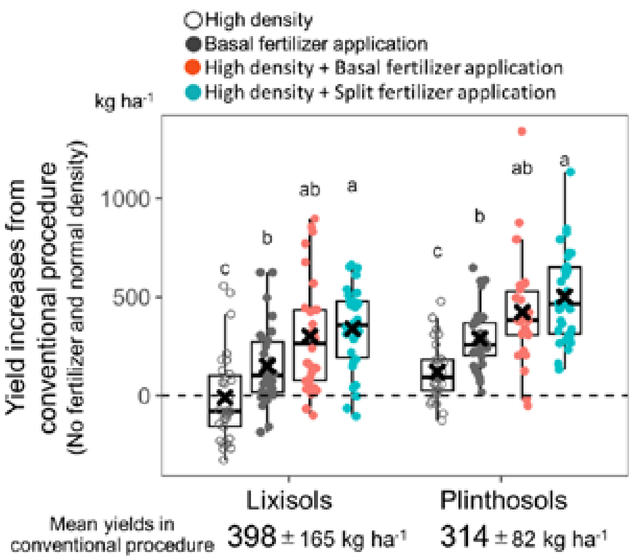


Fig. 1. Effects of fertilization and high plant density on cowpea yield in the dominant soil types of Sudan Savanna
Results of cultivating three cowpea varieties in the central region of Burkina Faso in 2018 and 2019. Each treatment shows variation over 2 years, with 3 varieties and 5 repetitions (n=30). Different letters indicate significant differences in means at $p < 0.05$. The '×' symbol represents the mean value.

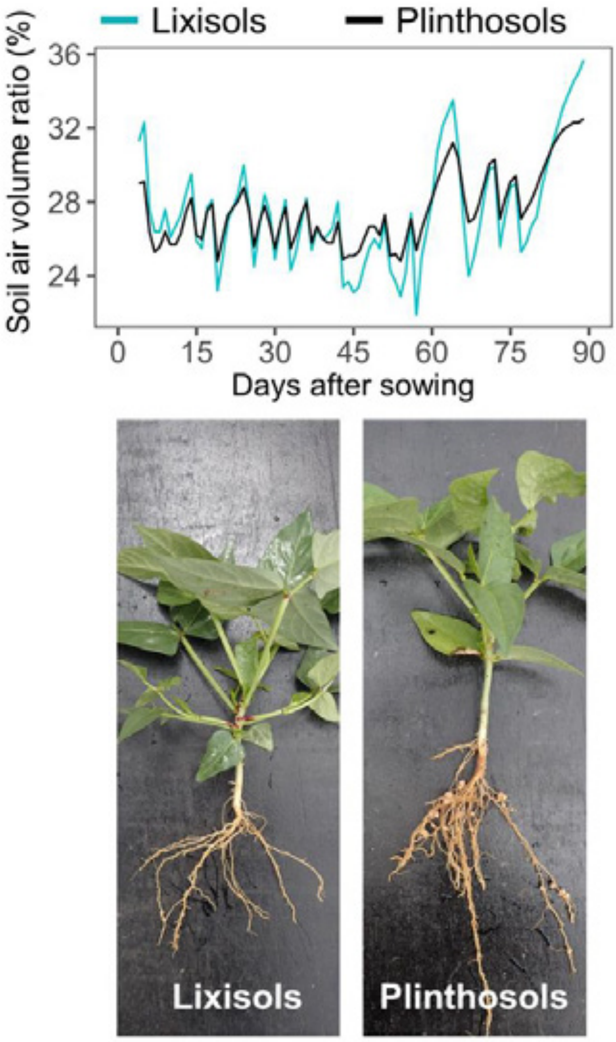


Fig. 2. Changes in soil air-volume ratio during the growth period (top) and appearance of cowpea root in each soil type (bottom)
Top: Lixisols are more prone to a decrease in soil air-volume ratio immediately after rainfall compared to Plinthosols, making them susceptible to waterlogging due to oxygen deficiency shortly after rainfall. Bottom: Cowpea grown in Lixisols showed minimal nodulation, and its root development was poorer compared to that in Plinthosols. The photos were taken in each soil type at four weeks after sowing.

decrease in soil oxygen levels and subsequent inhibition of root development due to elevated soil temperature (Fig. 2). Doubling the plant density from the recommended rate resulted in 1.5 times increase in yield in Plinthosols without fertilization, while the increase in yield was smaller in Lixisols (Fig. 1). Combining fertilization and high plant density resulted in higher yield increases than fertilization alone in both soil types (Fig. 1). Splitting fertilization into basal and top-dressing applications also yielded higher than applying all fertilizers at once as basal dressing (Fig. 1).

Soil types vary within a few hundred meters, allowing farmers to efficiently improve cowpea yields by adjusting fertilization rates and planting densities based on soil type within their fields. The ideal timing for top-dressing is around the 4th week after sowing during the maximum vegetative growth period. However, in the Sudan Savanna, this period coincides with the peak of the rainy season, posing a risk of nutrient leaching if heavy rainfall occurs shortly after top-dressing, especially in Plinthosols.

Reference

Iseki et al. (2023) *Field Crops Research* 292: 108825. © The Author(s) 2023
https://doi.org/10.1016/j.fcr.2023.108825
Figures reprinted/modified with permission.

(Iseki, K., Ikazaki, K. [JIRCAS], Batieno, B.J. [INERA])

TOPIC 14

Estimating the impact of climate change on cowpea production in Sudan Savanna using field cultivation data

In the semi-arid region of West Africa known as the Sudan Savanna, cowpea — a drought-resistant legume crop — is widely cultivated. Despite its importance as a protein source in the region, the yield per unit area is extremely low, and there are concerns about the increasing impact of extreme weather events such as heavy rainfall and drought due to climate change in the future. Addressing climate change, including predicting future production variability and identifying its causes, is urgently needed.

Yield prediction models can estimate crop yields by inputting meteorological conditions such as rainfall and temperature, as well as information about soil fertility and water characteristics. However, existing models targeting cowpea are specialized in predicting yields in optimal environments with minimal environmental stress, making it difficult for them to be applied to the harsh environments in Africa. To reveal the impact of climate change on cowpea production, this study aims to improve the accuracy of yield prediction models by utilizing field cultivation data in the Sudan Savanna accumulated in previous studies.

We created a yield prediction model using data from the cultivation of 20 cowpea varieties (n=1380) over four years with varying rainfall conditions in two representative soil types, Lixisols and Plinthosols, in the region. This allowed us to estimate yields in a wide range of environments, including dry and wet conditions (Fig. 1). Based on the latest global climate change predictions (Coupled Model Intercomparison Project Phase 6, CMIP6), it is forecasted that in West Africa, over the next 30 years, rainfall during the cowpea cultivation period (July to October) as well as the number of days with heavy rainfall exceeding 30 mm will increase (Fig. 2 top). The estimated yield model revealed that with increased rainfall and more days of heavy rainfall, cowpea yields in Lixisols will significantly decrease (Fig. 2 bottom). Furthermore, it is predicted that although cowpea yield reductions during drought periods will be mitigated compared to the present, drought-induced yield reductions will continue to be most severe in Plinthosols (Fig. 3).

Lixisols are relatively fertile and have high yields, making them significant areas for crop production. However, it is anticipated that excessive soil moisture stress will worsen due to increased rainfall, necessitating measures such as introducing tolerant varieties. In Plinthosols, drought-induced yield reductions are relatively greater than the reduction caused by excessive soil moisture, highlighting the need to control drought impact in the future.

Lixisols
(1 month after sowing, 2016)

Plinthosols
(Harvesting time, 2017)

Fig. 1. Cultivation of cowpea in two dominant soil types in the Sudan Savanna
Twenty local varieties were cultivated for four years (2016-2019) in two dominant soil types in Sudan Savanna, namely Lixisols and Plinthosols. Lixisols (left) are prone to waterlogging shortly after rainfall, while Plinthosols (right) are susceptible to drought due to intermittent rainfall cessation.

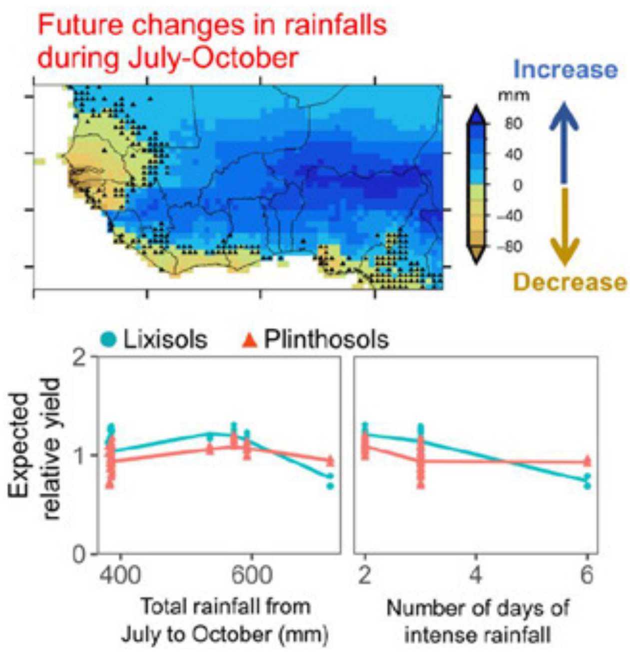


Fig. 2. Predictions of rainfall changes in West Africa and cowpea yield responses
(Top): Future predictions (2020-2049) compared to the present (1990-2019) regarding total rainfall during the cowpea growth period (mid-July to mid-October). Analysis results from CMIP6 simulations. Black dots indicate locations where the changes are statistically significant at the 5% level. (Bottom): Predicted relative yield in response to increased rainfall and number of heavy rainfall days (30 mm or more per day). The line represents local polynomial regression.

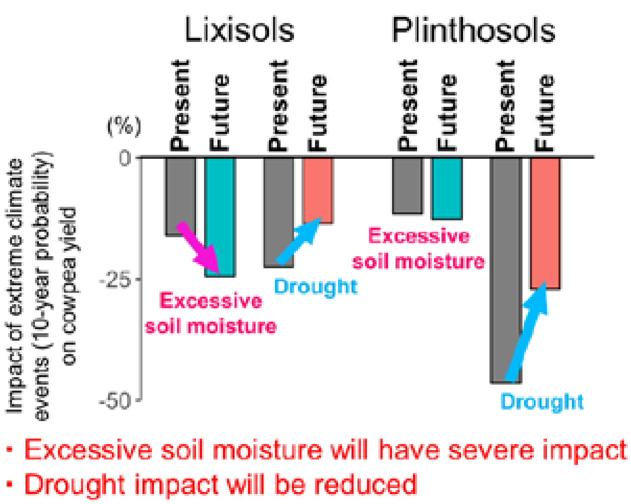


Fig. 3. Impact of extreme weather events on cowpea yields in different soil types
Comparison of cowpea yield reduction rates in Lixisols and Plinthosols during excessive soil moisture stress and drought stress, comparing the present (1990-2019) and future (2020-2049).

Reference

Iizumi et al. (2023) *Agricultural and Forest Meteorology* 344: 109783. © The Author(s) 2023
https://doi.org/10.1016/j.agrformet. 2023.109783
Figures reprinted/modified from Iizumi et al. (2023).

(Iseki, K., Ikazaki, K., Sakai, T. [JIRCAS], Iizumi, T. [NARO], Shiogama, H. [NIES], Imada, Y. [Tokyo Univ.], Batieno, B.J. [INERA])

TOPIC 15

Kinoshita and Shiranui, soybean varieties resistant to Asian soybean rust, have a second resistance gene

Asian soybean rust (ASR) is a major soybean disease that causes early yellowing and defoliation of soybean, resulting in reduced yield. This disease is widespread in soybean production areas around the world, especially in tropical and subtropical regions, and is a serious impediment to the stable supply of soybeans to international markets. In recent years, the susceptibility of the ASR pathogen to fungicides has decreased, resulting in increased control costs and environmental impact. Soybean varieties with resistance genes (*Rpp*) against ASR have since been developed in various regions. The soybean varieties Kinoshita and Shiranui were identified in 2008 as ASR-resistant varieties carrying *Rpp5*. These two varieties have shown resistance to many soybean rusts in various regions and are widely used in Latin America and Asia as parents for resistance variety development. However, their resistance to a wide range of rusts suggested that both varieties may also possess resistance other than *Rpp5*. Therefore, this study was conducted to determine the resistance potential of the Kinoshita and Shiranui varieties in order to appropriately and effectively utilize their resistance to a wide range of ASR pathogens in variety development.

The resistant varieties Kinoshita and Shiranui were crossed with susceptible varieties to produce F_2

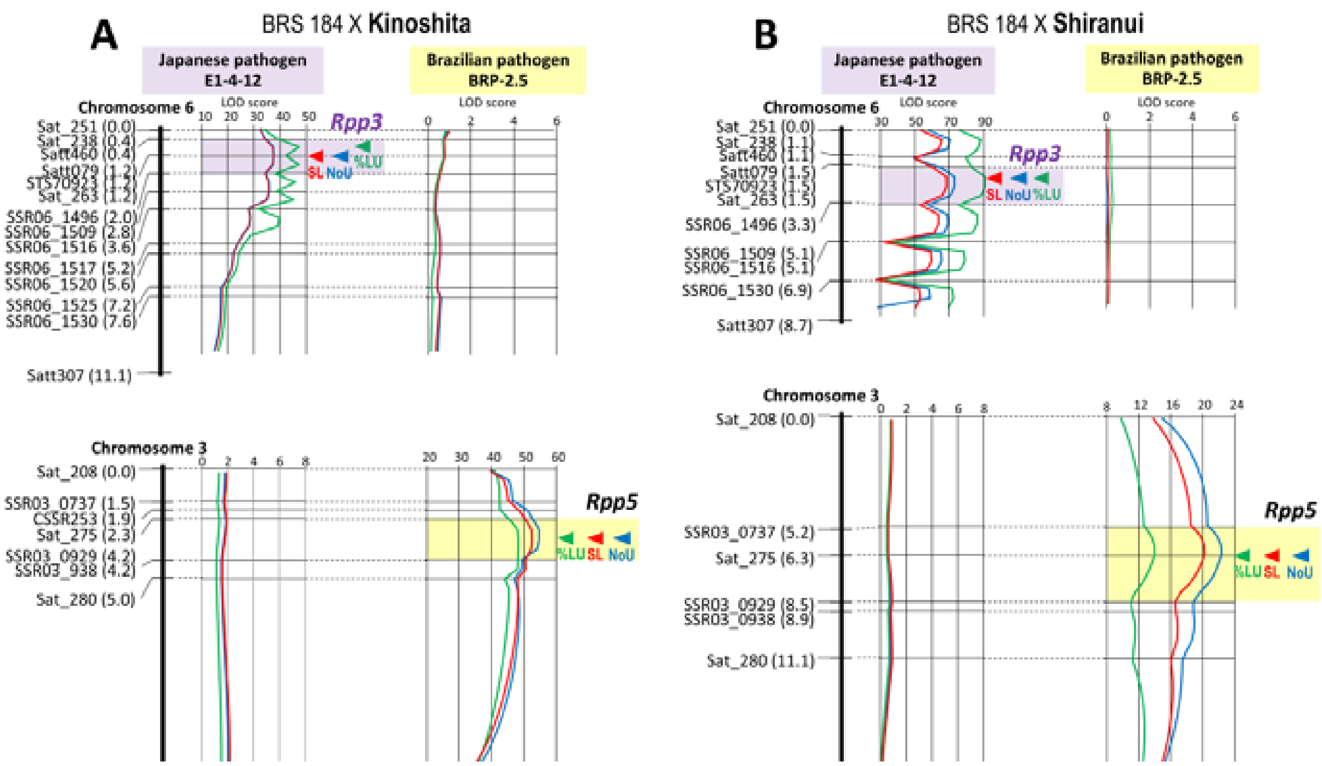


Fig. 1. Genetic maps around resistance loci *Rpp3* and *Rpp5* for Asian soybean rust in Kinoshita (A) and Shiranui (B) mapping populations

Each mapping population was created by crossing with the susceptible variety BRS 184. The DNA marker names and genetic distances from the top marker are shown on the left side of each linkage group, and the LOD values and their peak positions in QTL analysis for resistance-related traits (NoU: numbers of uredinia per lesion; %LU: frequency of lesions with uredinia; SL: Sporulation level) against E1-4-12 and BRP-2.5 strains are shown on the right side of each linkage group.

Table 1. Genetic effects and variance explained (VE) of the resistance genes *Rpp3* and *Rpp5* in the number of uredinia per lesion (NoU)

Parents of population	Resistance gene	Nearest marker	Pathogenic strain	**Additive effect [1)]**	**Dominance effect [1)]**	Variance-explained (%)
BRS 184 × Kinoshita	*Rpp5*	SSR03_0929	BRP-2.5	**-1.15**	**-0.03**	82.60%
	Rpp3	Sat_263	E1-4-12	**-0.81**	**-0.74**	51.50%
BRS 184 × Shiranui	*Rpp5*	Sat_275	BRP-2.5	**-0.97**	**-0.09**	52.29%
	Rpp3	Sat_263	E1-4-12	**-0.82**	**-0.81**	52.37%

1) Genetic effects (additive and dominant effects) are relative effects of the resistant (Kinoshita or Shiranui) allele to the susceptible (BRS 184) allele. *Rpp5* of Kinoshita and Shiranui are codominant due to their less dominant effects, while *Rpp3* of both varieties are completely dominant.

populations. Each F_2 population was inoculated with the Japanese ASR strain E1-4-12 and the Brazilian strain BRS-2.5, which differ greatly in virulence, and evaluated for ASR resistance-related traits, respectively. QTL analysis of resistance-related traits was performed to identify resistance loci for each pathogen strain. QTL analysis revealed that Kinoshita and Shiranui possess loci *Rpp3* and *Rpp5*, which exhibit resistance to ASR strains E1-4-12 and BRP-2.5, respectively (Fig. 1). The *Rpp3* carried by both varieties was resistant only to strain E1-4-12 of the two strains used in this study, and the *Rpp5* of both varieties was effective only against strain BRP-2.5. The *Rpp5* and *Rpp3* of the Kinoshita and Shiranui varieties have similar genetic effects as well as genetic loci, suggesting that the two varieties may have the same or very similar resistance-type alleles in *Rpp5* and *Rpp3*, respectively (Table 1).

Because ASR pathogen in the soybean field is known to be diverse, both *Rpp5* and *Rpp3* should be introduced when Kinoshita and Shiranui are used for developing varieties with ASR resistance that have the same levels of resistance as Kinoshita and Shiranui. For the two resistance loci *Rpp3* and *Rpp5*, the use of DNA markers flanking and sandwiching the loci allows for effective and efficient selection for resistant plants in breeding for ASR resistance.

Reference

Yamanaka et al. (2023) *Plants* 12: 2263 © The Author(s) 2023

The figure and the table were modified from Yamanaka et al. (2023).

(Yamanaka, N. [JIRCAS] and Aoyagi, L.N. [JIRCAS, Present address: NARO])

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 (FY 2021-2025) 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 for solving global issues has been accelerating, while the continuous progress of science and technology has brought about great changes 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, it is expected that comprehensive information linking socioeconomics, food nutrition, and technological development will be collected, analyzed, and disseminated. 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 an effort to establish our position as among Japan's leading information centers on scientific topics related to global food security, climate change, and food systems.

In FY 2023, we organized several international events in addition to JIRCAS International Symposium 2023, which featured innovations to enhance the resilience of tropical forests and sustainability of the forest industry. One event is a seminar on millets, recognizing 2023 as the "International Year of Millets." Another is a seminar on food systems in Africa, which was held as a Tokyo International Conference on African Development (TICAD) 30th Anniversary official side event. Moreover, we organized a commemorative networking event, the JIRCAS Southeast Asia Liaison Office 50th Anniversary Symposium, in Bangkok, Thailand.

Our original "Pick Up" articles sought to provide updates on the status of global food security, which is facing growing uncertainties over fuel, fertilizer, and food volatilities induced by the interlinked impacts of COVID-19, climate change, and conflicts. In addition to analyzing 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. Examples include models that evaluate the environmental, nutritional, and other socio-economic 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 Model Plant Factory System, and 3) Establishment of a platform to support and promote practical application/societal implementation of JIRCAS's research results.

In FY 2023, regarding work relating to shrimp, JIRCAS continued research on the development of seed production technology suitable for commercial usage and methodology for achieving artificial maturation of female prawns under re-circulating rearing systems. In addition, JIRCAS's first institute-related business venture, ShrimpTech JIRCAS, Inc. (established February 2022), was reorganized as a fully-fledged corporation as of July 2023, and is currently engaged in consulting activities related to re-circulating aquaculture of the Pacific whiteleg shrimp, *Litopenaeus vannamei*, and customized research.

Regarding plant factory-related research, staff researchers at JIRCAS's Tropical Agriculture Research Front (TARF) located on Ishigaki Island, 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. Based on results obtained at TARF, strawberry cultivation research was initiated in collaboration with Indonesia's Universitas Padjadjaran in order to introduce the above-mentioned Asian Monsoon Model Plant Factory technology into Indonesia.

Regarding the establishment of our platform for promoting research results, a multi-site trial of a soybean cultivar candidate having high rust resistance, "Misionera INTA-JIRCAS (tentative)," and an evaluation of its resistance to rust was conducted in Argentina. Breeding lines of the main Indonesian rice variety "Situ Bagendit" containing a blast field resistance gene were confirmed to have improved resistance to ear blast. In addition, JIRCAS created a series of Microsoft Excel programs in 2018 entitled "Support Programs for Farm Management Planning" to assist smallholder farmers in Africa to achieve better crop yields and maximize total household income. Data transfer work is now underway using linear programming to enable the support programs to run on smartphone applications (Android and iOS).

[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, particularly in developing countries/regions. 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 promotes 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 our subtropical island research facility. In addition, by sharing and providing information and technologies, we aim to strengthen collaborations that will lead to the formation of networks with domestic and overseas research institutions to promote the utilization of tropical crop genetic resources. In FY 2023, the sugarcane variety TPJ04-768, which was developed by interspecific hybridization using wild genetic resources of sugarcane under the collaboration between JIRCAS and the Khon Kaen Field Crops Research Center in Thailand, has been officially named as "DOA Khon Kaen 4 (KK4)" and approved as a recommended variety by the Thai government.

[Green Asia]

In 2021, Japan formulated the Strategy for Sustainable Food Systems, "MIDORI," which aims to enhance agricultural productivity potential and sustainability through innovation as a new approach for sustainable food systems. In line with this strategy, JIRCAS has been assigned to implement the "Green Asia" project (full title: Accelerating application of agricultural technologies which enhance production potentials and ensure sustainable food systems in the Asia-Monsoon region).

The International Scientific Advisory Board for Strategy MIDORI, which consists of internationally renowned agricultural scientists and representatives from agricultural research institutes in the Asia-Monsoon region, was formed to guide the activities of Green Asia. In FY 2023, the third advisory board meeting was held in hybrid format in September 2023, and the fourth meeting was held online in March 2024. The International Center for Strategy "MIDORI," established under the project, has facilitated the collection, analysis, and sharing of existing and latest information on agricultural, forestry, and fisheries technologies in collaboration with domestic and overseas research institutes under advice from the advisory board.

Some of the research products of Green Asia in FY 2023 includes the "Technology Catalog Contributing to Production Potential and Sustainability in the Asia-Monsoon Region Ver.2.0," a compilation of technologies developed by JIRCAS, NARO, FFPRI and FRA or through international collaboration. Technologies listed in Technology Catalog can potentially be scaled out to the Asia-Monsoon region, if tailored to local contexts, and have attracted a lot of interest from stakeholders in the region. Technologies in Technology Catalog have been listed in the ASEAN-Japan MIDORI Cooperation Plan. Technology Catalog has also been introduced on the websites of the UN Food Systems Coordination Hub and the ASEAN Secretariat.

To disseminate the research activities and scalable technologies under Green Asia, JIRCAS held a joint symposium with NARO at the 6th International Rice Congress (IRC), attended the MAFF event at COP28, and presented various Green Asia activities in international fora such as the ASEAN Forum and workshops.

TOPIC 1

An integrated environmental control system and supplemental lighting increase strawberry production in subtropical regions

Strawberries (*Fragaria* × *ananassa* Duch.) are popular fruits consumed worldwide, and the demand for high-quality strawberries has been increasing in tropical and subtropical regions. This study aimed to elucidate the effects of environmental control and daytime LED supplemental lighting on strawberry production in a subtropical climate. Two strawberry cultivars, namely 'Yotsuboshi' and 'Benihoppe,' were grown by forcing culture in three greenhouses: (1) conventional greenhouse, with side vents open and no other environmental controls; (2) controlled environment (CE) greenhouse, equipped with an integrated environmental control system to cool air and growing medium; and (3) CE and LED greenhouse (CE&LED), equipped with an integrated environmental control system and LED supplemental lighting during the day.

Daily mean air and growing medium temperatures are lower in CE and CE&LED than in the conventional due to the combination of nighttime cooling, ventilation, shading, fogging, and medium cooling systems (Table 1). Even in the subtropical region, the temperature in greenhouses could be kept cooler by integrated environmental control. On Ishigaki Island, where the experiment was conducted, photosynthetic photon flux density (PPFD) increases in CE&LED in winter regardless of weather conditions (Fig. 1a, b). However, after April, when daily solar radiation exceeds 20 MJ m^{-2}, PPFD does not differ among greenhouses on sunny days (Fig. 1c). Conversely, even after April, PPFD increases with LED supplemental lighting during cloudy days (Fig. 1d). The integrated environmental control allows CE to produce yields comparable to the mean yield in Japan (Fig. 2). Environmental control also improves the percentage of

Table 1. Daily mean air temperatures and mean growth medium temperatures by month

Greenhouse	Nov	Dec	Jan	Feb	Mar	Apr	May
				Daily mean air temperature			
Conventional	23.1	21.5	20.0	19.3	23.1	25.5	25.3
CE	19.9	18.4	17.7	17.8	21.2	23.2	22.6
CE & LED	21.1	19.1	18.8	18.9	21.5	22.8	22.5
				Mean growth medium temperature			
Conventional	23.2	21.8	21.2	19.9	23.9	26.8	26.5
CE	17.2	16.7	16.3	16.6	17.8	18.9	18.7
CE & LED	18.2	17.3	17.1	17.4	18.8	19.8	19.8

Air temperature was measured at a height of 1.5 m in the center of the greenhouse, and medium temperature was measured at a depth of 5 cm between plants.

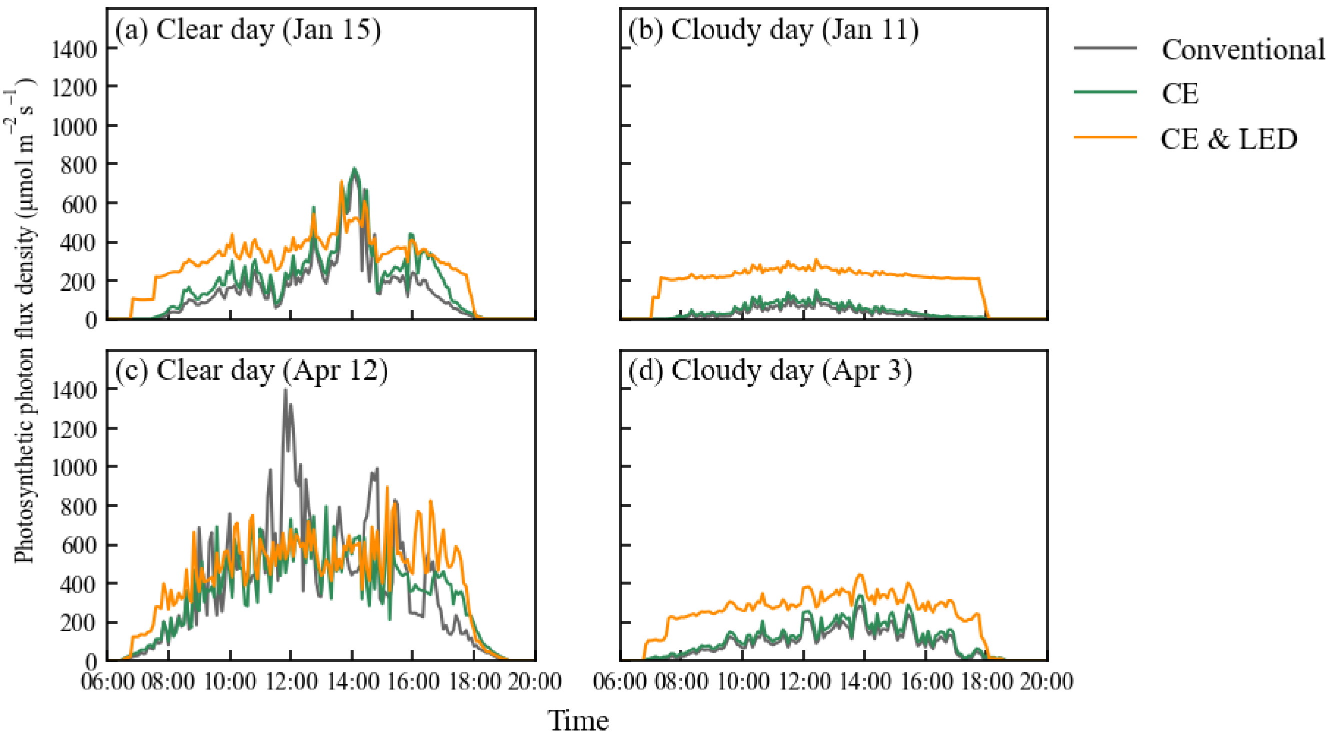


Fig. 1. Daily photosynthetic photon flux density in the conventional, controlled environment (CE), and LED (CE&LED) greenhouses on sunny and cloudy days

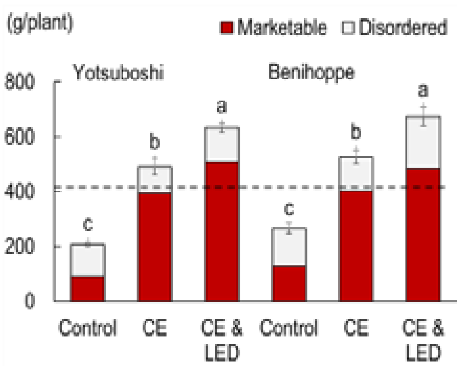


Fig. 2. Total and marketable yield
Marketable fruits weighing 6 g or more. Different letters indicate significant differences at the 5% level. The dashed line indicates Japanese average (410 g/plant).

Table 2. Number of fruits, fruit weight, and soluble solid content (SSC)

	Number of fruits (fruits/plant)	Fruit weight (g)	SSC
		Greenhouse	
Conventional	34.9 c	10.6 b	7.4 c
CE	45.3 b	13.6 a	7.7 b
CE & LED	56.2 a	14.1 a	8.0 a
		Cultivar	
Yotsuboshi	47.3	12.5	7.7
Benihoppe	43.7	14.5	7.7
	NS	NS	NS

Different letters indicate significant differences at the 5% level.

marketable fruits weighing 6 g or more. Yield in CE&LED has significantly increased compared to CE. The number of fruits harvested and soluble solid content (SSC) in fruit increase when environmental control and LED supplemental lighting are used together (Table 2).

By introducing the integrated environmental control system, strawberry yield and quality improve in hot and humid environments such as subtropical regions. In addition, the combination of environmental control and supplemental daytime LED lighting is an effective technique for improving yield and fruit quality. On the other hand, since the effect is limited in environments where solar radiation exceeds 20 MJ m^{-2}, it is necessary to consider local weather conditions when introducing LED lighting.

Reference

Nakayama and Nakazawa. (2023) *Scientia Horticulture* 321: 112349. © Elsevier B.V. 2023

Figures and tables reprinted/modified from Nakayama and Nakazawa (2023) with permission.

(Nakayama, M. [JIRCAS], Nakazawa, Y. [CITIZEN ELECTRONICS Co., Ltd.])

TOPIC 2

Improvement of sugarcane root characteristics through intergeneric hybridization between sugarcane and *Erianthus*

In order to improve crop productivity and sustainable production under climate change, crops that are tolerant to drought stresses need to be developed. Improving root characteristics is an important breeding target to increase the productivity of crops grown under drought conditions. In sugarcane (*Saccharum* spp. hybrid), an important crop for global food and energy production, there is concern about increasing drought damage and a need to improve drought tolerance through root improvement. However, there have been few reports on root improvement in sugarcane, and the limitations of improvement using existing breeding materials have been pointed out. *Erianthus arundinaceus*, a genetic resource of a closely related genus of sugarcane, has large and deeply developed roots, making it highly adaptable to drought. Its roots also show high deposition of lignin, which is one of the major components of plant cell walls and is also associated with drought stress tolerance. Therefore, it has great potential to be a promising breeding material for improving the root characteristics of sugarcane. This study evaluated the root characteristics of an intergeneric F1 hybrid of sugarcane and *E. arundinaceus* to assess the potential for introducing the root characteristics of *E. arundinaceus* into sugarcane through intergeneric hybridization.

Field experiments were carried out at the Japan International Research Center for Agricultural Sciences using the sugarcane cultivar NiF8, *E. arundinaceus* clones, and their intergeneric F_1 hybrid J08-12. We evaluated root distribution from 0 to 120 cm depth and fiber composition. J08-12 and *E. arundinaceus* clones had greater root dry weight per stool and smaller shoot-root ratios than NiF8 (Table 1, Fig. 1). Regarding root distribution, J08-12 and *E. arundinaceus* clones had significantly greater root dry weights and root length densities than NiF8 in the deep soil layers (Table 2, Fig. 1). Root lignin contents were low in NiF8, high in *E. arundinaceus* clones, and intermediate in J08-12 (Table 1). These results indicate that intergeneric hybridization of sugarcane and *E. arundinaceus* could successfully introduce root characteristics of *E. arundinaceus*, such as deep root distribution and high lignin content, into sugarcane. Improving sugarcane root characteristics through intergeneric hybridization with *E. arundinaceus* will be a powerful strategy to improve drought tolerance and achieve sustainable sugarcane production in the future.

Table 1. Agronomic traits and root characteristics of the intergeneric F_1 hybrid J08-12

Experiment	Clone	Dry matter yield (t ha^{-1})	Stalk number (stalks ha^{-1})	Root dry weight (g $stool^{-1}$)	Shoot-root ratio	Lignin content (mg g^{-1}-DW)
Exp. 1	J08-12	31.9 ns[1)]	131,305 *	80 ns	18 *	163 ns
	NiF8	20.3	63,161	24	35	140
	IJ76-349	58.8 *	117,041 *	251 *	10 *	193 *
	JW630	46.1 *	552,315 *	170 *	12 *	228 *
Exp. 2	J08-12	31.6 ns	145,688 ns	65 ns	26 ns	166 *
	NiF8	27.3	100,714	42	30	133
	JIRCAS1	51.7 *	588,810 *	214 *	16 *	199 *

* and n.s. indicate significant differences at $p < 0.05$ and no significant difference from NiF8, respectively, according to the Dunnett test. Exp. 1 is the mean of three years of data harvested in January 2011, January 2012, and December 2012. Exp. 2 is the mean of two years of data harvested in January 2014 and February 2015. NiF8 is the sugarcane cultivar. IJ76-349, JW630, and JIRCAS1 are *Erianthus* clones. J08-12 is an intergeneric F_1 hybrid between NiF8 and JIRCAS1.

Table 2. Root length density of J08-12 at different soil depths (cm cm^{-3})

Experiment	Clone	Soil depth					
		0-20 cm	20-40 cm	40-60 cm	60-80 cm	80-100 cm	100-120 cm
Exp. 1	J08-12	1.07 ns[1)]	0.49 ns	0.41 *	0.30 ns	0.23 ns	0.24 *
	NiF8	0.85	0.61	0.20	0.11	0.08	0.04
	IJ76-349	3.18 *	1.20 *	0.66 *	0.30 ns	0.34 *	0.37 *
	JW630	3.03 *	1.31 *	0.62 *	0.33 ns	0.31 *	0.26 *
Exp. 2	J08-12	1.55 ns	0.61 ns	0.53 ns	0.45 *	0.29 *	0.21 *
	NiF8	1.28	0.55	0.36	0.18	0.09	0.04
	JIRCAS1	2.53 ns	1.09 ns	0.65 ns	0.56 *	0.32 *	0.32 *

* and n.s. indicate significant differences at $p > 0.05$ and no significant difference from NiF8, respectively, according to the Dunnett test. Exp. 1 evaluated the root of the second ratoon crops, which was harvested in January 2011, January 2012, and December 2012. Exp. 2 evaluated the root of the first ratoon crop, harvested in January 2014 and February 2015.

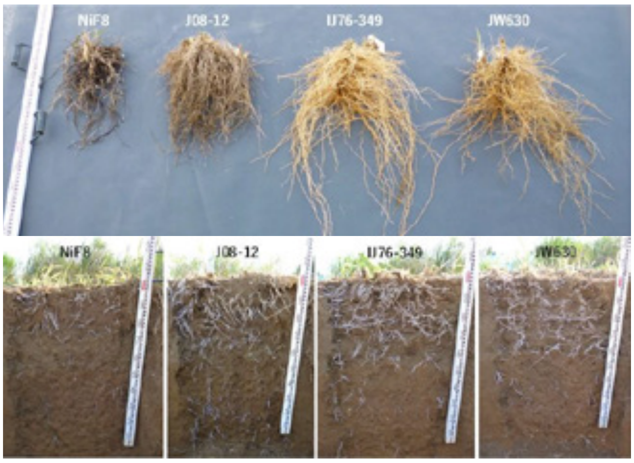


Fig. 1. Amount (top) and distribution (bottom) of roots of J08-12
J08-12 has more roots and deeper root distribution than NiF8 (Exp. 1).

Reference

Terajima et al. (2023) *Field Crops Research* 297: 108920.
© The Author(s) 2023
The tables and figure were reprinted/modified from Terajima et al. (2023).

(Terajima, Y., Sugimoto, A., Takagi, H., Ando, S. [JIRCAS], Tippayawat, A. [Khon Kaen Field Crops Research Center], Irei, S. [Okinawa Prefectural Agricultural Research Center], Hayashi, H. [Univ. of Tsukuba])

TOPIC 3

Photosynthetic capacity of passion fruit genotypes at high temperatures is determined by transpiration capacity under non-stressed conditions

Passion fruit (*Passiflora* spp.) is mostly indigenous to the tropical highlands, generally with decreasing growth and productivity in high temperature conditions. Purple passion fruit (*P. edulis*) has lower juice acidity with excellent fresh eating quality, but its growth and productivity are severely inferior at high temperatures. Yellow passion fruit (*P. edulis* f. *flavicarpa*) is tolerant to high temperatures and can be cultivated in some tropical lowlands, but its juice shows high acidity and is not suitable for fresh consumption. Hybrids of these species have been bred in various areas of the world. However, summer productivity remains poor, and little is known about the leaf photosynthetic responses to high temperatures, which can affect growth during hot summers.

We measured the individual leaf photosynthesis of 13 genotypes of passion fruit at high temperatures above 30°C using a portable gas-exchange system in a growth chamber under precisely controlled environments (Fig. 1) to analyze the traits that correlated highly with photosynthetic capacity. At leaf temperatures up to 40°C, gross and net photosynthetic rates decreased mainly due to stomatal closure, while above 40°C, only the net photosynthetic rate decreased due to increased respiration (Fig. 2). The reduction in photosynthesis at high leaf temperatures above 35°C was strongly correlated ($p < 0.01$) with transpiration rate and stomatal conductance under non-stress conditions (leaf temperature of 30°C), and genotypes with well-opened stomata exhibiting higher transpiration rates showed a smaller net photosynthetic rate reduction at high temperatures (Fig. 3). The reductions in net photosynthetic rate at high temperatures and the values of transpiration rate and stomatal conductance under non-stress conditions (leaf temperature of 30°C) were strongly correlated with stomatal size ($p < 0.01$) in 9 genotypes of *P. edulis* group (Table 1), excluding 4

Fig. 1. Measurement in a growth chamber
Photosynthesis measurements were conducted in 13 passion fruit genotypes.

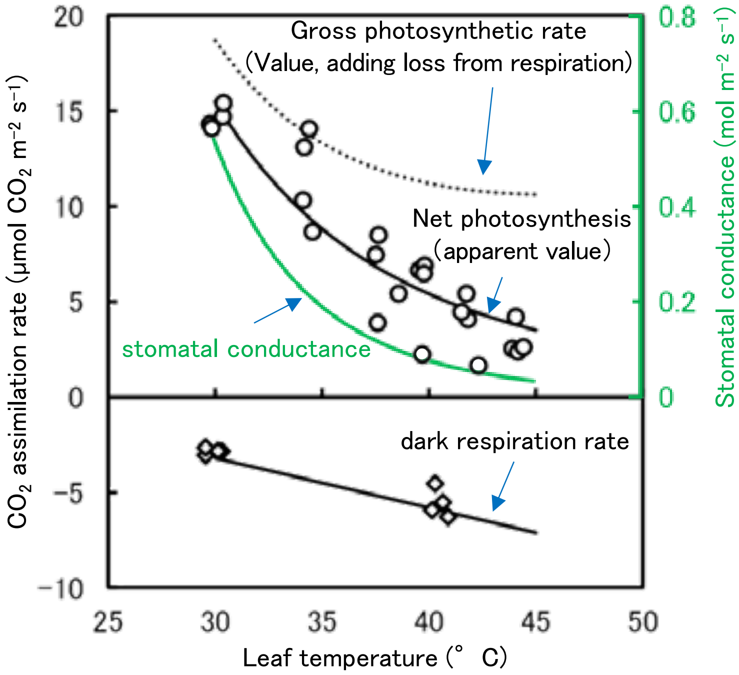


Fig. 2. Relationship between leaf temperature and photosynthetic rate, respiration rate, and stomatal conductance (cultivar 'Ruby Star')
Sigmoidal curve and linear regression were performed.

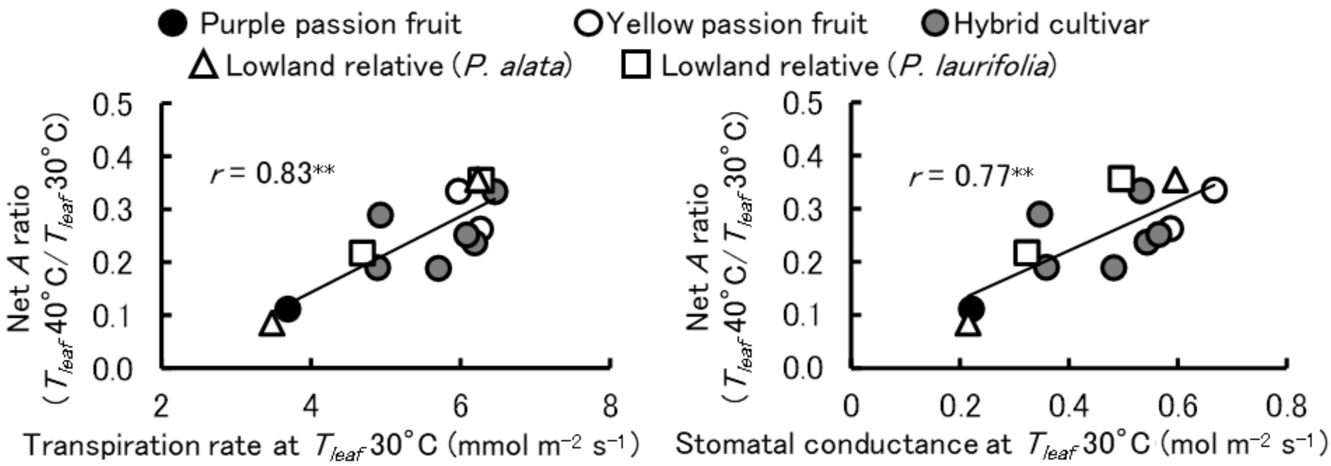


Fig. 3. Relationship between photosynthetic rate (*A*) reduction at high temperature and transpiration under non-stress condition at leaf temperature (T_{leaf}) of 30°C
** represents significant correlation at $p < 0.01$.

Table 1. Correlation coefficients between photosynthetic reduction and transpiration capacity and stomatal traits (excluding lowland relatives)

	Stomatal density	Stomatal size
Net A ratio (T_{leaf} 35°C/ T_{leaf} 30°C)	−0.76 **	0.43 NS
Net A ratio (T_{leaf} 40°C/ T_{leaf} 30°C)	−0.55 NS	0.90 **
Net A ratio (T_{leaf} 45°C/ T_{leaf} 30°C)	−0.60 NS	0.82 **
Transpiration rate at T_{leaf} 30°C	−0.67 *	0.79 **
Stomatal conductance at T_{leaf} 30°C	−0.59 NS	0.88 **

* and ** indicate significant correlation at $p < 0.05$ and $p < 0.01$, respectively. NS means no significance.

genotypes of lowland relatives (*P. alata* and *P. laurifolia*). These results indicate that genotypes with larger stomatal sizes maintained higher net photosynthetic rates at extremely high leaf temperatures above 40°C and had higher net photosynthetic rates and stomatal conductance under non-stress conditions.

This information can be useful for further selection of passion fruit genotypes with resilience to ongoing global warming. We need to consider separately the application to crossbreeding using lowland relatives, in which stomatal traits did not clearly correlate with transpiration capacity; however, transpiration capacity under non-stress conditions can be one of the target traits for breeding passion fruit genotypes that are highly tolerant to high temperatures.

Reference

Matsuda and Takaragawa (2023) *The Horticulture Journal* 92: 412–423. © The Japanese Society for Horticultural Science

The figures were reprinted/modified from Matsuda and Takaragawa (2023) with permission.

(Matsuda, H., Takaragawa, H. [JIRCAS])

Training and Invitation Programs

Information Events

Invitation Programs at JIRCAS

In keeping with its role as an international research center, JIRCAS has implemented several invitation programs for foreign researchers and administrators 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. Amid the lingering restrictions on travel and other activities caused by the COVID-19 pandemic, JIRCAS managed to strengthen its invitation programs in FY 2023. The following is a summary of JIRCAS invitation programs implemented in FY 2023.

Administrative Invitation Program

The purpose of this program is to invite administrators with a high level of specialized knowledge or management capabilities to Japan for strategic discussions to promote collaborative activities between the counterpart organizations and JIRCAS and to share cutting-edge information in the field through various workshops, seminars, and international symposiums organized by JIRCAS. In FY 2023, a total of twenty-five (25) administrators visited JIRCAS under this program. The names of administrators who visited JIRCAS and their length of stay are listed below.

Administrative Invitations, FY 2023

Name	Institution/Organization	Duration
Bram Govaerts	International Maize and Wheat Improvement Center, Mexico	May 20 - 25, 2023
Viktor Maurice Kommerell	International Maize and Wheat Improvement Center, Mexico	May 20 - 26, 2023
Qixian Lai	The Institute of Rural Development, Zhejiang Academy of Agricultural Sciences, China	Aug. 23 - 29, 2023
Fuyan Ke	The Institute of Rural Development, Zhejiang Academy of Agricultural Sciences, China	Aug. 23 - 29, 2023
Yadav Rajender Kumar	Indian Council of Agricultural Research (ICAR), India	Sep. 10 - 16, 2023
Rai Arvind Kumar	Indian Council of Agricultural Research (ICAR), India	Sep. 10 - 16, 2023
Satyendra Kumar	Indian Council of Agricultural Research (ICAR), India	Sep. 10 - 16, 2023
Mohamad Zabawi Bin Abdul Ghani	Malaysian Agricultural Research and Development Institute (MARDI), Malaysia	Sep. 19 - 23, 2023
Aniadila Binti Kamaruddin*	Malaysian Agricultural Research and Development Institute (MARDI), Malaysia	Sep. 19 - 23, 2023
Fan Shenggen	China Agricultural University, China	Sep. 20 - 23, 2023
Ishak Bin Mohd Yusuff	SIRIM Berhad, Industrial Biotechnology Research Centre, Malaysia	Nov. 12 - 18, 2023
Astimar Binti Abdul Aziz	Malaysia Palm Oil Board (MPOB), Malaysia	Nov. 12 - 18, 2023
K Sudesh Kumar C Kanapathi Pillai	Universiti Sains Malaysia (USM), Malaysia	Nov. 12 - 21, 2023
Wan Mohd Shukuri Wan Ahmad	Forest Research Institute Malaysia (FRIM), Malaysia	Nov. 15 - 20, 2023
Sonya Dewi Santoso	Center for International Forestry Research (CIFOR) and World Agroforestry (ICRAF), Indonesia	Nov. 16 - 19, 2023
Batmunkh Damdin	Ministry of Food, Agriculture, and Light Industry (SID, MoFALI), Mongolia	Feb. 12 - 17, 2024
Kadirbyek Dagys	Mongolian University of Life Sciences (MULS), Mongolia	Feb. 12 - 17, 2024
Dxomeku Israel Kwame	University for Development Studies (UDS), Ghana	Mar. 9 - 17, 2024
Owusu Emmanuel Yaw	University for Development Studies (UDS), Ghana	Mar. 9 - 17, 2024

Administrative Invitations, FY 2023		
Name	Institution/Organization	Duration
Ophelia Asirifi Amoako	University for Development Studies (UDS), Ghana	Mar. 9 - 17, 2024
Pablo Luis S. Azcona	Sugar Regulatory Administration (SRA), Philippines	Mar. 24 - 31, 2024
Ignacio Santillana	Sugar Regulatory Administration (SRA), Philippines	Mar. 24 - 31, 2024
Ma. Mitzi V. Mangwag	Sugar Regulatory Administration (SRA), Philippines	Mar. 24 - 31, 2024
David Andrew L. Sanson	Sugar Regulatory Administration (SRA), Philippines	Mar. 24 - 31, 2024
Juan Andres T. Corro	Sugar Regulatory Administration (SRA), Philippines	Mar. 24 - 31, 2024

*own expense

Counterpart Researcher Invitation Program

The purpose of this program is to invite researchers from counterpart organizations of JIRCAS to facilitate competent collaboration by strengthening ties among researchers and improving research capabilities. The invited counterparts carry out data analysis in close cooperation with Japanese researchers, and they conduct experiments and advanced research using high-precision equipment. This makes it possible to effectively promote research activities. Besides JIRCAS, researchers from counterpart organizations also conduct in-depth research at other MAFF-affiliated national research and development agencies, prefectural research institutes, or national universities in Japan. A total of forty-one (41) researchers were invited under this program in FY 2023. The names of counterpart researchers who visited JIRCAS, their research themes, and duration of stay are listed below.

Counterpart Researcher Invitations, FY 2023			
Name	Institution/Organization	Research Theme	Duration
Nur Hanis Alisa Binti Md Hasri	Universiti Sains Malaysia, Malaysia	Gene expression analysis for the development of OPT high-sugar technology	May 11 - Nov. 2, 2023
Sreyneang Nhim	King Mongkut's University of Technology Thonburi, Thailand	Advancement of Microbial Saccharification Technology by Improving *Thermobrachium celere* A9	May 15 - Nov. 1, 2023
Gao Xiang	Chinese Academy of Agricultural Sciences, China	Nitrogen dynamics and plant physiological analysis in field trials of BNI-enabled crops (wheat and sorghum)	Jun. 1 - Dec. 28, 2023
Mohd Amar Shafiq Bin Saipol Anuar	Universiti Sains Malaysia, School of Biological Sciences, Malaysia	Elucidation of the effect of palm seedlings on OPT mixed soil on soil microbial flora and isolation of decomposing microbes	Jun. 19 - Sep. 1, 2023
Kristine Samoy Pascual	Philippine Rice Research Institute, Philippines	Development of cost-effective greenhouse gas emission reduction technology for small-scale farmers in Southeast Asia	Jun. 26 - Jul. 3, 2023
Sangdaun Chanachai	Khon Kaen Field Crops Research Center, Department of Agriculture, Thailand	Development of new type of sugarcane and high biomass crops for sugar and/or fiber utilization under adverse agricultural environments by using sugarcane-related germplasm	Aug. 2 - 13, 2023
Ya-Ping Lin	World Vegetable Center, Taiwan	Production of heat-tolerant tomato	Sep. 4 - 20, 2023
Santiago Tarqui Tarqui	Universidad Mayor de San Andrés, Bolivia	Strengthening of Resilience in Arid Agro-Ecosystems Vulnerable to Climate Change, Through Research on Plant Resources and Technological Applications	Sep. 13 - Oct. 14, 2023
Patthra Pason	King Mongkut's University of Technology Thonburi, Thailand	Development of biomass saccharification technology using anaerobic microbes	Oct. 27 - Nov. 2, 2023

Counterpart Researcher Invitations, FY 2023			
Name	Institution/Organization	Research Theme	Duration
Chakrit Tachaapaikoon	King Mongkut's University of Technology Thonburi, Thailand	Development of biomass saccharification technology using anaerobic microbes	Oct. 27 - Nov. 2, 2023
Jimmy Casto Ciancas Jimenez	FUNDACIÓN PROINPA, Bolivia	Strengthening of Resilience in Arid Agro-Ecosystems Vulnerable to Climate Change, Through Research on Plant Resources and Technological Applications	Nov. 3 - 23, 2023
Lam Thi Nhung	Plant Protection Research Institute, Vietnam	Establishment of IPM system for controlling rice planthoppers in the overwintering region in Indochina Peninsula	Nov. 6 - 15, 2023
Roni Ridwan	National Research and Innovation Agency, Indonesia	Fermentation control of silage and total mixed ration (TMR) prepared with rice straw and development of livestock feeding technology	Nov. 6 - 18, 2023
Ki Ageng Sarwono	National Research and Innovation Agency, Indonesia	Fermentation control of silage and total mixed ration (TMR) prepared with rice straw and development of livestock feeding technology	Nov. 6 - 18, 2023
Leh Cheu Peng	Universiti Sains Malaysia (USM), Malaysia	Sustainable Replantation of Oil Palm by Adding Value to Oil Palm Trunk through Scientific and Technological Innovation	Nov. 13 - 18, 2023
Chee Jiun Yee	Universiti Sains Malaysia (USM), Malaysia	Sustainable Replantation of Oil Palm by Adding Value to Oil Palm Trunk through Scientific and Technological Innovation	Nov. 13 - 18, 2023
Azura Binti Ahmad	Universiti Sains Malaysia (USM), Malaysia	Sustainable Replantation of Oil Palm by Adding Value to Oil Palm Trunk through Scientific and Technological Innovation	Nov. 13 - 18, 2023
Nur Liyana Binti Jufika Ahmad	Industrial Biotechnology Research Centre, Malaysia	Sustainable Replantation of Oil Palm by Adding Value to Oil Palm Trunk through Scientific and Technological Innovation	Nov. 13 - 18, 2023
Rafidah Binti Jalil	Forest Research Institute Malaysia (FRIM), Malaysia	Sustainable Replantation of Oil Palm by Adding Value to Oil Palm Trunk through Scientific and Technological Innovation	Nov. 13 - 18, 2023
Latifah Binti Jasmani	Forest Research Institute Malaysia (FRIM), Malaysia	Sustainable Replantation of Oil Palm by Adding Value to Oil Palm Trunk through Scientific and Technological Innovation	Nov. 13 - 18, 2023
Norliyana Binti Haji Zin Zawawi	Malaysia Palm Oil Board (MPOB), Malaysia	Sustainable Replantation of Oil Palm by Adding Value to Oil Palm Trunk through Scientific and Technological Innovation	Nov. 13 - 18, 2023
Weerakorn Saengsai	Khon Kaen Field Crops Research Center, Thailand	Development of new type of sugarcane and high biomass crops for sugar and/or fiber utilization under adverse agricultural environments by using sugarcane-related germplasm	Nov. 14 - Dec. 2, 2023
Eny Faridah	Universitas Gadjah Mada, Indonesia	Development and dissemination of tropical forestry seeds and seedlings that are adaptable to climate change and productivity	Dec. 7 - 15, 2023
Eko Prasetyo	Universitas Gadjah Mada, Indonesia	Development and dissemination of tropical forestry seeds and seedlings that are adaptable to climate change and productivity	Dec. 7 - 15, 2023
Widiyatno	Universitas Gadjah Mada, Indonesia	Development and dissemination of tropical forestry seeds and seedlings that are adaptable to climate change and productivity	Dec. 13 - 22, 2023

Counterpart Researcher Invitations, FY 2023			
Name	Institution/Organization	Research Theme	Duration
Ajay Kumar Bhardwaj	Indian Council of Agricultural Research (ICAR), India	Confirmation of *Leymus racemosus* N chromosome short arm (Lr#N-SA) introduction to Indian elite materials, and learning the methodology of JIRCAS BNI-wheat experiment in Hachimandai field	Feb. 18 - 25, 2024
Chandra Nath Mishra	Indian Council of Agricultural Research (ICAR), India	Confirmation of *Leymus racemosus* N chromosome short arm (Lr#N-SA) introduction to Indian elite materials, and learning the methodology of JIRCAS BNI-wheat experiment in Hachimandai field	Feb. 18 - 22, 2024
Harikrishna	Indian Council of Agricultural Research (ICAR), India	Confirmation of *Leymus racemosus* N chromosome short arm (Lr#N-SA) introduction to Indian elite materials, and learning the methodology of JIRCAS BNI-wheat experiment in Hachimandai field	Feb. 18 - 25, 2024
Manish Kumar Vishwakarma	Indian Council of Agricultural Research (ICAR), India	Confirmation of *Leymus racemosus* N chromosome short arm (Lr#N-SA) introduction to Indian elite materials, and learning the methodology of JIRCAS BNI-wheat experiment in Hachimandai field	Feb. 18 - 25, 2024
Denny Irawati	Universitas Gadjah Mada, Indonesia	Evaluation of genetic resources of tropical forests and development of carbon recycling technologies from unutilized biomass in Indonesia	Feb. 26 - Mar. 10, 2024
Analuddin	Universitas Halu Oleo, Indonesia	Study on Conservation and Management of Mangroves in Indonesia	Mar. 2 - 6, 2024
Muhammad Zamrun F.	Universitas Halu Oleo, Indonesia	Enhancing Climate Change Resilience of Socio-Ecological Systems in the Coral Triangle and Its Surrounding Areas	Mar. 2 - 8, 2024
Takdir Saili	Universitas Halu Oleo, Indonesia	Enhancing Climate Change Resilience of Socio-Ecological Systems in the Coral Triangle and Its Surrounding Areas	Mar. 2 - 8, 2024
Viska Inda Variani	Universitas Halu Oleo, Indonesia	Enhancing Climate Change Resilience of Socio-Ecological Systems in the Coral Triangle and Its Surrounding Areas	Mar. 2 - 8, 2024
Armid	Universitas Halu Oleo, Indonesia	Enhancing Climate Change Resilience of Socio-Ecological Systems in the Coral Triangle and Its Surrounding Areas	Mar. 2 - 8, 2024
N. Rollon	University of the Philippines, Philippines	Enhancing Climate Change Resilience of Socio-Ecological Systems in the Coral Triangle and Its Surrounding Areas	Mar. 2 - 10, 2024
Green Ann A. Cruz	University of the Philippines, Philippines	Assessment of the recovery process of Philippine mangroves after typhoon damage	Mar. 2 - 10, 2024
Giannina Marie G. Albano	University of the Philippines, Philippines	Evaluation of mangrove restoration process in abandoned aquaculture ponds in the Philippines	Mar. 2 - 10, 2024
Sahadev Sharma	Universiti Malaya, Malaysia	Development of silvicultural techniques that take into account the effects of vegetation change on ecosystem functions	Mar. 2 - 10, 2024
Mohammed Rizman Bin Idid	Universiti Malaya, Malaysia	Development of silvicultural techniques that take into account the effects of vegetation change on ecosystem functions	Mar. 2 - 10, 2024
Marina Monserrat-Diez*	University of Vienna, Austria	Soil nitrification related microbial flora of BNI-enabled wheat field at JIRCAS	Mar. 17 - Jun. 1, 2024

*own expense

Project Site Invitation Program

The purpose of the Project Site Invitation Program is to support international travel for counterpart researchers, not only to collaborate with JIRCAS scientists in the project sites but also to provide opportunities to actively participate in discussions at international symposiums. In FY 2023, a total of eleven (11) researchers participated in this program and played significant roles in the symposiums and workshops with JIRCAS researchers, as listed below.

Project Site Invitations, FY 2023

Name	Institution/Organization	Purpose	Duration
Mohammad Ashik Iqbal Khan	Bangladesh Rice Research Institute, Bangladesh	1st UN Food Systems Stocktaking Moment Side-Event: "Strategy MIDORI" and Innovation Initiatives for Transforming into Sustainable Agriculture and Food Systems in the Asia Monsoon Region	Jul. 23 - 27, 2023
Deepak Pandey	Nepal Agricultural Research Council, Nepal	Participation to Joint Coordination Committee and Joint Technical Committee of SATREPS BNI-enabled wheat project conducting in India	Aug. 26 - Sep. 2, 2023
Khem Raj Pant	Nepal Agricultural Research Council, Nepal	Participation to Joint Coordination Committee and Joint Technical Committee of SATREPS BNI-enabled wheat project conducting in India	Aug. 26 - Sep. 2, 2023
Mahesh Subedi	Nepal Agricultural Research Council, Nepal	Participation to Joint Coordination Committee and Joint Technical Committee of SATREPS BNI-enabled wheat project conducting in India	Aug. 26 - Sep. 2, 2023
Simone Vongkhamho	National Agriculture and Forestry Research Institute, Lao PDR	Participation in an international seminar on teak clone forestry for sustainable management	Oct. 1 - 5, 2023
Thav Sopheak	Royal University of Agriculture, Cambodia	To attend the JIRCAS-CTU Climate Change Project Workshop 2023 and exchange views on climate change measures in the agriculture sector	Nov. 29 - Dec. 3, 2023
Chhun Vireak	Royal University of Agriculture, Cambodia	To attend the JIRCAS-CTU Climate Change Project Workshop 2023 and exchange views on climate change measures in the agriculture sector	Nov. 29 - Dec. 3, 2023
Ouk Rachana	Royal University of Agriculture, Cambodia	To attend the JIRCAS-CTU Climate Change Project Workshop 2023 and exchange views on climate change measures in the agriculture sector	Nov. 29 - Dec. 3, 2023
Chea Sophors	Royal University of Agriculture, Cambodia	To attend the JIRCAS-CTU Climate Change Project Workshop 2023 and exchange views on climate change measures in the agriculture sector	Nov. 29 - Dec. 3, 2023
Khem Raj Pant	Nepal Agricultural Research Council, Nepal	Presentation in COP 28 Tech & Innovation	Dec. 8 - 12, 2023
Puspa Rizki Andhani	ASEAN Economic Community (AEC) Department, Indonesia	The JIRCAS Southeast Asia Liaison Office 50th Anniversary Symposium	Dec. 13 - 15, 2023

Fellowship Programs at JIRCAS

JIRCAS Visiting Research Fellowship Program

The JIRCAS Visiting Research Fellowship Program is one of the activities of JIRCAS designed to accelerate scientific research and advance the expertise of nominated researchers from developing countries. The program offers the opportunity to conduct research under the supervision of JIRCAS researchers.

Since the inception of the JIRCAS Visiting Research Fellowship Program in 1992, JIRCAS has invited talented researchers from research organizations in developing countries to conduct research. Due to the impact of the COVID-19 pandemic, the start of the program for each FY 2021 JIRCAS fellow was delayed. However, all six fellows completed their work under the supervision of JIRCAS researchers, with fruitful results. In FY 2023, three new researchers were awarded the JIRCAS Fellowship. They commenced their research at JIRCAS HQ in Tsukuba in October 2023 and will continue their work with their supervisors until October 2024. The list of fellows, their research topics, and periods of stay is shown below.

JIRCAS Visiting Research Fellowship at Tsukuba

Name	Institution/Organization	Research Theme	Duration
Sarkodee-Addo Elsie Akua Serwaa	University of Ghana, 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 - Sep. 30, 2023
Arafa Ramadan Ahmed	Agricultural Research Center, Egypt	Genetic analysis of resistance against Cercospora Leaf Blight (CLB) disease in soybean germplasm	Apr. 17, 2022 - Apr. 3, 2023
Rollano-Peñaloza Oscar Miguel	University Mayor de San Andrés, Bolivia	Elucidation of the molecular basis for strengthening the resilience of quinoa	Apr. 17, 2022 - Sep. 29, 2023
Sornyotha Somphit	King Mongkut's Institute of Technology Ladkrabang, Malaysia	Elucidation of the decomposition mechanism of microorganisms that decompose protein-mixed agricultural waste and its application	Apr. 25, 2022 - Sep. 29, 2023
Dinh Hoan Xuan	Plant Protection Research Institute, Vietnam	Identification of a growth-promoting gene for enhancing soybean yield potential	May 5, 2022 - May 1, 2023
Jiang Mingli	Nanjing Agricultural University, China	BNI-characterization of maize parental lines to develop phenotyping methodology for evaluation of double haploid population for BNI-capacity	Jun 5, 2022 - Jun. 6, 2023
Cheawchanlertfa Pattsarun	Mahidol University / Biochemical Technology, Thailand	Identification and application of genes involved in dramatic improvement of degradation ability of cellulose-saccharifying microorganisms	Oct. 15, 2023 - Oct. 16, 2024
Zhang Haiyan	Hunan Academy of Agricultural Sciences, China	BNI-characterization of maize parental lines to develop phenotyping methodology for evaluation of double haploid population for BNI-capacity	Oct. 9, 2023 - Oct. 8, 2024
Zhang Wei	Jiangsu Academy of Agricultural Sciences, China	"Elucidation of genetic mechanism controlling root development in soybean"	Oct. 16, 2023 - Oct. 16, 2024

Other Fellowships

The JSPS International Postdoctoral Fellowships Program provides opportunities for postdoctoral researchers from other countries to conduct collaborative research with leading research groups in universities and other Japanese institutions. JIRCAS hosted one JSPS International Fellow in FY 2023, as listed below.

JIRCAS Fellowship			
Name	Institution/Organization	Research Theme	Duration
Mandal Mohammad Shamim Hasan	Hiroshima University, Japan	Simulating mangrove reforestation under future climate change	Apr. 1, 2023 - Mar. 31, 2025

Workshops

"Millets - How to unlock their potentials to address nutritional, agricultural, and climate challenges"

In commemoration of the International Year of Millets 2023, the Japan International Research Center for Agricultural Sciences (JIRCAS) organized a seminar titled "Millets - How to unlock their potentials to address nutritional, agricultural, and climate challenges" on September 26, 2023. The event provided a platform for domestic and international researchers to discuss the latest advances in millet research and their potential applications.

The opening remarks were delivered by Dr. Yukiyo Yamamoto, Vice-President of JIRCAS, followed by Mr. Yukio Uchida, Deputy Director-General of the Agriculture, Forestry, and Fisheries Research Council at the Ministry of Agriculture, Forestry, and Fisheries (MAFF), and Ms. Eriko Hibi, Director of the FAO Liaison Office in Japan. Dr. Kazuo Nakashima, JIRCAS Program Director (Food), provided insights into the seminar's context, aligning with the International Year of Millets 2023.

Dr. C. Tara Satyavathi, Director of the Indian Institute of Millets Research (IIMR) under the Indian Council of Agricultural Research (ICAR), delivered the first keynote address, titled "IMR as a Global Center of Excellence on Millets - Achievements and Focus Areas of Research," while Dr. Jacqueline d'Arros Hughes, Director General of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), presented the second keynote address, titled "Millets - Agriculture, Food, and Nutrition in a Changing World. "

Prof. Makoto Kawase from Tokyo University of Agriculture then shared insights in his presentation, titled "Reappraisal of Millets with a Long History of Cultivation: Inspiring Sustainable Survival of Mankind." Dr. Tadashi Yoshihashi and Dr. Guntur Venkata Subbarao of JIRCAS followed with their presentation on "JIRCAS's Efforts on BNI-Enabled Sorghum and Millets to Enhance Both Productivity and Sustainability of Food Systems."

The Q&A session witnessed active participation, with numerous questions raised and answered by the speakers. At the end of the seminar, Mr. Osamu Koyama, President of JIRCAS, thanked the participants and expressed hope that the event would serve as a catalyst for international research by raising awareness of the role and benefits of these small yet remarkable grains.

By holding this seminar, we were able to raise awareness of the role and benefits of millets, improve our presence, strengthen collaboration with partners, and contribute to the Millet Initiative launched at the G20 Meeting of Agricultural Chief Scientists (MACS).

Keynote address from Dr. C. Tara Satyavathi

Photo of the seminar at the venue

TICAD 30th Anniversary Official Side Event “Toward Building a Sustainable and Resilient Food System in Africa”

To commemorate the 30th anniversary of the Tokyo International Conference on African Development (TICAD) in 2023, JIRCAS organized a hybrid seminar, titled “Toward Building a Sustainable and Resilient Food System in Africa,” at CO-EN, a casual event space inside Tsukuba Center Building next to Tsukuba Station, on December 1, 2023 (Friday), from 14:00 to 16:00. This seminar was approved as a TICAD 30th Anniversary Official Side Event by the Ministry of Foreign Affairs of Japan.

Agricultural development in Africa calls for an appropriate approach that recognizes and respects its diversity in agricultural production and food consumption. The purpose of the seminar was to raise awareness about Africa’s diversity and challenges in the food system and to improve understanding of the importance of JIRCAS research in addressing global issues in cooperation with Africa. The seminar presented various issues related to agriculture in Africa, Japan’s contributions, the history and current status of international joint research, and directions for future research. The content, which targeted the general public interested in Africa and international joint research, covered a wide range of fields related to African agriculture. The seminar was conducted in Japanese, with the exception of one presentation that was consecutively translated. Most of the presenters were from JIRCAS.

Dr. Kazuo Nakashima (Food Program Director) opened the seminar, followed by Dr. Norihito Kanamori (Project Leader, Information Hub Project), who served as seminar emcee and introduced the issues related to agriculture, forestry, and fisheries in Africa and Japan. The session on rice farming system was moderated by Dr. Yasuhiro Tsujimoto (Project Leader, Africa Rice Farming System Project), and the three speakers who presented their research during this session were Mr. Njato Michael Rakotoarisoa (Ph.D. Student, Nagoya University) on crops, Dr. Naoko Oka (Senior Researcher) on water resources, and Dr. Sakiko Shiratori (Senior Researcher) on nutrition supplies. The session on upland farming system was moderated by Dr. Satoshi Nakamura (Project Leader, Africa Upland Farming System Project). This session featured senior researchers Drs. Kenta Ikazaki, Papa Saliou Sarr, and Junji Koide, who gave presentations on soil, microorganisms, and agricultural management, respectively. After a lively question-and-answer session regarding the entire seminar, Dr. Miyuki Iiyama (Information Program Director) provided the closing address.

There were 25 in-person and 107 online participants, representing various affiliations including JIRCAS, other national research institutes, universities, private companies, NGOs, foundations, and relevant government agencies. Results of the post-seminar survey showed mostly positive responses. Specifically, 95% of the respondents expressed high satisfaction (74% very satisfied, 21% somewhat satisfied) with the overall content. Regarding understandability, 48% of respondents found it “very easy to understand,” while 50% said that it was “easy to understand,” together accounting for 98% of the total. In addition, participants praised the approach to solving specific problems, which they found helpful and easy to understand even for non-specialists. There were also comments appreciating the nice venue and the peaceful atmosphere.

A video of the event was later posted on the JIRCAS YouTube channel (split into four parts, as below).
https://www.youtube.com/watch?v=ZnK-HDxFSs4&t=1s (part 1)
https://www.youtube.com/watch?v=vvnEKIkza3Q&t=2s (part 2)
https://www.youtube.com/watch?v=m8bvTwyPy1Y&t=3s (part 3)
https://www.youtube.com/watch?v=DvRHdHveXvI&t=1s (part 4)

On-site participants

Speakers

Symposium Marks 50th Anniversary Milestone for JIRCAS Southeast Asia Liaison Office

The JIRCAS Southeast Asia Liaison Office, a long-standing pillar of collaborative research, celebrated its 50th anniversary with a symposium held at the Asawin Grand Convention Hotel on December 14, 2023. The occasion marked a significant milestone since its establishment in 1972 and, notably, was convened without the hindrance of travel restrictions imposed by the COVID-19 pandemic.

In the opening session, JIRCAS President Osamu Koyama expressed his sincere appreciation to the Government of Thailand and the Department of Agriculture for their unwavering support over the past five decades. He expressed his gratitude to the dedicated institutional researchers who, through their collective efforts, have contributed to the remarkable legacy of the Office. Mr. Takuro Tasaka, Minister Plenipotentiary of the Embassy of Japan, and Mr. Phatchayaphon Meunchang, Deputy Director General of the Thai Department of Agriculture, added their voices in congratulatory speeches, acknowledging the enduring cooperation between Japan and Thailand.

The symposium was divided into two parts. The first part featured extensive presentations by both JIRCAS and its Thai counterparts, highlighting the rich history and consequential results of joint research in soil science, livestock management, forestry practices, food production, plant pest control, aquaculture, and plant breeding.

In the second part, JIRCAS highlighted the innovative Green Asia Project, a pioneering initiative to promote sustainable agricultural practices. The FAO Regional Office for Asia and the Pacific (FAORAP) outlined its strategic initiatives in the Asia-Pacific region, in line with the FAO Science and Innovation Strategy formulated last June. The ASEAN Secretariat provided insights into the recently launched ASEAN Sustainable Agriculture Guidelines, forged in October of the same year, and explored their interplay with cutting-edge agricultural technology. The ensuing discussion focused on shaping the future trajectory of JIRCAS collaborative research in Southeast Asia and fostering international collaborations.

This commemorative symposium, witnessed by 46 in-person participants and 34 online attendees, not only paid tribute to the rich legacy of the JIRCAS Southeast Asia Liaison Office, but also served as a platform for envisioning a future marked by continued excellence in collaborative research and sustainable agricultural progress.

Commemorative photo

International Symposiums, Workshops, and Seminars, FY 2023			
1	Field Review Meeting on the Demonstration Test of Sugarcane Deep Planting Technology and Plowing of Residues to Improve Productivity and Environmental Conservation in Sugarcane Cultivation	April 25, 2023	Ishigaki, Okinawa, Japan
2	The 2nd Joint Coordination Committee (JCC) Meeting for the SATREPS Bolivia Superfoods Project	May 11, 2023	Online
3	Regional Meeting on Intermittent Irrigation	May 30, 2023	Phnom Penh, Cambodia (hybrid)
4	Briefing Session on the Use of the Brachiaria Variety "Isan"	June 30, 2023	Ishigaki, Okinawa, Japan (hybrid)
5	The 50th Tropical Agriculture Research Front (TARF) Public Lecture	June 30, 2023	Ishigaki, Okinawa, Japan
6	"Strategy MIDORI" and Innovation Initiatives for Transforming into Sustainable Agriculture and Food Systems in the Asia-Monsoon Region (1st UN Food Systems Stocktaking Moment (STM) Side Event)	July 24, 2023	Rome, Italy
7	National Quinoa Summit 2023	August 27, 2023	Kembuchi, Hokkaido, Japan (partly online)
8	Joint Coordination Committee Meeting for the SATREPS project titled "Establishment of nitrogen-efficient wheat production system in Indo-Gangetic Plains by the deployment of BNI technology"	September 1, 2023	New Delhi, India
9	Kick-off Meeting for the "Technology Establishment for Regional-adapted Regenerative Agriculture in Africa (TERRA Africa)" Project	September 6, 2023	Tamale, Ghana
10	The 51st Tropical Agriculture Research Front (TARF) Public Lecture	September 12, 2023	Ishigaki, Okinawa, Japan
11	The Agricultural Genetics Institute (AGI)-JIRCAS Kickoff Meeting on Rice Blast Research under the Green Asia Project	September 12, 2023	Hanoi, Vietnam
12	The 5th Research Network Meeting for Reducing Greenhouse Gas Emissions in the Livestock Industry	September 21, 2023	Obihiro University of Agriculture and Veterinary Medicine, Hokkaido, Japan
13	The Third Meeting of the International Scientific Advisory Board for Strategy "MIDORI"	September 21-22, 2023	Tokyo, Japan
14	Damnak Ampil Irrigation District S2-2L Farmers' Water Conservancy Association Meeting	September 22, 2023	Pursat Province, Cambodia
15	Seminar on "Millets - How to unlock their potentials to address nutritional, agricultural, and climate challenges"	September 26, 2023	Hibiya Kokusai Building, Tokyo, Japan (hybrid)
16	Workshop on "Sustainable Production and Propagation of Small Indigenous Species in Ubon Ratchathani and Neighboring Regions"	September 30, 2023	Warin Chamrap District, Thailand
17	International Seminar on "Improving the clonal teak plantation for sustainable management of monsoon forest"	October 2-4, 2023	Yogyakarta, Indonesia
18	The 1st Joint Coordination Committee (JCC) Meeting for the SATREPS project titled "Strengthening Tropical Forest Resilience Based on Management and Utilization of Genetic Resources Capable of Climate Change Adaptation"	October 6, 2023	Yogyakarta, Indonesia (hybrid)
19	Workshop titled "Explore the future of Ishigaki" and Water Symbiosis Seminar titled "Towards Ishigaki Island where water, people, and life coexist in harmony"	October 15, 2023	Ishigaki, Okinawa, Japan
20	International Rice Congress (IRC) Contributed Events	October 17, 2023	Manila, Philippines

International Symposiums, Workshops, and Seminars, FY 2023			
21	Seminar on "Neglected and Underutilised Plant Species — Contributions and potential for sustainable food systems in Sub-Saharan Africa"	October 26, 2023	Tokyo, Japan (hybrid)
22	The 5th SATREPS Joint Coordination Committee (JCC) Contract Adjustment Conference	November 14, 2023	OTEMACHI ONE, Tokyo, Japan (hybrid)
23	SATREPS Palm Trunk Special Seminar titled "The Future of the Palm Oil Industry: Biomass Utilization and Sustainability Initiatives"	November 14, 2023	OTEMACHI ONE, Tokyo, Japan (hybrid)
24	JIRCAS International Symposium 2023: Innovations to enhance the resilience of tropical forests and sustainability of the forest industry	November 17, 2023	United Nations University, Tokyo, Japan
25	SAADC2023 (International Conference on Sustainable Animal Agriculture for Developing Countries 2023) Parallel Session on "Improving Livestock GHG Inventory in SE Asia"	November 21-22, 2023	Vientiane, Laos
26	JIRCAS-Can Tho University (CTU) Climate Change Project Annual Meeting 2023	November 30, 2023	Can Tho, Vietnam (hybrid)
27	TICAD 30th Anniversary Official Side Event: Towards Building a Sustainable and Resilient Food System in Africa	December 1, 2023	Tsukuba, Japan (hybrid)
28	The 52nd TARF Public Lecture	December 12, 2023	Ishigaki, Okinawa, Japan
29	Symposium Commemorating the 50th Anniversary of the Establishment of the Southeast Asia Liaison Center	December 14, 2023	Bangkok, Thailand
30	The 2nd Technical Committee Meeting on the "Survey on Support for the Promotion of Rice Cultivation in Africa (Ghana)"	February 7, 2024	Akuse Town, Ghana (hybrid)
31	The 2nd Technical Committee Meeting on the "Survey on Support for the Promotion of Rice Cultivation in Africa (Tanzania)"	February 22, 2024	Moshi Town, Tanzania (hybrid)
32	Plenary Dialogue for Public-Private Partnerships to Promote the Utilization of Joint Crediting Mechanism (JCM) in the Agricultural Sector	March 1, 2024	Tokyo, Japan
33	International Workshop on "Mangrove Management and Monitoring: Long-term mangrove monitoring considering the climate change risks"	March 4-9, 2024	Tsukuba and Ishigaki, Japan (hybrid)
34	Seminar on "Simple pesticide susceptibility monitoring methods for rice plant hoppers"	March 4-6, 2024 and March 19-20, 2024	Session 1: Hanoi, Vietnam Session 2: Nam Dinh, Vietnam
35	2023 Steering Committee Meeting of the Forest Research Institute (FRIM)-JIRCAS Project	March 13, 2024	Kuala Lumpur, Malaysia (hybrid)
36	The Fourth Meeting of the International Scientific Advisory Board for Strategy "MIDORI"	March 15, 2024	Online
37	Special Seminar on "Sustainable Sugarcane Cultivation Systems"	March 29, 2024	JIRCAS, Tsukuba, Japan (hybrid)

Appendix

Publishing at JIRCAS

English

1. JARQ (Japan Agricultural Research Quarterly)

   Vol. 57 No. 3 (Published in July 2023)

   Vol. 57 No. 4 (Published in October 2023)

   Vol. 58 No. 1 (Published in January 2024)

   Vol. 58 No. 2 (Published in April 2024)

2. Annual Report

   2022 (Published on 20 September 2023)

3. JIRCAS Newsletter

   No.95 (Published on 7 November 2023)

   No.96 (Published on 26 March 2024)

Japanese

1. Kōhō JIRCAS

   Vol. 12 (Published on 10 October 2023)

   Vol. 13 (Published on 29 February 2024)

2. JIRCAS NEWS

   No.95 (Published on 7 November 2023)

   No.96 (Published on 26 March 2024)

Refereed Journal Articles 2023-2024

Program A

Akutsu, H., Na'iem, M.*, Indrioko, W.S., Purnomo, S., Uchiyama, K., Tsumura, Y., Tani, N.* (2023.10) Comparing modeling methods of genomic prediction for growth traits of a tropical timber species, *Shorea macrophylla*. *Frontiers in Plant Science*, 14. https://doi.org/10.3389/fpls.2023.1241908.

Arai, M.*, Wagai, R. (2023.11) Does rice paddy management increase soil organic carbon in the warm temperate and tropical regions? *Geoderma Regional*, 36: e00738.

Bassar, A.T.M.Z.*, Suwa, R., Kanda, T., Dannoura, M. (2023.12) Carrying capacity for tree biomass of a subtropical mangrove along a river in Japan inferred from forest structural features. *Ecological Research*, https://doi.org/10.1111/1440-1703.12437.

Binsulong, B., Gunha, T., Kongphitee, K., Maeda, K., Sommart, K.* (2023.9) Enteric methane emissions, rumen fermentation characteristics, and energetic efficiency of holstein crossbred bulls fed total mixed ration silage with cassava instead of rice straw. *Fermentation*, 9: 850.

DeArmond, D.*, Rovai, A., Suwa, R., Higuchi, N. (2023.12) The Challenges of Sustainable Forest Operations in Amazonia. *Current Forestry Reports*, https://doi.org/10.1007/s40725-023-00210-4.

Epron, D.*, Mochidome, T., Bassar, A.T.M.Z., Suwa, R. (2023.8) Variability in methane emissions from stems and buttress roots of *Bruguiera gymnorrhiza* trees in a subtropical mangrove forest. *Ecological Research*, https://doi.org/10.1111/1440-1703.12415.

Gayathiri, M., Pulingam, T., Lee, K.T., Din, A.T.M., Kosugi, A., Sudesh, K.* (2023.12) Sustainable oil palm trunk fibre based activated carbon for the adsorption of methylene blue. *Scientific Reports*, 13: 22137.

Hamada, K.*, Eguchi, S., Hirano, N., Asada, K., Oka, N. (2023.6) Assessing nitrogen flow and nitrogen footprint in the food system of a subtropical island with a scenario to mitigate nitrogen load impacted by trade-dependent agriculture. *Environmental Research Letters*, 18: 075010.

Hamada, K.*, Nakamura, S., Kanda, T., Takahashi, M. (2023.11) Effects of biochar application depth on nitrate leaching and soil water conditions. *Environmental Technology*, https://doi.org/10.1080/09593330.2023.2283403.

Hoang, T.N., Minamikawa, K., Tokida, T., Wagai, R., Tran, T.X.P., Tran, T.H.D., Tran, D.H.* (2023.11) Higher rice grain yield and lower methane emission achieved by alternate wetting and drying in central Vietnam. *European Journal of Agronomy*, 151: 126992.

Hoban, S.*, da Silva, J.M., Mastretta-Yanes, A., Grueber, C.E., Heuertz, M., Hunter, M.E., Mergeay, J., Paz-Vinas, I., Fukaya, K., Ishihama, F., Jordan, R., Köppä, V., Latorre-Cárdenas, M.C., MacDonald, A.J., Rincon-Parra, V., Sjögren-Gulve, P., Tani, N., Thurfjell, H., Laikre, L.* (2023.5) Monitoring status and trends in genetic diversity for the Convention on Biological Diversity: An ongoing assessment of genetic indicators in nine countries. *Conservation Letters*, https://doi.org/10.1111/conl.12953.

Ichie, T.*, Igarashi, S., Tamura, S., Takahashi, A., Tanaka, K., Hyodo, F., Tayasu, I., Meleng, P., Azani, M.A., Wasli, M.E., Matsuoka, M. (2023.8) Accurate dating of tropical secondary forests using wood core Δ 14C in Malaysia. *Forest Ecology and Management*, 546: 121346.

Igarashi, S.*, Yoshida, S., Kenzo, T., Sakai, S., Nagamasu, H., Hyodo, F., Tayasu, I., Mohamad, M., Ichie, T. (2024.3) No evidence of carbon storage usage for seed production in 18 dipterocarp masting species in a tropical rain forest. *Oecologia*, https://doi.org/10.1007/s00442-024-05527-w.

Iida, S.*, Noguchi, S., Levia, D.F., Araki, M., Nitta, K., Wada, S., Narita, Y., Tamura, H., Abe, T., Kaneko, T. (2024.2) Effects of forest thinning on sap flow dynamics and transpiration in a Japanese cedar forest. *Science of the Total Environment*, 912: 169060.

飯田真一 *, 田中憲蔵 , 清水貴範 , 荒木誠 , 壁谷直記 , 清水晃 , 宮本麻子 , 漢那賢作 , 古堅公 (2023.4) 樹液流測定による水節約型と水消費型に着目した常緑広葉樹スダジイの水利用特性の評価 . *日本水文科学会誌* , 53(4): 43–54.

Inoue, Y.*, Araki, M.G., Kitaoka, S., Tsurita, T., Sakata, T., Saito, S., Tanaka, K.* (2023.5) Seasonal changes in leaf water relations in regards to leaf drought tolerance in mature *Cryptomeria japonica* canopy trees. *Journal of Forest Research*, https://doi.org/10.1080/13416979.2023.2205719.

Kawai, K.*, Kenzo, T., Ito, S., Kanna, K. (2023.6) Size-related changes in leaf, wood, and bark traits in even-aged *Falcataria falcata* trees. *Tropics*, 32(1): 15–27.

Kawai, K.*, Marod, D., Hara, M., Somwiphat, W., Okada, N. (2024.2) Different predictions of traits on elevational distribution of Fagaceae species between ever-wet and seasonally dry regions in Southeastern Asia. *Plant Ecology*, https://doi.org/10.1007/s11258-023-01394-2.

Kikuchi, T.*, Anzai, T., Ouchi, T. (2023.9) Assessing spatiotemporal variability in the concentration and composition of dissolved organic matter and its impact on iron solubility in tropical freshwater systems through

a machine learning approach. *Science of the Total Environment*, 904: 166892.

Koda, K.*, Girmay, G., Berihu, T. (2023.10) Conservation Technology Model Fit for Farmlands in a Micro-watershed on the Ethiopian Highlands. *Japan Agricultural Research Quarterly*, 57(4): 269–279.

Lim, H., Kobayashi, M.J., Marsoem, S.N., Irawati, D., Kosugi, A., Kondo, T., Tani, N. (2023.8) Transcriptomic responses of oil palm (*Elaeis guineensis*) to waterlogging at plantation in relation to precipitation seasonality. *Frontiers in Plant Science*, 14: 1213496.

Migita, C., Chiba, Y., Tanaka, K.* (2023.8) Direct measurement of the three-dimensional distribution of leaf area density and light conditions in a mature oak stand by the cube method. *Journal of Forestry Research*, https://doi.org/10.1007/s11676-023-01646-x.

Noda, I.*, Himmapan, W., Furuya, N., Hitsuma, G. (2023.10) Taper equations for evaluating private plantation teak (*Tectona grandis*) in Thailand. *Japan Agricultural Research Quarterly*, 57(4): 329–343.

Oniki, S.*, Dagys, K., Yetyekbai, M. (2024.2) Market economy and norms of grassland utilization in Mongolia. *Society & Natural Resources*, https://doi.org/10.1080/08941920.2024.2312929.

Otaka, J.*, Subbarao, G.V., MingLi, J., Ono, H., Yoshihashi, T.* (2023.8) Isolation and characterization of the hydrophilic BNI compound, 6-Methoxy-2(3H)-benzoxazolone (MBOA), from maize roots. *Plant and Soil*, 489: 341–359.

Petroli, C.D.*, Subbarao, G.V., Burgueño, J.A., Yoshihashi, T., Li, H., Duran, J.F., Pixley, K.V. (2023.8) Genetic variation among elite inbred lines suggests potential to breed for BNI-capacity in maize. *Scientific Reports*, 13: 13422.

Pramono, A., Adriany, T.A., Al Viandari, N., Susilawati, H.L., Wihardjaka, A., Sutriadi, M.T., Yusuf, W.A., Ariani, M., Wagai, R., Tokida, T., Minamikawa, K.* (2024.1) Higher rice yield and lower greenhouse gas emissions with cattle manure amendment is achieved by alternate wetting and drying. *Soil Science and Plant Nutrition*, https://doi.org/10.1080/00380768.2023.2298775.

Qian, H., Zhu, X., Huang, S., Linquist, B., Kuzyakov, Y., Wassmann, R., Minamikawa, K., Martinez-Eixarch, M., Yan, X., Zhou, F., Sander, B.O., Zhang, W., Shang, Z., Zou, J., Zheng, X., Li, G., Liu, Z., Wang, S., Ding, Y.*, van Groenigen, K.J.*, Jiang, Y.* (2023.9) Greenhouse gas emissions and mitigation in rice agriculture. *Nature Reviews Earth & Environment*, https://doi.org/10.1038/s43017-023-00482-1.

Satake, A.*, Imai, R., Fujino, T., Tomimoto, S., Ohta, K., Na'iem, M., Indrioko, S., Widiyatno, Purnomo, S., Molla-Morales, A., Nizhynska, V., Tani, N., Suyama, Y., Sasaki, E., Kasahara, M. (2023.6) The molecular clock in long-lived tropical trees is independent of growth rate. *eLife*, 12: RP88456.

Shiraki, S.*, Kywa, E., Thur, A., Lae, L.M., Thin, M.C., Kyaw, M., Aung, K.T. (2023.12) The general ratooning ability of rice yield-related traits: a meta-analysis. *Agronomy Journal*, https://doi.org/10.1002/agj2.21521.

Siriatcharanon, A.K., Sutheeworapong, S., Baramee, S., Waeonukul, R., Pason, P., Kosugi, A., Uke, A., Ratanakhanokchai, K., Tachaapaikoon C.* (2024.2) Discovery of a novel cellobiose dehydrogenase from *Cellulomonas palmilytica* EW123 and its sugar acids production. *Journal of Microbiology and Biotechnology*, 34(2): 457–466.

Suhaimi, A.H., Kobayashi, M.J., Satake, A., Lee, S.L., Muhammad, N., Otani, T., Kondo, T., Tani, N.*, Yeoh, S.H.* (2023.4) Characterization of leaf transcriptome in a tropical tree species, *Shorea curtisii*, over a flowering season. *JARQ*, 57(2): 139–144.

Suhaimi, A.H., Kobayashi, M.J., Satake, A., Ng, C.C., Lee, S.L., Muhammad, N., Numata, S., Otani, T., Kondo, T., Tani, N.*, Yeoh, S.H.* (2023.11) An ecological transcriptome approach to capture the molecular and physiological mechanisms of mass flowering in *Shorea curtisii*. *Peer J*, 11: e16368.

Tanaka, K.*, Ichie, T., Norichika, Y., Kamiya, K., Inoue, Y., Ngo, K.M., Lum, S.K.Y. (2023.9) Drought tolerance in dipterocarp species improved through interspecific hybridization in a tropical rainforest. *Forest Ecology and Management*, 548: 121388.

Uke, A., Sornyotha, S., Baramee, S., Tachaapaikoon, C., Pason, P., Waeonukul, R., Ratanakhnokchai, K., Kosugi, A.* (2023.4) Genomic analysis of *Paenibacillus macerans* strain I6, which can effectively saccharify oil palm empty fruit bunches under nutrient-deficient conditions. *Journal of Bioscience and Bioengineering*, https://doi.org/10.1016/j.jbiosc.2023.03.016.

渡辺守 , 村下秀文 , 高野伸 , 中矢哲郎 (2023.5) アジアモンスーン地域における間断灌漑普及に向けた展開方向 . *水土の知：農業農村工学会誌* , 91(5): 11–14.

Widiyatno*, Wibowo, A., Novitasari, D., Seta, G.W., Prehaten, D., Hidayati, F., Nugroho, W.D., Hardiwinoto, S., Na'iem, M., Tani, N. (2023.11) Effect of improved planting stock on tree growth, wood properties, and soil fertility of teak plantations 10 years after planting. *Forest Science and Technology*, https://doi.org/10.1080/21580103.2023.2277190.

Wulansari, S., Heng, S., Ketbo, P., Baramee, S., Weanukul, R., Pason, P., Ratanakhanokchai, K., Uke, A., Kosugi, A., Tachaapaikoon, C.* (2023.4) A novel D-psicose 3-epimerase from halophilic anaerobic *Iocasia fonsfrigidae* and its application in coconut water. *International Journal of Molecular Sciences*, 24(7): 6394.

Xiao, M., Liu, Y.*, Bayer, E.A., Kosugi, A., Cui, Q., Feng, Y. (2024.1) Cellulosomal hemicellulases: indispensable players for ensuring effective lignocellulose bioconversion. *Green Carbon*, https://doi.org/10.1016/j.greenca.2024.01.003.

Yoshikai, M.*, Nakamura, T., Herrera, E.C., Suwa, R., Rollon, R., Ray, R., Furukawa, K., Nadaoka, K. (2023.10) Representing the impact of *Rhizophora* mangroves on flow in a hydrodynamic model (COAWST_rh v1.0): the importance of three-dimensional root system structures. *Geoscientific Model Development*, 16: 5847–5863.

Program B

Agrahari, R.K., Kobayashi, Y., Enomoto, T., Miyachi, T., Sakuma, M., Fujita, M., Ogata, T., Fujita, Y., Iuchi, S., Kobayashi, M., Yamamoto, Y.Y., Koyama, H.* (2023.12) STOP1-regulated SMALL AUXIN UP RNA55 (SAUR55) is involved in proton/malate co-secretion for Al tolerance in Arabidopsis. *Plant Direct*, https://doi.org/10.1002/pld3.557.

Bureenok, S.*, Pitiwittayakul, N., Saenmahayak, B., Saithi, S., Yuangklang, C., Cai, Y., Schonewille, J.T. (2024.1) Effects of fibrolytic enzyme supplementation on feed intake, digestibility and rumen fermentation characteristics in goats fed with Leucaena silage. *Small Ruminant Research*, 231: 107200.

Dinh, L.T., Ueda, Y., Gonzalez, D., Tanaka, J.P., Takanashi, H., Wissuwa, M.* (2023.8) Novel QTL for lateral root density and length improve phosphorus uptake in rice (*Oryza sativa* L.). *Rice*, 16: 37.

Du, Z., Yamasaki, S., Oya, T., Cai, Y.* (2023.8) Cellulase–lactic acid bacteria synergy action regulates silage fermentation of woody plant. Biotechnology for Biofuels and Bioproducts, 16: 125.

Du, Z., Yamasaki, S., Oya, T., Nguluve, D., Euridse, D., Tinga, B., Macome, F., Cai, Y.* (2023.12) Microbial network and fermentation modulation of Napier grass and sugarcane top silage in southern Africa. Microbiology Spectrum, e03032-23.

Du, Z., Yang, F., Fan, J., Yamasaki, S., Oya, T., Nguluve, D., Kumagai, H., Cai, Y.* (2023.9) Silage preparation and sustainable livestock production of natural woody plant. *Frontiers in Plant Science*, 14: 1253178.

Fang, J., Du, Z., Cai, Y.* (2023.7) Fermentation regulation and ethanol production of total mixed ration containing apple pomace. *Fermentation*, 9: 692.

羽佐田勝美, ポンサニット･ポンナチット, 山田隆一 (2023.12) ラオス農山村におけるタンパク質摂取の季節変動とその要因 . *開発学研究* , 34(2): 10–18.

Ichinose, Y.*, Nishigaki, T., Shibata, M., Kilasara, M., Shinjo, H., Funakawa, S. (2023.5) Carbon and nutrient budgets of the Chagga home garden system in the Kilimanjaro highlands, Tanzania. *Soil Use and Management*, https://doi.org/10.1111/sum.12923.

Iizumi, T.*, Iseki, K., Ikazaki, K., Sakai, T., Shiogama, H., Imada, Y., Batieno, B.J. (2023.11) Increasing heavy rainfall events and associated excessive soil water threaten protein-source legume in dry environments of West Africa. *Agricultural and Forest Meteorology*, 109783.

Ikazaki, K.*, Nagumo, F., Simporé, S., Barro, A. (2023.11) Understanding yield-limiting factors for sorghum in semi-arid sub-Saharan Africa: beyond soil nutrient deficiency. *Soil Science and Plant Nutrition*, https://doi.org/10.1080/00380768.2023.2279582.

Jia, Q., Zhou, M., Xiong, Y., Wang, J., Xu, D., Zhang, H., Liu, X., Zhang, W., Wang, Q., Sun, X.*, Chen, H.* (2024.2) Development of KASP markers assisted with soybean drought tolerance in the germination stage based on GWAS. *Frontiers in Plant Science*, 15: 1352379.

Johnson, J.M.*, Ali, I., Dossou-Yovo, E.R., Senthilkumar, K., Tsujimoto, Y., Asai, H., Saito, K. (2023.7) Inorganic fertilizer use and its association with rice yield gaps in sub-Saharan Africa. *Global Food Security*, 38: 100708.

Kawaguchi, R., Suriyasak, C., Matsumoto, R., Sawada, Y., Sakai, Y., Hamaoka, N., Sasaki, K., Yamane, K., Kato, Y., Bailly,C., Ishibashi, Y*. (2023.6) Regulation of reactive oxygen species and phytohormones in osmotic stress tolerance during seed germination in indica rice. *Frontiers in Plant Science*, 14: 1186960.

Khin-May-Chit-Maung, Toyokawa, M., Saito, H., Yurimoto, T. (2023.6) Reproductive cycle of the edible oyster *Crassostrea belcheri* in the Myeik coastal area of southern Myanmar. *Japan Agricultural Research Quarterly*, 57(3): 241–249.

Maeno, K.O.*, Piou, C., Whitman, D.W., Ould Ely, S., Ould Mohamed, S., Jaavar, M.E.H., Ould Babah Ebbe, M.A. (2023.4) How molting locusts avoid cannibalism. *Behavioral Ecology*, https://doi.org/10.1093/beheco/arad025.

Nagata, K., Nonoue, Y., Matsubara, K., Mizobuchi, R., Ono, N., Shibaya, T., Ebana, K., Ogiso-Tanaka, E., Tanabata, T., Sugimoto, K., Taguchi-Shiobara, F., Yonemaru, J., Uga, Y., Fukuda, A., Ueda, T., Yamamoto, S., Yamanouchi, U., Takai, T., Ikka, T., Kondo, K., Hoshino, T., Yamamoto, E., Adachi, S., Sun, J., Kuya, N., Kitomi, Y., Iijima, K., Nagasaki, H., Shomura, A., Mizubayashi, T., Kitazawa, N., Hori, K., Ando, T., Yamamoto, T., Fukuoka, S.*, Yano, M. (2023.6) Development of 12 sets of chromosome segment substitution lines that enhance allele mining in Asian cultivated rice. *Breeding Science*, https://doi.org/10.1270/jsbbs.23006.

Nagatoshi, Y., Ikazaki, K., Kobayashi, Y., Mizuno, N., Sugita, R, Takebayashi, Y., Kojima, M., Sakakibara, H., Kobayashi, N.I., Tanoi, K., Fujii, K., Baba, J., Ogiso-Tanaka, E., Ishimoto. M., Yasui, Y., Oya, T., Fujita, Y.* (2023.8) Phosphate starvation response precedes abscisic acid response under progressive mild drought in plants. *Nature Communications*, 14: 5047.

Nakagawa, A.C.S.*, Oya, T. (2023.4) Contrasting responses to prolonged drought stress and mitigation effects of manure application on plant growth of two tropical forage legumes. *African Journal of Agricultural Research*, 19(4): 407–418.

Nasukawa, H.*, Tajima, R., Pereira, M.C.F., Nakamura, S., Fukuda, M., Naruo, K., Egami, T., Oya, T., Ito, T. (2023.7) Comparative verification of Mehlich 3 soil analysis in Northern Mozambique using microwave plasma-atomic emission spectrometry. *Soil Science and Plant Nutrition*, https://doi.org/10.1080/00380768.2023.2238217.

Nignan, I.*, Ouedraogo, J., Nakamura, S., Serme, I., Coulibaly, K. (2023.10) Effets du mode d'application d'engrais phosphatés (CBKCa et TSP) sur la productivité du mil (*Pennisetum glaucum* (L.) R. Br) au centre ouest du Burkina Faso. *International Journal of Biological and Chemical Sciences*, 17(6): 2312–2324.

Nishigaki, T.*, Tsujimoto, Y., Rakotonindrina, H., Andriamananjara, A. (2023.8) Estimation of P retention capacity by the water content of soil kept with a saturated NaCl solution in a desiccator. *Soil Science and Plant Nutrition*, https://doi.org/10.1080/00380768.2023.2245420.

Odama, E., Tsujimoto, Y., Yabuta, S., Akagi, I., Chepkoech, R., Soe, I., Sakagami, J.* (2023.10) Effect of P-dipping on growth of NERICA 4 rice in different soil types at initial growth stage. *Sustainability*, 15(21): 15402.

Oo, A.Z.*, Asai, H.*, Kawamura, K., Marui, J., Nakahara, K., Takai, T., Saito, H., Win, K.T., Pariasca-Tanaka, J. (2023.8) Optimizing phosphorus management to increase grain yield and nutritional quality while reducing phytic acid concentration in black rice (*Oryza sativa* L.). *Frontiers in Sustainable Food Systems*, 7: 1200453.

Oo, A.Z.*, Asai, H.*, Win, K.T., Marui, J., Saito, H. (2023.4) Seed phytic acid concentration affects rice seedling vigor irrespective of soil phosphorus bioavailability. *Physiologia Plantarum*, https://doi.org/10.1111/ppl.13913.

Oo, A.Z., Tsujimoto, Y.*, Rakotoarisoa, N.M., Andrianary, B.H. (2023.9) Localized phosphorus application via P-dipping doubles applied P use efficiency and avoids weather-induced stresses for rice production on P-deficient lowlands. *European Journal of Agronomy*, 149: 126901.

Park, C., Liu, D., Wang, Q., Xu, D.* (2023.5) Identification of quantitative trait loci and candidate genes controlling the tocopherol synthesis pathway in soybean (*Glycine max*). *Plant Breeding*, https://doi.org/10.1111/pbr.13104.

Park, C., Nguyen, T.T., Liu, D., Wang, Q., Xu, D.* (2023.11) A QTL allele from wild soybean enhances protein content without reducing oil content. *Plant Genetic Resources-Characterization and Utilization*, https://doi.org/10.1017/S1479262123000850.

Rafaliarivony, S., Ranarijaona, H.L.S., Rasoafalimanana, M., Radanielina, T., Wissuwa, M.* (2023.10) Evaluation of salinity tolerance of lowland rice genotypes (*Oryza sativa* L.) at the reproductive stage. *African Journal of Agricultural Research*, 19(4): 945–961.

Raharimanana, V., Yamaguchi, T., Tsujimoto, Y.*, Oo, A.Z., Nishigaki, T., Rakotonindrina, H., Katsura, K.* (2023.11) A machine learning approach is effective to elucidate yield-limiting factors of irrigated lowland rice under heterogeneous growing conditions and management practices. *Field Crops Research*, 304: 109170.

Rajonandraina, T., Rakotoson, T., Wissuwa, M., Ueda, Y., Razafimbelo, T., Andriamananjara, A., Kirk, G.J.D. (2023.6) Mechanisms of genotypic differences in tolerance of iron toxicity in field-grown rice. *Field Crops Research*, 298: 108953.

Rajonandraina, T., Ueda, Y.*, Wissuwa, M., Kirk, G.J.D., Rakotoson, T., Manwaring, H., Andriamananjara, A., Razafimbelo, T. (2023.7) Magnesium supply alleviates iron toxicity-induced leaf bronzing in rice through exclusion and tissue-tolerance mechanisms. *Frontiers in Plant Science*, 14: 1213456.

Rakotoarisoa, N.M., Tsujimoto,Y.*, Oo, A.Z., Tashiro, T., Kano-Nakata, M., Ehara, H. (2023.10) Dipping vigorous seedling roots in phosphorus-enriched slurry at transplanting efficiently increases lowland rice yields. *Crop and Environment*, 2: 202–208.

Rakotondramanana, M., Wissuwa, M.*, Ramanankaja, L., Razafimbelo, T., Stangoulis, J., Grenier, C.* (2024.2) Stability of grain zinc concentrations across lowland rice environments favors zinc biofortification breeding. *Frontiers in Plant Science*, 15: 1293831.

Ramahaimandimby, Z.*, Shiratori, S., Rafalimanantsoa, J., Sakurai, T. (2023.11) Animal-sourced foods production and early childhood nutrition: Panel data evidence in central Madagascar. *Food Policy*, 121: 102547.

Scholz, R., Gamarra, M.A.F., Vargas, M.J., Yamanaka, N.* (2024.3) Yearly changes in virulence of *Phakopsora pachyrhizi* isolates in Paraguay. *Tropical Plant Pathology*, https://doi.org/10.1007/s40858-024-00639-3.

Sengseng, T., Okutsu, T., Songnui, A., Boonchuay, J., Sakunrang, C., Wonglapsuwan, M.* (2023.7) Molecular markers of ovarian germ cells of banana prawn (*Fenneropenaeus merguiensis*). *Current Issues in Molecular Biology,* 45(7): 5708–5724.

Shaibu, A.G., Prosper, K.*, Eliasu, S., Oka, N. (2024.1) Land suitability for irrigation of small reservoirs using spatial techniques in the upper regions of Ghana. *Irrigation and Drainage*, https://doi.org/10.1002/ird.2913.

Shiratori, S.*, Rafalimanantsoa, J., Razafimbelonaina, H.S.A. (2023.11) Rice preference in rural Madagascar: A study of producer and consumer preferences. *Cogent Food & Agriculture*, 9(2): 2281092.

Soma, D., Iwasaki, S.*, Fukuda, M., Nakamura, S., Bambara, D., Nagumo, F. (2023.6) Effect of slow-release phosphorus components in calcined and acidulated phosphate rock significantly correlated with ground-water levels in lowland rice cultivation in Center West Burkina Faso. *International Journal of Plant Production*, https://doi.org/10.1007/s42106-023-00258-z.

Sun, L., Xue, Y.*, Xiao, Y., Gele, T., Wu, X., Na N., Wu, N., Qili, M., Zhao, Y., Cai, Y.* (2023.5) Community synergy of lactic acid bacteria and cleaner fermentation of oat silage prepared with a multispecies microbial inoculant. *Microbiology Spectrum*, https://doi.org/10.1128/spectrum.00705-23.

Takada, K., Nishigaki, T., Tsujimoto, Y., Iseki, K.* (2024.1) Genotypic variation of phosphorus accumulation in wild cowpea relatives (*Vigna vexillata*) grown under phosphorus deficiency. *Plant Production Science*, https://doi.org/10.1080/1343943X.2023.2299643.

Takai, T.* (2023.11) Potential of rice tillering for sustainable food production. *Journal of Experimental Botany*, https://doi.org/10.1093/jxb/erad422

Tanaka, Y.*, Watanabe, T., Katsura, K., Tsujimoto, Y., Takai,T., Tanaka, T.S.T., Kawamura, K., Saito, H., Homma, K., Mairoua, S.G., Ahouanton, K., Ibrahim, A., Senthilkumar, K., Semwal, V.K., Matute, E.J.G., Corredor, E., El-Namaky, R., Manigbas, N., Quilang, E.J.P., Iwahashi, Y., Nakajima, K., Takeuchi, E., Saito, K.* (2023.7) Deep learning enables instant and versatile estimation of rice yield using ground-based RGB images. *Plant Phenomics*, 5: 0073.

Thirawut, S., Sutjaritthammajariyangkun, W., Rukkasikorn, W., Punyawattoe, P., Noonart, U., Kobori, Y.* (2023.6) Pesticide susceptibility monitoring of fall armyworms (*Spodoptera frugiperda* (J.E. Smith)): a simple methodology for information-sharing among Southeast Asian countries. *CABI Agriculture and Bioscience*, 4: 19.

Toyota, K., Matsushima, H., Osanai, R., Okutsu, T., Yamane, F., Ohira, T.* (2023.12) Dual roles of crustacean female sex hormone during juvenile stage in the kuruma prawn *Marsupenaeus japonicus*. *General and Comparative Endocrinology*, 344: 114374.

Traore, B.*, Traore, M., Birba, S., Nacro, H.B., Sarr, P.S., Ouattara, B. (2023.4) Short-term effect of calcined phosphate rock on soil macrofauna diversity and abundance in lixisol in a semi-arid area of Burkina Faso. *International Journal of Innovation and Applied Studies*, 39(2): 655–666.

Ueda, Y., Yanagisawa, S.* (2023.8) Transcription factor module NLP–NIGT1 fine-tunes NITRATE TRANSPORTER2.1 expression. *Plant Physiology*, https://doi.org/10.1093/plphys/kiad458.

Wang, J, Zhou, M., Zhang, H., Liu, X., Zhang, W., Wang, Q., Jia, Q., Xu, D., Chen, H.*, Su, C.* (2024.2) A genome-wide association analysis for salt tolerance during the soybean germination stage and development of KASP markers. *Frontiers in Plant Science*, 15: 1352465.

Yamanaka, N.*, Aoyagi, L.N., Hossain, M.M., Aoyagi, M.F., Muraki, Y. (2023.6) Genetic mapping of seven kinds of locus for resistance to Asian soybean rust. *Plants*, 12(12): 2263.

Yurimoto, T.*, Kassim, F.M., Man, A., Abdrahim, M. (2024.1) Reproduction status of the angelwing clam, *Pholas orientalis* (Gmelin, 1791), obtained from Selangor, Malaysia. *EQA-International Journal of Environmental Quality*, 59: 33–41.

Program C

Chuekittisak, R.*, Sansayawichai, T., Khumon, S., Thongplew, A., Kaphet, P., Tippayawat, A., Jungpol, P., Worasatit, N., Romyen, L., Srihata, B., Khamsueb, B., Jirakkakul, P., Pratcharoenwanich, R., Malipan, A., Wangpen, J., Ponragdee, W., Sugimoto, A., Tagane, S., Sato, M., Ishiki, K., Tagkagi, H., Matsuoka, M., Terajima, Y., Ando, S. (2023.4) Alternative renewable energy sugarcane. *Agrica*, 11(2): 97–108.

Deng, Y., Liu, J.*, Xie, W., Liu, X., Lv, J., Zhang, R., Wu, W., Geng, Y., Boulange, J. (2024.1) Impact of carbon pricing on mitigation potential in Chinese agriculture: A model-based multi-scenario analysis at provincial scale. *Environmental Impact Assessment Review*, 105: 107409.

Fawcett, J.A.*, Takeshima, R., Kikuchi, S., Yazaki, E., Katsube-Tanaka, T., Dong, Y., Li, M., Hunt, H.V., Jones, M.K., Lister, D.L., Ohsako, T., Ogiso-Tanaka, E., Fujii, K., Hara, T., Matsui, K., Mizuno, N., Nishimura, K., Nakazaki, T., Saito, H., Takeuchi, N., Ueno, M., Matsumoto, D., Norizuki, M., Shirasawa, K., Li, C.*, Hirakawa, H.*, Ota, T.*, Yasui, Y.* (2023.8) Genome sequencing reveals the genetic architecture of heterostyly and domestication history of common buckwheat. *Nature Plants*, 9(8): 1236–1251.

Gu, M., Chen, H., Wu, W., Zhao, M.* (2023.7) 価値感知、風険規避対糧食種植戸気候適応性行為的影響−来自黒豫湘 3 省 1145 份糧食種植戸調研的証据 (Effects of value perception and risk aversion on farmers' adoption of adaptive behavior to climate change). *干旱区資源与環境* (*Journal of Arid Land Resources and Environment*), 37(7): 66–74.

Jin, S., Ma, B., Zheng, Y., Jin, X.*, Wu, W. (2023.7) The short-term impact of food safety standards on agri-products exports: Evidence from Japan's positive list system on Chinese vegetable export. *Journal of Agricultural Economics*, https://doi.org/10.1111/1477-9552.12561.

Leon, A.* (2024.3) A synthesis of the evidence regarding the efficacy of alternative field management practices in rice cultivation using life cycle assessment. *Science of the Total Environment*, 171693.

Magudeeswari, P., Balakrishnan, D.*, Fukuta, Y., Saito, H., Saitheja, D., Pranay, G., Padmashree, R., Barbadikar, K.M., Badri, J., Senguttuvel, P., Sruthi, K., Ladhalakshmi, D., Padmavathi, G., Subbarao, L.V., Sundaram, R.M., Sarla, N. (2024.1) Linkage mapping and quantitative trait loci detection for seedling vigor and grain size in advanced backcross introgression lines from wild accessions of *Oryza nivara*. *Genetic Resources and Crop Evolution*, https://doi.org/10.1007/s10722-023-01834-y.

Mahmud, Q.M., Bhuiyan, M.R., Hossain, M.M., Ausraf, N., Islam, M.S., Hera, M.H.R., Rashid, M.M., Akanda, M.A.M., Hossain, M.M.*, Chowdhury, M.T.I., Latif, M.A., Obara, M., Fukuta, Y., Khan, M.A.I.* (2024.1) Pathogenicity of rice blast isolates (*Pyricularia oryzae*) in irrigated lowland of Bangladesh. *Journal of Phytopathology*, 172: e13271.

Matsuda, H.* (2024.1) Jackfruit (*Artocarpus heterophyllus* Lam.) grafting as affected by nitrogen fertilizer application to irrigation water. *Scientia Horticulturae*, 324: 112596.

Matsuda, H.*, Takaragawa, H. (2023.6) Leaf photosynthetic reduction at high temperatures in various genotypes of passion fruit (*Passiflora* spp.). *The Horticulture Journal*, 92(4): 412–423.

Matsuda, H.*, Takaragawa, H. (2024.1) Applicability of a closed and rapid gas-exchange system to leaf photosynthetic measurements in tropical fruit trees. *Environmental Control in Biology*, 62(1): 1–10.

Nakayama, M.*, Nakazawa, Y. (2023.7) Effects of environmental control and LED supplemental lighting on strawberry growth and yield in a subtropical climate. *Scientia Horticulturae*, 321: 112349.

Nishimura, K.*, Kokaji, H., Motoki, K., Yamazaki, A., Nagasaka, K., Mori, T., Takisawa, R., Yasui, Y., Kawai, T., Ushijima, K., Yamasaki, M., Saito, H., Nakano, R., Nakazaki, T.* (2024.3) Degenerate oligonucleotide primer MIG-seq: an effective PCR-based method for high-throughput genotyping. *Plant Journal*, https://doi.org/10.1111/tpj.16708.

Ohara, S.*, Hamada, Y., Terajima, Y., Ishida, T., Kikuchi, Y., Fukushima, Y., Sugimoto, A. (2024.1) Effect of single-boiling crystallization of high-yielding sugarcane KY01-2044 on sugar and molasses production. *Food Science and Technology Research*, 30(1): 47–56.

岡村昌樹 , 荒井 (三王) 裕見子 *, 大平陽一 , 石川淳子 , 小林伸哉 (2024.1) 画像解析による黄化籾率測定に基づく水稲登熟期間の品種間差決定要因の解析 . *日本作物学会紀事* , 93(1): 9–23.

Oniki, S.*, Berhe, M., Negash, T., Etsay, H. (2023.4) Do economic incentives crowd out motivation for communal land conservation in Ethiopia? *Forest Policy and Economics*, 150: 102948.

Ouchida, K., Kanematsu, Y., Fukushima, Y., Ohara, O., Sugimoto, A., Hattori, T., Terajima, Y., Okubo, T., Kikuchi, Y.*, (2023.5) Coordinated integration of agricultural and industrial processes: a case study of sugarcane-derived production. *Process Integration and Optimization for Sustainability*, 7: 1191–1209.

Sakaigaichi, T.*, Terajima, Y., Suematsu, K., Kamada, E., Kobayashi, A., Kawata, Y. (2023.7) Analysis of sweetpotato shoot traits diversity and its relationship with storage root yield under short-period cultivation. *Genetic Resources and Crop Evolution*, 71: 397–411.

Shiratori, S.*, Tobita, Y., Sawadogo-Compaoré, E.M.F.W. (2023.5) Food security, nutritional supply, and nutrient sources in rural Burkina Faso. *Nutrients*, 15(10): 2285.

Takaragawa, H.*, Matsuda, H. (2023.7) Rapid evaluation of leaf photosynthesis using a closed-chamber system in a C4 plant, sugarcane. *Plant Production Science*, 26(2): 174–186.

Takaragawa, H.*, Matsuda, H., Terajima, Y. (2023.4) Acidic soil tolerance of sugarcane and *Erianthus* root assessed by cell membrane stability. *Plant Root*, 17(4): 26–35.

Terajima, Y.*, Sugimoto, A., Tippayawat, A., Irei, S., Hayashi, H. (2023.4) Root distribution and fibre composition of intergeneric F1 hybrid between sugarcane and *E. arundinaceus*. *Field Crops Research*, 108920.

Ushio, M.*, Saito, H., Tojo, M., Nagano, A.J. (2023.9) An ecological network approach for detecting and validating influential organisms for rice growth. *eLife*, 12: RP87202.

Wu, W.*, Xu, Y. (2024.2) Factors affecting climate adaptation behavior among grain farmers in China. *Environment, Development and Sustainability*, https://doi.org/10.1007/s10668-024-04500-0.

Xia, S.*, Takakura, J., Wu, W., Blanchard, J.L., Heneghan, R.F., Yamakawa, T., Tsuchiya, K., Hasegawa, T., Fujimori, S., Takahashi, K. (2023.9) Potential environmental and nutritional benefits of replacing ruminant meat with forage fish. *Sustainable Production and Consumption*, 40: 265–276.

Xu, Q.*, Xuan, T.*, Li, S.*, Saito, H.* (2023.4) Editorial: For a sustainable future: novel insights into agronomically important traits in cereal crops. *Frontiers in Plant Science*, https://doi.org/10.3389/fpls.2023.1197864.

Yuan, R., Jin, S., Wu, W.* (2024.1) Interactive effects of information and trust on consumer choices of organic food: Evidence from China. *Appetite*, 192: 107115.

Yuan, R., Jin, S., Zhou, L.*, Chien, H., Wu, W. (2024.1) Promoting eco-labeled food consumption in China: The role of information. *Agribusiness*, https://doi.org/10.1002/agr.21896.

Zhang, Q., Li, B., Liu, J.*, Deng, Y., Zhang, R., Wu, W., Geng, Y. (2024.1) Assessing the distributional impacts of ambitious carbon pricing in China's agricultural sector. *Ecological Economics*, 217: 108082.

Others

Ezoe, A., Iuchi, S., Sakurai, T., Aso, Y., Tokunaga, H., Vu, A.T., Utsumi, Y., Takahashi, S., Tanaka, M., Ishida, J., Ishitani, M., Seki, M.* (2023.4) Fully sequencing the cassava full-length cDNA library reveals unannotated transcript structures and alternative splicing events in regions with a high density of single nucleotide variations, insertions–deletions, and heterozygous sequences. *Plant Molecular Biology*, https://doi.org/10.1007/s11103-023-01346-4.

Fujii, K.*, Zheng, J., Zhou, Z., Fang, Y. (2024.3) Quantitative assessment of soil acidification in four Chinese forests affected by nitrogen deposition. *Plant and Soil*, https://doi.org/10.1007/s11104-024-06602-0.

降籏英樹 (2023.4) タイ国タムルアン洞窟遭難事故における救出活動からの学び . *水土の知：農業農村工学会誌* , 91(4): 7–10.

Masuda, S., Gan, P., Kiguchi, Y., Anda, M., Sasaki, K., Shibata, A., Iwasaki, W., Suda, W., Shirasu, K.* (2024.3) Uncovering microbiomes of the rice phyllosphere using long-read metagenomic sequencing. *Communications Biology*, 7(357): 1–13.

Matsuda, H., Higuchi, H.*, Miyaji N., Okabe, M. (2023.6) Anatomical study of salak (*Salacca wallichiana* C. Mart.): Post-pollination high temperature accelerates pollen-tube elongation but inhibits subsequent fertilization. *The Horticulture Journal*, 92(4): 384–392.

Nambu, R.*, Morishige, T (2024.3) Comparison of sediment collection efficiency between light and simple bucket type and the Smith-McIntyre bottom-samplers. *Fisheries Engineering*, 60(3): 117–124.

Suzuki, H., Ito, T., Ogata, T., Tsukahara, Y., Nelson, R.S., Sasaki, N., Matsushita, Y.* (2024.1) Overexpression of NtERF5, belonging to the ethylene response factor gene family, inhibits potato virus X infection and enhances expression of jasmonic acid/ethylene signaling marker genes in tobacco. *Journal of General Plant Pathology*, https://doi.org/10.1007/s10327-023-01166-w.

田村浩喜 , 野口正二 *, 阿部俊夫 , 飯田真一 (2024.3) 希有な温暖少雪年を含む 3 寒候期のスギ人工林小流域からの流出特性 . *水文科学会誌* , 54: 13–23.

田中憲蔵 *, 大曽根陽子 , 橋本昌司 (2023.6) 1950 年以降のスギとヒノキの生理生態学的研究に関する文献数の変化とその社会・環境的な背景 . *森林立地* , 65(1): 29–37.

Win, K.T.*, Wasai-Hara, S., Tanaka, F., Oo, A.Z., Minamisawa, K., Shimoda, S., Imaizumi-Anraku, H.* (2023.10) Synergistic N_2-fixation and salt stress mitigation in soybean through dual inoculation of ACC deaminase-producing *Pseudomonas* and *Bradyrhizobium*. *Scientific Reports*, 13: 17050.

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

During the Second Medium-Term Goal period (FY 2006 - FY 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 (FY 2011 - FY 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 (FY 2016 - FY 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 (FY 2021 - FY 2025), 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 (MIDORI)." 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 Chief 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.

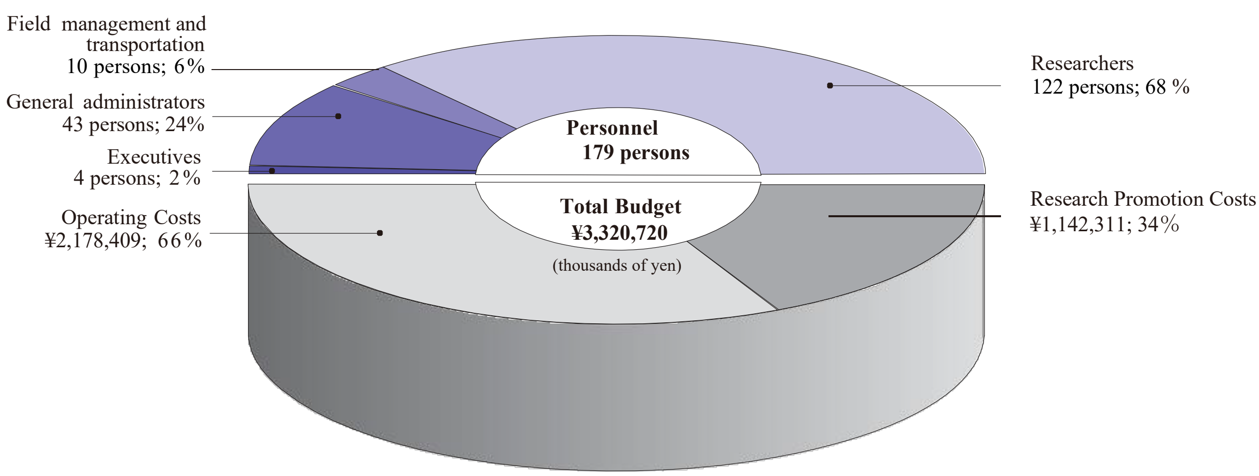
FINANCIAL OVERVIEW

Fiscal Year 2023

	thousands of yen
TOTAL BUDGET	**3,320,720**
OPERATING COSTS	**2,178,409**
Personnel (179)	1,894,082
President (1), Vice-President (1), Executive Advisor & Auditor (2)	
General administrators (43) Field management (10) Researchers (122) * Number of persons shown in ( )	
Administrative Costs	284,327

RESEARCH PROMOTION COSTS	**1,142,311**
Research and development	635,601
Overseas dispatches	160,144
Collection of research information	145,900
International collaborative projects	177,093
Fellowship programs	23,573

Budget FY 2023 (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, Food and Agriculture Organization of the United Nations (FAO) Liaison Office in Japan

JIRCAS Staff in FY 2023

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
Misaki Ohashi, Information Management Staff

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
Tomoyuki Okutsu, Head

Research Management Section
Mie Kasuga, Head
Hiroko Furuno, Intellectual Property Expert

Field Management Section
Hiroyuki Ishiyama, Field Operator
Kaichi Matayoshi, Field Operator

Communications Advisor
Baltazar Antonio

Research Support Office
Masaki Shiraishi, Head

Research Coordination Section
Yuji Ebihara, Head
Toshiki Kikuchi, International Affairs Expert
Sota Toyoshima, Overseas Travel and Invitation Program Subsection Staff
Gen-ichiro Hanaoka, Research Coordination Subsection Staff
Naomi Yamaguchi, Overseas Affairs Subsection Head

Research Support Section
Akemi Nomiya, Head
Harumi Sawasato, Support Subsection Staff
Yuma Sukegawa, Support Subsection Staff

Research Platform Office
Eizo Tatsumi, Head

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

Safety Management Section
Masaki Morishita, Head

Administration Division

Hiroshi Mizufune, Director

General Affairs Section
Takashi Oosato, Head
Katsunori Kanno, General Affairs Assistant Head
Jun Yatabe, Personnel Management Assistant Head
Takehito Kato, General Affairs Staff
Shoko Yoshida, Welfare Subsection Staff
Yoshiyuki Seki, Personnel Subsection 1 Head
Yume Nakano, Personnel Subsection 1 Staff
Asami Takatsu, 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
Takuro Ebihara, Accounting Subsection Staff
Takayuki Yamamoto, Audit Subsection Head
Aki Tamura, Audit Subsection Staff
Itsuko Ikeda, Procurement Subsection 1 Head
Yuta Nagata, Procurement Subsection 2 Staff
Tadahisa Akiyama, Facilities Subsection Head
Natsumi Sakurai, Accounting Subsection Staff

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

Risk Management Office

Satoru Nirasawa, Head

Compliance Management Section
Noriko Osonoe, Management Subsection Staff

Acceptance Section
Akira Hirokawa, Head

Audit Office

Yoshinori Kawasaki, Head

Rural Development Division

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

Senior Researchers
Shinji Hirouchi, Agricultural Engineering
Koichi Takenaka, Rural Development Forestry
Mamoru Watanabe, Rural Development
Hideki Furihata, Agricultural Engineering
Naoko Oka, Agriculture Water Management
Haruyuki Dan, Rural Development
Hiroshi Ikeura, Irrigation
Masakazu Yamada, Agricultural Engineering
Shutaro Shiraki, Rural Development
Katsumi Hasada, Rural Development
Ken-ichi Uno, Agricultural Engineering

Researchers
Shin-ya Iwasaki, Soil Science
Kayo Matsui, Soil Science
Fumi Okura, Irrigation and Drainage
Taishin Kameoka, Area Studies
Ke Zhang, Agricultural Information Engineering

Social Sciences Division

Yasuro Funaki, Director

Senior Researchers
Shunji Oniki, Agricultural Economics
Shintaro Kobayashi, Environmental Economics
Toru Sakai, Remote Sensing and GIS
Eiichi Kusano, Agricultural Economics
Junji Koide, Agricultural Economics
Ai Leon, Environmental Impact Assessment
Jun Furuya, Agricultural Economics

Researchers
Rie Muraoka, Agricultural Economics
Guenwoo Lee, Development Economics and International Cooperation Studies
Wenchao Wu, Agricultural Economics
Ryosuke Ozaki, Agricultural Economics
Yoshie Yageta, Agricultural Development

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
Donghe Xu, Plant Molecular Genetics
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
Shimpei Aikawa, Applied Microbiology
Takuya Ogata, Plant Molecular Biology
Kotaro Iseki, Crop Science and Breeding
Takeshi Kashiwa, Plant Pathology
Kazuhiro Sasaki, Plant Breeding and Genetics
Ken Hoshikawa, Horticulture Science
Masahiro Kishii, Wheat Wide Crossing and Cytogenetics

Researchers
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
Satoshi Nakamura, Soil Science
Yoichi Kobori, Entomology
Yasuhiro Tsujimoto, Crop Science

Senior Researchers
Tetsuji Oya, Crop Science
Kazunori Minamikawa, Biogeochemistry
Toshiyuki Takai, Crop Science and Genetics
Koki Maeda, Environmental Science, Manure Management and Microbial Ecology
Papa Saliou Sarr, Soil Microbiology
Aung Zaw Oo, Crop Science
Kenta Ikazaki, Soil Science
Kotaro Maeno, Entomology
Hidetoshi Asai, Crop Science
Guntur V. Subbarao, Crop Physiology, Genetics & Nutrition

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
Yoshiaki Ueda, Plant Physiology and Genetics
Kanako Takada, Crop Science
Jinsen Zheng, Soil Science

Forestry Division

Shoji Noguchi, 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
Isao Tsutsui, Aquaculture
Ryogen Nanbu, Benthic Biology
Tatsuya Yurimoto, Aquatic Biology
Bong Jung Kang, Aquatic Animal Physiology

Researcher
Minoru Saito, Aquatic Ecology
Ryuya Matsuda, Marine Phycology

Tropical Agriculture Research Front

Hide Omae, Director

Public Relations Officer
Kunimasa Kawabe, Plant Pathology

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

Senior Researchers
Shotaro Ando, Soil Science
Nobuya Kobayashi, Plant Breeding
Takuma Ishizaki, Plant Molecular Biology
Yoshifumi Terajima, Sugarcane Breeding
Hiroki Saito, Molecular Breeding and Genetics
Ken Okamoto, Agricultural Engineering

Researchers
Hiroki Tokunaga, Plant Molecular Genetics
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
Masato Shimajiri,, Head
Takashi Komatsu, Machine Operator
Masakazu Hirata, Machine Operator
Yasuteru Shikina, Machine Operator
Masashi Takahashi, Machine Operator
Masahide Maetsu, Machine Operator
Yuto Hateruma, Machine Operator
Takaya Shinmori, Machine Operator

The Japanese Fiscal Year and Miscellaneous Data

The Japanese Fiscal Year and the Annual Report 2023

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) 2023 covers the period from April 1, 2023 through March 31, 2024.

The Annual Report 2023 summarizes the full extent of JIRCAS activities that occurred during this period. The subsequent Annual Report will detail events and programs from April 1, 2024 through March 31, 2025 (FY 2024).

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 2023

(April 2023-March 2024) No.30 (October 2024)

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

2024年（令和6年）10月 31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

JAPAN INTERNATIONAL RESEARCH CENTER
FOR AGRICULTURAL SCIENCES