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Special 100th Issue

Special Feature

Five Years at JIRCAS

Advancing Research and Social Implementation to Tackle Global Challenges

Japan International Research Center For Agricultural Sciences

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Five Years at JIRCAS

JIRCAS TODAY

【Research Highlights】

Looking Back on Five Turbulent and Fulfilling Years

The 5th Medium to Long-Term Plan, launched in April 2021 with no end in sight to the COVID-19 pandemic, got off to a turbulent start. International travel restrictions were in place from the preparation stage, but we were able to launch and continue our research activities thanks to the dedicated cooperation of our overseas collaborative research partners, based on long-standing relationships of trust. On top of these challenges, geopolitical risks, including the 2022 invasion of Ukraine, exacerbated instability in the global food system, and political and social unrest in key research partner countries like Myanmar continued, significantly limiting our on-site, problem-solving collaborative research activities.

Meanwhile, as global issues such as climate change have become increasingly apparent, the United Nations has undertaken numerous activities to achieve the SDGs. At the UN Food Systems Summit in September 2021, it was confirmed that activities from food production to consumption must be transformed into sustainable systems. Japan also aims to become carbon neutral by 2050, and in May 2021, the MIDORI Strategy for Sustainable Food Systems was formulated as a medium- to long-term policy guideline to achieve both improved productivity and sustainability in the food, agriculture, forestry and fisheries industries through innovation. Furthermore, in 2024, the Basic Act on Food, Agriculture and Rural Areas was revised for the first time in 25 years, and new policies were implemented, including those for "ensuring food security" and "establishing a food system in harmony with the environment."

In its fifth term, JIRCAS was given the following lofty mission: "As Japan's leading research institution in the field of international agriculture, forestry, and fisheries, JIRCAS shall work to improve agricultural, forestry, and fisheries technology in Japan and around the world, and contribute to the development of sustainable agriculture, forestry, and fisheries." The organization was structured into four operational segments: "Planning," "Environment," "Food," and "Information," and a system was put in place to enable streamlined and effective business operations. Improvements were also made to the distinctive "Matrix System," in which researchers from various specialized fields participate in multiple interdisciplinary research projects. In addition, the newly established Information and Public Relations Office promoted public relations and collaboration, and governance was strengthened, including the promotion of digital transformation (DX).

Years of steady research efforts have paid off: Biological Nitrification Inhibition (BNI)-enhanced wheat has become a world-class research achievement

and has been deployed in countries including Japan. Phosphorus fertilization techniques in Africa and microbial saccharification of agricultural waste in Asia have also been widely adopted. A paddy field methane reduction methodology through water management has been adopted as a bilateral carbon credit methodology, leading to participation in international rulemaking. The "Green Asia" project, which contributes to the Green Food System Strategy, has compiled a catalog of many scalable technologies developed with Japanese institutions for the Asian monsoon region, and has conducted field demonstrations of promising technologies that combine productivity and sustainability. These activities have been presented at numerous international conferences and meetings of international organizations, including the G7 Agriculture Ministers' Meeting held in Japan, contributing to international discussions on global food security and the establishment of sustainable agriculture and food systems.

The circumstances surrounding the global agriculture, forestry, and fisheries industries and international collaborative research are constantly changing. In particular, in the tropical and subtropical regions and developing countries that we serve, the need for new technologies is changing dramatically due to economic globalization, urbanization, and rapid economic growth. JIRCAS's activities during its "5th Phase," a turbulent and fulfilling five years, were remarkable, but compared to its lofty mission, it is still only halfway there. JIRCAS will celebrate its 60th anniversary in 2030. Toward a new stage in resolving food and environmental issues through science and technology, under the motto "Together for our food, and planetary health," we will continue to work steadily with local partners on field-centered international collaborative research and create new value for all humanity.

KOYAMA Osamu
President

Five Years at JIRCAS: R&D Management for Addressing Global Challenges

The 5th Medium to Long-Term Plan of JIRCAS (FY2021–2025) was launched amid the COVID-19 pandemic. In FY2022, the pandemic was somehow brought under control, and COVID-19 was reclassified as a Class V Infectious Disease under Japan's Infectious Disease Law. However, the global situation has continued to undergo dramatic changes, such as the sharp increases in food and fertilizer prices due to Russia's invasion of Ukraine, and the movement toward establishing a new world order under the second Trump Administration in the United States. Even under these circumstances, JIRCAS continued its R&D activities and achieved various outputs that contribute to the accomplishment of its mission, namely, solving global food and environmental problems. Since detailed research results will be presented by Program Directors in the later part of this newsletter, this report focuses on JIRCAS's R&D management, which successfully maximized research outcomes despite constraints on budget and human resources.

At the beginning of the 5th Medium to Long-Term Plan period, when overseas travels were strictly restricted due to the COVID-19 pandemic, our challenge was how we can carry out our research without significant delays. We solved this problem and successfully maintained effective and efficient research implementation frameworks by promoting the research activities of our counterpart researchers in developing regions. We also utilized research facilities at the Tropical Agricultural Research Front (TARF) of JIRCAS located on Ishigaki Island, Japan, which lies in a subtropical region, allowing us to conduct field experiments under conditions similar to those in developing regions. Even under circumstances that restricted face-to-face communication, JIRCAS counterpart researchers implemented research activities without any difficulty. This was mainly because JIRCAS has successfully built mutual understanding with counterpart researchers thanks to our more than half a century of collaborative research, in which both JIRCAS and partner institutions contribute resources such as budget, personnel, materials, and ideas to implement research that provides mutual benefits. The human resources developed through this long history of research collaborations also contributed greatly to research implementation under the difficult conditions caused by the COVID-19 pandemic.

With regard to strengthening partnerships among academia, industry, and government, JIRCAS has around 150 memoranda of understanding (MOUs) with domestic and international research institutes and universities. The number of research collaborations under these MOUs also increased significantly compared to the 4th Medium to Long-Term Plan period (FY2016–2020). JIRCAS strengthened its partnership with CGIAR (Consultative Group on International Agricultural Research), the world's largest global agricultural innovation network. Notably, JIRCAS collaborated with international research organizations under CGIAR and successfully secured large-scale external research funding exceeding USD 20 million. JIRCAS also worked closely with other national research institutes in Japan, especially the National Agriculture and Food Research Organization (NARO), the Forest Research and Management Organization (FRMO) and the Japan Fisheries Research and Education Agency (FRA), to carry out research collaborations, convene information exchange meetings, and co-organize symposiums. One significant achievement was the publication of the "Technology Catalog Contributing to Production Potential and Sustainability in the Asia-Monsoon Region," produced under the Green Asia Project (Accelerating application of agricultural technologies which enhance production potentials and ensure sustainable food systems in the Asia-Monsoon region).

To improve productivity in agriculture, forestry, and fisheries through the social implementation of research results, it is critically important to appropriately manage and utilize these research findings as intellectual property. JIRCAS promotes patent and plant breeder's rights applications when research outcomes are anticipated to be used by industries, while prioritizing their wide utilization in developing regions as "global public goods." JIRCAS registered 22 patents and 11 plant breeder's rights during FY2021–2024. Among these intellectual property rights is the feed grass variety, "Isan," which is suitable for temperate zones and has several favorable characteristics including high yield, strong drought tolerance, and high crude protein content. It is expected to be widely used in Thailand as well as in Japan, where it is already registered as a plant variety. It is also noteworthy that a sugarcane variety developed through collaboration between JIRCAS and the Department of Agriculture (DOA), Thailand, with high bagasse production

capability, was endorsed as the recommended variety "DOA Khon Kaen 4" in Thailand. This marks the first time that the results of joint research with Japan have been adopted by the Thai sugarcane sector.

Following the enforcement of the Basic Act on Science, Technology, and Innovation in Japan, JIRCAS is now able to provide various forms of support, including investment in venture companies that utilize JIRCAS research outputs. JIRCAS formulated the necessary internal rules for accrediting venture companies eligible for intensive support by JIRCAS and for implementing investment procedures based on government guidelines. Two start-up companies in which JIRCAS researchers serve as presidents have already been accredited by JIRCAS. One is ShrimpTech JIRCAS, Inc., which utilizes a patented technology for an Indoor Shrimp Production System (ISPS). The other is JIRCAS Dream Biomass Solutions Co. (JDBS), which utilizes patents related to the "Multi-Biomass Treatment Process" of unused biomass generated by the palm oil industry. JIRCAS has invested in JDBS and is actively engaged in its business development.

JIRCAS also strengthened its partnerships with Japanese government administrative organizations. JIRCAS President KOYAMA Osamu delivered a presentation entitled "Science, Technology, and Innovation for Sustainable Agri-food Systems" at the G7 Agriculture Ministers' Meeting held in April 2023 in Miyazaki, Japan, which strongly impressed G7 representatives with Japan's commitment to global food security and environmental sustainability through science, technology, and innovation. He also served as an advisor to Japan's Ministry of Agriculture, Forestry and Fisheries and represented Japan at the Agriculture Innovation Mission for Climate (AIM4C) ministerial meeting, a global initiative established at the UN Climate Change Conference in Glasgow (COP26) that encourages investments in climate-smart agriculture and food systems innovation to accelerate climate action, held in February 2022 in Dubai, UAE.

JIRCAS will continue to implement effective and efficient R&D management during the 6th Medium to Long-Term Plan period (from FY2026), ensuring that its activities make a tangible contribution to the future of the Earth and global food systems.

SUGINO Tomohide
Director, Research Planning and Partnership Division

A Review of JIRCAS's Fifth Medium to Long-Term Plan Period

Perhaps the most significant event during this Fifth Medium to Long-Term Plan period was the novel coronavirus (COVID-19). This virus shook the world, drawing us into a world of unknowns and uncertainty. There was also a sense of fear, with no end in sight, about what the future held.

Amidst this, we struggled in the dark, but at JIRCAS, we also began to explore ways to overcome this crisis.

In a sense, this crisis may have brought about the acceleration of "teleworking" and the widespread adoption of "web conferencing."

While "teleworking" has been discussed as part of diverse work styles, we have overturned conventional wisdom, with mandatory work-from-home orders to reduce attendance and the shift from face-to-face meetings to web conferencing to avoid crowds. Today, we have a culture where no one is resistant to web conferencing, and everyone can participate in meetings simply by receiving a meeting link. This crisis may have

been a blessing in disguise. This experience made me realize what the often-heard phrase "turning a crisis into an opportunity" really means. When people find themselves in a difficult situation, they are able to find the potential to overcome any challenge.

On the research side, even though researchers were unable to travel abroad, they showed great ingenuity in overcoming the constraints and worked hard to achieve their medium- to long-term plans.

Another topic from a different perspective is that, for the first time since JIRCAS's relocation to Tsukuba Science City, funding for the construction of a new facility in the Tsukuba area has been included in the budget. This construction project is called the "Biological Nitrification Inhibition (BNI) Cultivation Management Building (FY2022 Supplementary Budget)," and approximately 300 million yen has been allocated for facility development.

The predecessor of the current JIRCAS organization was originally the Tropical Agriculture Research Center under the Ministry of Agriculture and Forestry of Japan. Tsukuba's agricultural, forestry, and fisheries research institutes (11 at the time) were gradually relocated beginning in the 1970s as part of the Tsukuba Science City Relocation Plan. The Tropical Agriculture Research Center was one of these institutes, and the common building where current researchers are based is also showing signs of aging. As a result, the cost of renovating facilities is enormous, and facility maintenance funds are barely sufficient to cover building renovations. Building a new research annex, including the additional running costs it would entail, had long seemed like little more than a pipe dream. However, needless to say, the BNI Cultivation Management Building stands as proof that it has been recognized by government agencies as an essential facility for advancing research.

While we may face many difficult situations during the 6th Medium to Long-Term Plan period, we will steadily move forward, even if it's just one or half step at a time, and steadfastly overcome any challenges that arise.

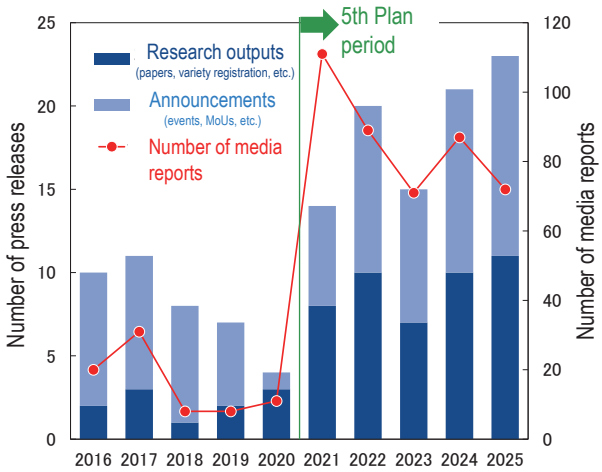
SUNAOKA Kiyoyuki
Director, Administration Division

Connecting Research and Society: Five Years of Public Relations and Outreach

Under the 5th Medium to Long-Term Plan, the Information and Public Relations Office was established as an independent organizational unit, creating a system dedicated to the specialized promotion of JIRCAS's activities. Through daily information exchange with research divisions, the office has organized research goals and outcomes, and acted as a bridge between research and society by disseminating information through press releases, the website, social media, and various publications.

Dissemination through press releases and media relations

The office proactively issued press releases and announcements on major research achievements and events to reach the public through the media. Over the past five years, 93 press releases were issued—about 2.3 times more than during the previous plan period. These releases resulted in a total of 430 news reports in newspapers and online media, a 5.5-fold increase. Among them, the release on "BNI-enhanced wheat,"



which maintains high productivity with reduced nitrogen fertilizer, drew significant attention with 97 media reports. The office also served as a liaison between reporters and researchers, ensuring accurate and effective media coverage. As a result, JIRCAS research appeared in 1,199 newspaper and online articles (including 246 overseas reports) and in 36 television and radio segments, providing valuable opportunities for the public to learn about JIRCAS's work. (Figures as of March 16, 2026)

Enhancing the website and online communication platforms

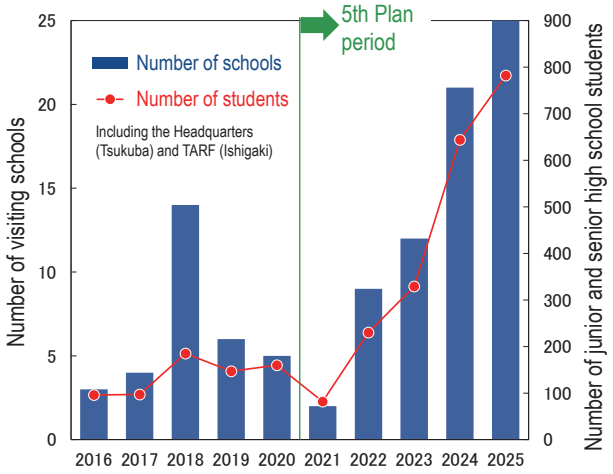
The JIRCAS website was comprehensively redesigned, introducing mutual links among project pages and keyword-based classification to make information easier to find. As a result, page views of key sections such as press releases, publications, and events increased by about 1.9 times, along with longer viewing durations and higher engagement. The launch of the institutional repository also enabled unified online access to research outputs and publications, with DOI assignment facilitating external database searches. Downloads of the Green Asia Report increased nearly five-fold, and access was recorded from over 78 countries, strengthening the foundation for international knowledge sharing.

Diverse communication through social media and video

Since opening the official X (formerly Twitter) account on the institute's anniversary, the office has shared research highlights and event updates, posting over 1,700 times and reaching 3,467 followers over five years. Through continuous content analysis and improvement, original posts achieved a strong engagement rate of 9.5%. On the YouTube "JIRCAS Channel," videos in Japanese and English introduced the 5th Medium to Long-Term Plan, featured short lectures by researchers, and streamed or archived international symposia, attracting 4,886 subscribers and about 220,000 views. These videos have been used for visitor orientation and as educational materials in overseas workshops, supporting outreach across time and distance. (Figures as of March 16, 2026)

Outreach and connecting with the next generation

Despite restrictions on in-person events during the COVID-19 pandemic, the office continued public engagement through online mini-lecture videos by researchers. Outreach programs were designed for three main target groups: the general public; researchers, graduate students, and JICA trainees; and junior and senior high school students. For the public, science events and open-house programs introduced research in an accessible way. For students and practitioners, lectures and facility tours provided insight into real-world agricultural issues and international research efforts. Special emphasis was placed on connecting with the next generation—2,067 students from 69 schools participated over five years. Using photos, videos, and real samples, the programs inspired interest in science and international research. Surveys indicated that many participants became more motivated to study science and consider research-related careers.



Looking back on the fifth planning phase

Over these five years, the Information and Public Relations Office has strengthened its role as both "supporter" and "bridge" connecting research and society. While public relations does not directly implement research outcomes, it plays a crucial role in communicating their significance, fostering dialogue, and building understanding that leads to future collaboration and application. Building on the foundation established during the 5th Plan, JIRCAS will continue sharing research findings on global agricultural, forestry, and fisheries issues with diverse domestic and international partners, contributing to joint learning and problem-solving.

OMORI Keisuke
Head, Information and Public Relations Office

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

Since the launch of the 5th Medium to Long-Term Research Plan in April 2021, we have spent five years conducting research to improve the sustainability of agriculture, forestry, and fisheries in developing regions while ensuring environmental conservation. In these areas, agriculture is a primary livelihood, and achieving efficient resource use without exceeding environmental limits—while adapting to climate change and reducing greenhouse gas (GHG) emissions—remains a critical challenge. Our program has therefore focused on developing technologies for climate change mitigation and adaptation.

During this period, global warming has continued to accelerate. In 2024, the global average temperature rose to 1.55°C above pre-industrial levels, and the 2023–2025 average is estimated at 1.48°C. UN Secretary-General António Guterres warned that the world may no longer succeed in limiting temperature rise to within 1.5°C, the target set by the Paris Agreement.

The main driver of this warming is the increase in GHG concentrations, particularly methane (CH_4), which has a warming potential 28 times that of carbon dioxide (CO_2). In 2023, CH_4 levels reached 2.6 times their pre-industrial concentration, the highest in 800,000 years. About 40% of global CH_4 emissions originate from agriculture, including emissions from flooded rice paddies, livestock digestion and manure, and the decomposition of agricultural waste. Nitrous oxide (N_2O), with 298 times the warming potential of CO_2, is another major GHG. In cereal production, a large share of applied nitrogen fertilizer remains unused by crops and is emitted as N_2O.

The resulting rise in temperature has intensified extreme weather events—droughts, floods, and heatwaves—posing serious threats to crop, livestock, and forest productivity. This undermines not only the sustainability of agriculture, forestry, and fisheries, but also the stability of societies in developing regions.

In response, the Environment Program has advanced the development of technologies to reduce GHG emissions across sectors (Fig. 1).

Development of comprehensive agricultural technologies for climate change mitigation and adaptation in Monsoon Asia [Climate Change Measures in Monsoon Asia]

For CH_4 mitigation in rice paddies, we integrated multi-country alternate wetting and drying (AWD) trial results with existing knowledge to develop a drainage decision matrix that supports yield improvement, water savings, and methane reduction simultaneously. This supports site-specific adoption of AWD based on local soil redox conditions and water availability. In the

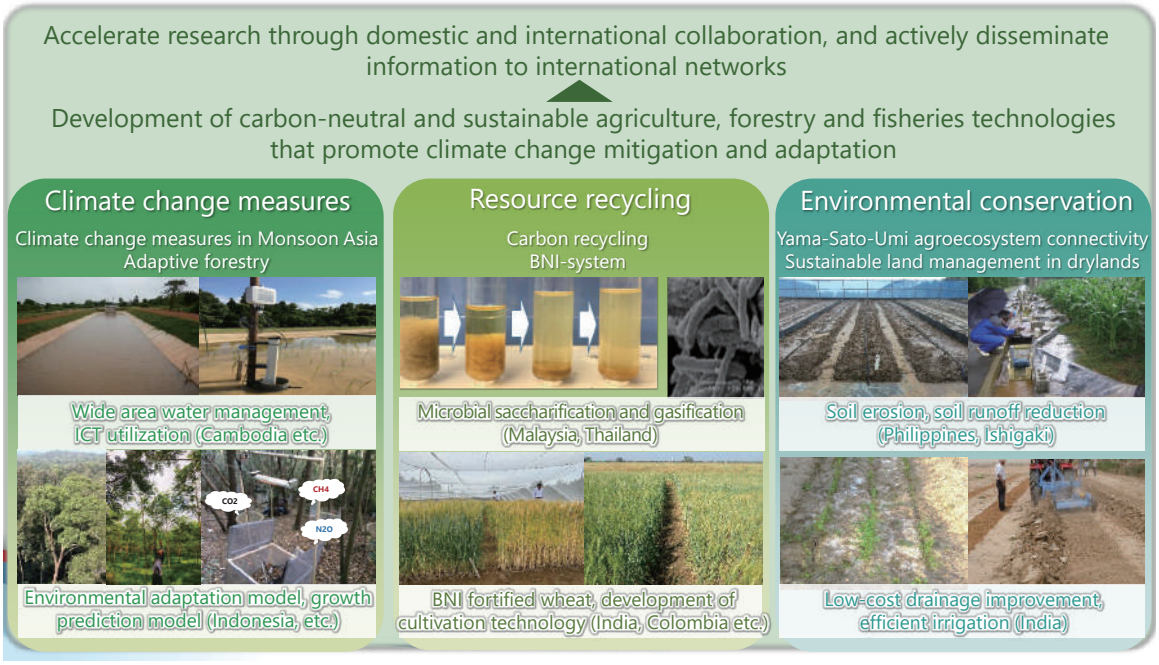


Fig. 1. Overview of the Environment Program

Philippines, we contributed to the formulation and registration of a Joint Crediting Mechanism (JCM) methodology targeting CH_4 reduction through water management, which is the first of its kind in the agricultural sector, facilitating broader application.

We also demonstrated the effectiveness of trace additions of cashew nut shell liquid (CNSL) in reducing enteric methane emissions from ruminants. Field trials with Vietnamese cattle provided key insights into its applicability and benefits under real-world conditions.

Photo. Field experiment in irrigated rice paddies in Cambodia

Development of carbon recycling technologies to address global issues caused by agricultural waste [Carbon Recycling]

In the field of carbon recycling, we developed technologies such as high-efficiency saccharification using cellulose-degrading microorganisms and "raw material diversification processing" to produce fuel pellets from palm residues and rice straw, offering alternatives to burning or improper disposal. Partnerships with private companies have enabled applications in brewery residue treatment and the production of recycled wood board feedstock and fuel pellets, supporting the development of a circular agricultural economy.

Development of planet-friendly agricultural production system using biological nitrification inhibition (BNI) technology [BNI-System]

For reducing N_2O emissions from upland fields, we achieved the world's first development of a wheat variety with enhanced biological nitrification inhibition (BNI). This "BNI-enabled wheat" could reduce lifecycle GHG emissions by about 9.5% across roughly 30% of the global wheat production area suited to its use. Breeding efforts in India and Japan are underway. Breeding platforms for BNI enhancement in crops such as maize and sorghum are also progressing.

Evaluation of genetic resources for strengthening productivity and adaptability of tropical forests [Adaptive Forestry]

Tropical forests are being degraded by environmental changes such as rising temperatures and overlogging. Genomic selection techniques have been used to accelerate the identification of elite lines. Growth prediction models have also been established to support advanced silviculture and sustainable forest management under changing environments.

Development and evaluation of environmental conservation technologies for tropical islands through an approach emphasizing Yama-Sato-Umi (Ridge-to-reef agroecosystem) connectivity [Yama-Sato-Umi Agroecosystem Connectivity]

In tropical island regions, we developed environmental conservation technologies based on ridge–village–sea linkages. These include nursery techniques for fast-growing tree seedlings, erosion-reducing systems combining mushroom logs and fruit trees, and deep planting techniques for sugarcane production that improve ecosystem sustainability in tropical islands.

Development of sustainable land management technologies under extreme weather conditions in drylands [Sustainable Land Management in Drylands]

In salt-affected areas due to irrigation agriculture, we evaluated shallow subsurface drainage technology using a Japanese Cut-soiler in the Indo-Gangetic Plain of India. The technique improved soil moisture and salinity conditions. Economic assessments were also conducted, and recommendations on optimal implementation scales have led to collaboration with local policymakers.

All of these initiatives were carried out through joint research with national research institutions and collaboration with local stakeholders in target countries. Going forward, the implementation of these technologies is expected to lead to more concrete contributions from developing regions toward solving global environmental challenges.

HAYASHI Keiichi
Program Director (Environment)

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

Over the five years since the launch of the current Medium to Long-Term Plan, global food systems have been severely challenged by the COVID-19 pandemic, rising geopolitical tensions, and the increasing frequency of climate-driven extremes such as droughts, floods, and heat waves. Under this growing uncertainty, the JIRCAS Food Program has pursued integrated research from fundamental science to implementation, aiming to build new food systems that simultaneously enhance productivity, sustainability, and resilience. The program consists of six projects: Resilient crops, Indigenous crops and foods design, Transboundary pest management, Ecosystem approach to aquaculture, Africa rice farming system, and Africa upland farming system (Fig.1). By integrating genetic resources, ecology, molecular mechanisms, and pathways to social implementation, the program has generated world-leading research outcomes. As the program enters its final year, these outcomes are contributing not only to addressing global food and nutrition challenges but also to strengthening the intellectual foundations that support Japan's food security and long-term climate adaptation capacity.

Development of resilient crops and production technologies [Resilient Crops]

Research advanced on crops capable of stable production under drought, salinity, and low soil fertility. In rice, genetic loci associated with phosphorus (P)-use efficiency, root system architecture, and mitigation of heat-induced sterility were identified, strengthening the basis for next-generation breeding. In soybean, salt-tolerance genes were introduced into local varieties, alongside the establishment of diagnostic and implementation technologies for major diseases. In quinoa, high-quality genome sequencing and virus–vector-based gene analysis platforms enabled elucidation of salt-tolerance mechanisms. In addition, a low-cost, reproducible ridge-based field system was developed to induce early-stage "invisible drought." Using this system, a novel drought-response mechanism—where P-deficiency responses precede abscisic acid responses—was discovered for the first time globally, providing an innovative indicator for early detection of yield-limiting mild drought stress.

Design of crop breeding and food processing of indigenous resources to create new and diversified demands [Indigenous Crops and Foods Design]

The project scientifically visualized the value of indigenous crop genetic resources and traditional foods to promote new demand creation. Genome-based breeding platforms for black rice revealed diversity in functional metabolites and pathways toward high-value

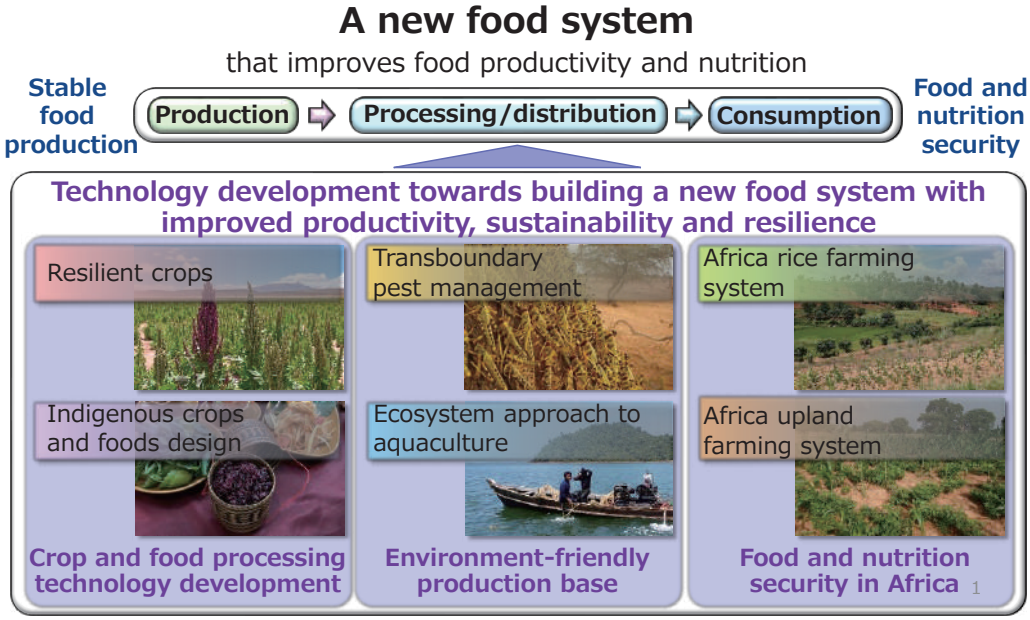


Fig. 1. Overview of the Food Program

utilization. In fermented foods, microbial resources such as thermotolerant lactic acid bacteria were used to develop processing technologies that enhance nutritional and functional properties. In West Africa, yam production systems were optimized through agronomic refinement and Unmanned Aerial Vehicle (UAV)-based evaluation.

Development of environment-friendly management systems against transboundary plant pests based on ecological characteristics [Transboundary Pest Management]

Ecological mechanisms underlying the occurrence, migration, and reproduction of transboundary pests were elucidated, strengthening the scientific basis for environmentally harmonized pest management. In desert locusts, globally recognized findings clarified mass mating and oviposition behaviors, optimal control windows during gregarious nymphal movement, and reproductive strategies enabling prediction of collective oviposition sites. Quantitative methods to evaluate insecticide application efficiency were also developed. For planthoppers, evaluation and rearing techniques incorporating natural enemies were established, while for fall armyworm, internationally comparable simplified sensitivity assays were developed, supporting integrated pest management (IPM) implementation.

Development and dissemination of sustainable aquaculture technologies in the tropical area based on the eco-system approach [Ecosystem Approach to Aquaculture]

Technologies supporting sustainable aquaculture under environmental change were developed in tropical regions. In tropical oyster farming, low-cost information and communication technology (ICT)-based monitoring and improved intermediate rearing devices enhanced survival and growth. For sea cucumbers, stage-specific rearing techniques and decision-support models were established. In addition, alternative seaweed species and seed production technologies were developed for algae with potential applications such as methane-reducing feed additives.

Development of sustainable rice cultivation and food production systems in Africa [Africa Rice Farming System]

An integrated framework was established to improve productivity and sustainability under water and nutrient constraints, with rice as the core crop. Irrigation measures were quantitatively evaluated and compiled into manuals for local application. New rice varieties were released using the *Pup1* locus and the P-efficient landrace DJ123, while the panicle number-enhancing gene *MP3* was identified and shown to increase yields by approximately 10% when introduced into major local varieties. Low-input, high-yield P-dipping techniques for P-deficient paddies were established, along with soil P diagnostic methods that improved yields, fertilizer-use efficiency, and farm income. Factors regulating carbon sequestration in paddy soils were also clarified. With support from the Japan International Cooperation Agency (JICA), dissemination of P-dipping technology and new varieties is now underway.

Development of soil and crop management technologies to stabilize upland farming systems of African smallholder farmers [Africa Upland Farming System]

This project developed decision-support technologies to enhance productivity, profitability, and sustainability for African smallholder farmers. Using multi-year datasets from northern Ghana, soil organic matter dynamics models quantified carbon inputs required for sustainable cropping, while spatiotemporal optimization models incorporating crop rotations were implemented as applications to support farm income maximization. Improved in-field fallow systems were systematized to achieve both erosion control and yield enhancement, contributing to soil conservation standard development. In addition, technologies for fertilizer production using low-grade phosphate rock were developed. Models for pond-based irrigation, irrigation suitability maps, rapid low-cost soil diagnostics using Inductively Coupled Plasma (ICP) full-spectrum analysis and deep learning, satellite-derived high-resolution soil maps, and yield prediction and probability visualization tools were established, strengthening farmer decision-making under extreme climate conditions.

FUJITA Yasunari
Program Director (Food)

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

The global situation surrounding food security has become increasingly complex and intertwined in recent years. Looking back over the past five years, following the COVID-19 pandemic and Russia's invasion of Ukraine, global food and fertilizer prices have soared to record highs. At the same time, global average temperatures have continued to rise, eventually exceeding the Paris Agreement target of 1.5°C in 2024, albeit temporarily. Over the first four years, Japan and the world made significant strides toward accelerating the decarbonization of food systems. However, since early 2025, due to changes in the US administration, the world has witnessed the collapse of the international order based on rules and trust. In times like these, there is an increasing need for constantly updated information on the science and technology needs required to solve global challenges. Through the following initiatives, this program has collected and analyzed information from multiple perspectives on challenges and development needs related to agriculture, forestry, and fisheries in developing regions and the global food system, and disseminated information on solutions to these challenges both domestically and internationally (Fig. 1).

Strategic information hub for international agricultural research [Information Hub]

This project regularly shared the latest scientific findings to contribute to improving global food security, collaborated with domestic and international research institutions and platforms, and explored collaboration needs and seeds with partners. As part of these efforts, it hosted more than 20 events on cutting-edge policy and cutting-edge research trends, selected themes based on global trends for the annual JIRCAS International Symposium, and held international seminars in collaboration with governments, inviting world-renowned researchers to share information on the global agenda. In addition to serving as a liaison for the international research platform, it also participated in the Intergovernmental Panels on Biodiversity and Climate Change as a leading expert, contributing to the formulation of the international agenda. Furthermore, the project delivered the latest information on global food security to a wide audience through its Pick Up blog. It also produced original content, such as surveys on the needs of consumers in developing countries for sustainable food, thereby establishing itself as an information center on food systems.

Practical application of global research results and establishment of a model platform for promoting private-sector research collaboration and creating new business ventures [Research Applications/ Ventures]

This project established a business model to disseminate JIRCAS's research findings and revitalize research activities by optimizing technologies adapted

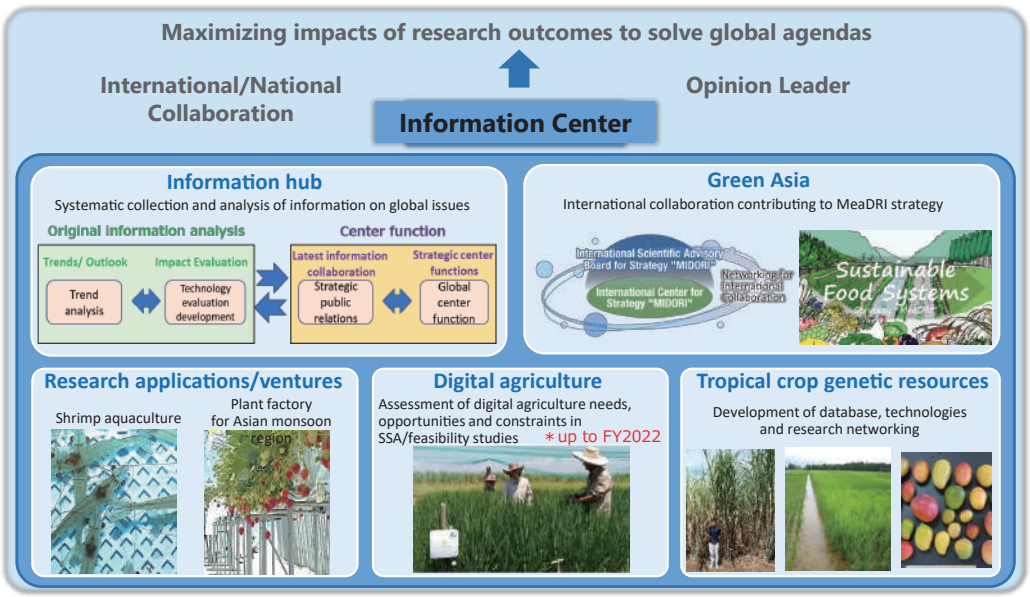


Fig. 1. Overview of the Information Program

to target countries and regions through diverse collaborations with domestic and international private companies. First, in shrimp research, we promoted the development of commercially suitable seed production technologies and artificial maturation methods for female shrimp using closed-loop aquaculture systems. Through a JIRCAS-spun-off venture (ShrimpTech JIRCAS Inc.), we provided information that contributes to the social implementation of closed-loop aquaculture of vannamei shrimp.

Second, at the Tropical Agriculture Research Front on Ishigaki Island, we collected and provided information on cultivation management conditions, including integrated environmental control, that achieve stable year-round production of high-quality fruit using the Asian Monsoon Plant Factory System (AMPFS), a technology developed in collaboration with private companies and the National Agriculture and Food Research Organization (NARO). We then conducted a demonstration study of year-round strawberry production using AMPFS in Indonesia. Furthermore, in order to promote the social implementation of the technologies that JIRCAS has developed up to the Fourth Medium to Long-Term Plan, we have established a research results dissemination platform for variety registration and promotion through collaborative research with countries in Asia and Latin America that have needs.

Advancement of tropical crop genetic resources utilization through the development of database, technologies and research networking [Tropical Crop Genetic Resources]

JIRCAS's Tropical Agriculture Research Front possesses diverse genetic resources, including sugarcane, indica rice, tropical fruits, and tropical grasses, which play important roles in food and energy production, as sources of calories and nutrients, as cash crops, and as feed. Amid concerns about global climate change, sustainable and stable production of these tropical crops is an urgent issue. At the same time, the introduction of tropical crops and their cultivation and extension technologies is expected to contribute to Japan's efforts to combat global warming and diversify food and nutrient sources.

This project leverages the diverse and abundant genetic resources of tropical crops and the geographical advantages of subtropical conditions to strategically develop genetic resource information, breeding techniques, varieties and materials, and cultivation and extension techniques. At the same time, we have promoted the utilization of tropical crop genetic resources through the formation of networks with domestic and international research institutions. In the current medium- to long-term period, we have achieved the promotion of the sugarcane variety KK4, developed in collaboration with Thailand, as a recommended variety, and the registration of "Isan" —the first tropical pasture variety of the *Urochloa* genus (formerly known as *Brachiaria*) in the Asian monsoon region—in Japan and Thailand. We have also promoted the development of technologies to advance the utilization of tropical crop genetic resources that can contribute to solving global issues, and have achieved many results in the development of indicators of drought and disease resistance, as well as technologies that contribute to solving hybrid sterility.

Accelerating application of agricultural technologies which enhance production potential and ensure sustainable food systems in the Asia-Monsoon region [Green Asia]

The Green Asia project, a four-year initiative launched in 2022, was aligned with the 'MIDORI Strategy for Sustainable Food Systems' (MIDORI Strategy) developed by the Japanese government. The project promoted scalable Japanese technologies in agriculture, forestry, and fisheries that support sustainable food systems in the Asia-Monsoon region under two pillars: strategic information dissemination and joint research for field trials.

Under the first pillar, we established an International Scientific Advisory Board comprised of renowned agricultural scientists and heads of major agricultural research institutions in the Asia-Monsoon region. Based on their advice, we collaborated with national research institutes and universities to develop the "Technology Catalog" and actively promoted it through international forums and ASEAN-related meetings, helping raise the visibility of Japanese technologies.

Under the second pillar, we conducted field trials to verify the local applicability of three technologies: alternate wetting and drying (AWD) irrigation, biological nitrification inhibition (BNI) wheat, and rice blast control. We disseminated valuable knowledge to accelerate social implementation. The experience gained through this project is expected to inform the next medium- to long-term plan, offering valuable lessons for public-academia-private collaboration to deploy scalable agricultural technologies that contribute to increasing productivity and ensuring sustainability in the Asia-Monsoon region and other parts of the Global South.

IIYAMA Miyuki
Program Director (Information)

JIRCAS TODAY

【Research Highlights】

Optimization of Biochar Application Depth Contributes to the Reduction of Nitrogen Leaching
—Pathway to Sustainable Agriculture by Suppressing Nitrogen Leaching Through Surface Application—

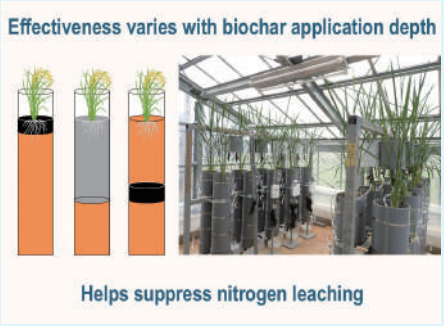
Using a pipe device developed by JIRCAS to precisely observe nitrogen dynamics in soil, the impact of biochar application depth on nitrogen leaching was clarified at the Tropical Agriculture Research Front in Ishigaki City.

In this study, changes in nitrogen leaching were investigated when carbonized materials were applied at different depths using "Kunigami Maji," a representative acidic soil of Okinawa.

The experiment compared four conditions — no application, surface layer application (0–5 cm), plow layer application (0–30 cm), and subsoil layer application (25–30 cm). Nitrogen fertilizer was applied, and surface irrigation was performed under each condition, measuring nitrogen leaching from the bottom of the pipes.

Results revealed significant differences in nitrogen leaching depending on biochar application depth. Surface applications (0–5 cm) resulted in a 12.3% reduction in nitrate leaching compared to no application, showing a significant effect on reducing nitrogen leaching. However, plow layer application (0–30 cm) resulted in a 6.4% increase in nitrate and a 164.1% increase in ammonium nitrogen, demonstrating clear differences based on depth.

These findings indicate that biochar application depth affects soil nitrogen adsorption capacity and crop drought stress, influencing nitrogen leaching. This study suggests that even with the same amount of biochar, selecting the appropriate application depth can maximize the effect of reducing nitrogen leaching.



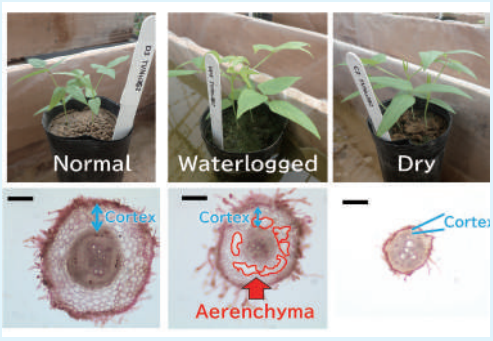
This research was published in the online edition of *Scientific Reports* on October 1, 2024 (Japan time).

Discovery of Cowpea Genetic Resources with Dual Tolerance to Drought and Waterlogging
—A Key Foundation for Developing Varieties Resistant to Extreme Weather from Climate Change—

A research team from JIRCAS and the International Institute of Tropical Agriculture (IITA) has discovered cowpea (*Vigna unguiculata*) genetic resources that exhibit dual tolerance to two opposing environmental stresses: drought and waterlogging. With climate change increasing both extreme droughts and soil waterlogging from heavy rainfall in West Africa's dry savanna, stable cowpea production has become a major challenge.

The researchers evaluated 99 cowpea lines, including cultivated and wild ancestor lines, and identified 10 lines (9 wild and 1 cultivated) that exhibit dual tolerance. One wild ancestor line, in particular, develops aerenchyma in its roots under waterlogged conditions and enhances water transport efficiency under drought, flexibly adapting root morphology to the soil moisture environment.

The identified wild lines are cross-compatible with cultivated cowpeas, providing potential for developing new varieties capable of stable production under extreme weather conditions.



This research was published in the online edition of *Frontiers in Plant Science* on June 12, 2025 (Japan time).

JIRCAS TODAY

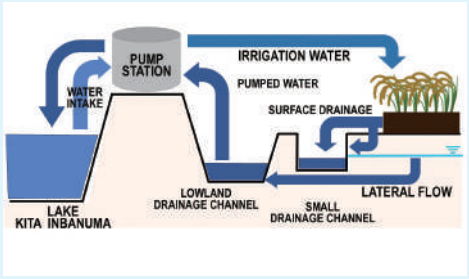
Overcoming Challenges in Drainage Measurement: Clarifying Paddy Field Drainage Characteristics in Lowlands with Cyclic Irrigation Systems —Contributing to the Design of Efficient Irrigation Systems for Lowland Paddy Fields—

A joint research team from JIRCAS, Tokyo University of Agriculture and Technology, and the Kanto Regional Agricultural Administration Office of the Ministry of Agriculture, Forestry and Fisheries has clarified the drainage characteristics of a cyclic irrigation system1 in the Inbanuma Second Phase National Land Improvement Project area in Chiba Prefecture, Japan.

In paddy field irrigation, calculating water use efficiency requires knowledge of both water inflows and outflows. However, measuring outflows is difficult due to the need for monitoring at all branching drainage channels. This study overcame that challenge by focusing on a cyclic irrigation system, where drainage is reused as irrigation water, enabling quantification of drainage volume at the paddy-field district level.

Field surveys conducted in 2021 and 2022 revealed that over 50% of irrigation water came from reused paddy drainage, including not only surface drainage2 but also part of the lateral flow3, which was recaptured and reused.

These findings provide the first quantitative data on the volume of reused paddy drainage in this setting. This data will allow for quantifying the water quality conservation effects at water sources, developing optimal pump operation strategies based on drainage behavior, and designing environmentally sound and efficient irrigation systems for lowland paddy fields



This research was published in the online edition of the *Journal of Hydrology: Regional Studies* on December 19, 2024 (Japan time).

[1] **Cyclic irrigation system**: an irrigation system that reuses drainage water from paddy fields as irrigation water.
[2] **Surface drainage:** the removal of surface water that accumulates on the field surface due to rainfall or irrigation, or the drained water itself.
[3] **Lateral flow:** a portion of the water that infiltrates from the field surface; it remains in soil near the surface and moves horizontally according to differences in elevation.

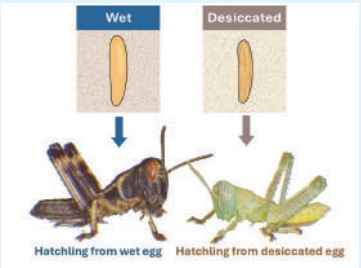
Unveiling the Desert Locust's Adaptation Strategy to Arid Conditions —Reserved Egg Yolk Prolongs Larval Survival—

JIRCAS, in collaboration with the French Agricultural Research Centre for International Development and the Mauritanian National Desert Locust Centre, has clarified how desert locust embryos improve their survival rates in harsh desert environments, particularly under dry conditions.

Locusts inhabiting the Sahara Desert often face extreme dryness and scarce food resources, forcing newly hatched larvae to employ unique strategies to survive.

This study found that although larvae hatched under dry conditions are smaller than those hatched in wet conditions, they retain more yolk (lipids) within their bodies. These hatchlings can survive for about twice as long as normal individuals even without access to food. Hatchlings in a starvation state had entirely consumed their yolk reserves, and hatchlings produced by removing yolk from their eggs did not experience extended survival. These findings suggest that the reserved yolk serves as an essential energy source, like a "lunch-box," after hatching.

The research results indicate that, as an adaptation strategy to dry environments, locust embryos flexibly allocate yolk—a limited resource—to enhance survival chances even in food-scarce conditions post-hatching. Understanding these adaptive mechanisms in nature is expected to contribute to more accurate predictions of locust population dynamics in the future.



This research was published in the online edition of *PNAS Nexus* on May 28, 2025 (Japan time).

JIRCAS TODAY

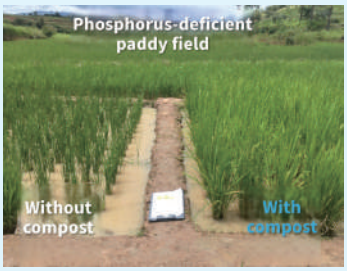
Achieving Higher Rice Yields in Phosphorus-Deficient Paddy Fields in Sub-Saharan Africa
—Development of Sustainable Rice Cultivation Technology Using Farmyard Manure from Smallholder Farmers—

JIRCAS, in collaboration with LRI (Laboratoire des RadioIsotopes/Radiation Research Institute) of the University of Antananarivo in Madagascar, examined the effects of farmyard manure (FYM) used by smallholder farmers in the central highlands of Madagascar.

The recent surge in global chemical fertilizer prices has placed a heavy burden on farmers, especially those with low purchasing power. Under these circumstances, developing rice cultivation technologies that can stably increase yields without relying on chemical fertilizers has become an urgent priority.

In this study, it was confirmed that applying FYM to phosphorus-deficient paddy fields significantly increased rice yields, achieving yield improvements comparable to those obtained with chemical fertilizers, in farmers' fields in the central highlands of Madagascar. Furthermore, combining FYM with nitrogen fertilizer and applying them continuously for four years resulted in a substantial enhancement of yield gains.

In addition, analyses of multiple field trials conducted in the Sub-Saharan Africa region corroborated the high effectiveness of FYM in phosphorus-deficient paddy fields. These findings are expected to contribute to strengthening food security and improving farmer incomes by providing practical rice cultivation techniques that utilize local resources.



This research was published in the online edition of *Field Crops Research* on May 13, 2025 (Japan time).

Establishing a Breeding Method for Fertile Hybrids That Overcome the Hybridization Barrier Between Asian Rice and African Rice
—Stable Development of Intermediate-Genotype Fertile Hybrids Through Tetraploidization and Diploidization—

A joint research group from JIRCAS and Hokkaido University has developed a new method to produce interspecific hybrids that carry nearly equal proportions of genes from both Asian cultivated rice (Asian rice) and African cultivated rice (African rice), while exhibiting stable seed fertility. Although African rice possesses useful traits such as resistance to diseases and environmental stresses, crosses with Asian rice often result in hybrid sterility, posing a major obstacle in breeding.

In this study, the researchers temporarily induced tetraploidy in the hybrid to reduce sterility and then used pollen culture to revert it to diploidy. As a result, they successfully generated hybrids that maintain an intermediate genomic composition between Asian and African rice while exhibiting stable seed fertility. The resulting hybrids are expected to serve as valuable breeding material for introducing desirable traits, such as disease resistance and environmental resilience from African rice, and represent a significant step toward new avenues in rice breeding.

This research was published in the online edition of *Theoretical and Applied Genetics* on June 27, 2025 (Japan time) as an open-access article.

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