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Special Feature

5th Medium to Long-Term Plan (2021-2025)

Japan International Research Center For Agricultural Sciences

In This Issue

Foreword

Our Main Tasks under the Fifth Medium to Long-Term Plan ……3

Special Feature

The Fifth Medium to Long-Term Plan

- (Program A: Environment)
  Development of agricultural technologies for climate change, resource recycling and environmental conservation ……4
- (Program B: Food)
  Technology development towards building a new food system with improved productivity, sustainability and resilience ……8
- (Program C: Information)
  Strengthening function as an international hub for providing strategic information on agriculture, forestry and fisheries, and mobilizing new research partnerships ……12

JIRCAS TODAY

【Research Highlights】

- Elucidating the behavior of desert locust survival in the desert — Realization of predicting behavior using a constructed model— ……14
- “More ammonium” in farmlands is key to mitigate nitrogen pollution and boost crop yields ……14
- World’s first discovery of a biological nitrification inhibitor in maize roots— First step to reducing nitrogen fertilization application and making the earth healthier ……15
- Evaluating the effectiveness of greenhouse gas reduction in the Mekong Delta, Vietnam — Integrated rice and beef production systems reduce GHG emissions by 22%— ……15

【JIRCAS Open House 2021 held online】 ……16

【JIRCAS is now on Twitter!】 ……16

Our Main Tasks under the Fifth Medium to Long-Term Plan

The Japan International Research Center for Agricultural Sciences (JIRCAS), a national research and development agency, started its new five-year Medium to Long-Term Plan in April 2021, the fifth plan since its transformation to an independent administrative agency. Its noble mission, redefined in its fifth Medium to Long-Term Target as mandated in March by the Minister of Agriculture, Forestry and Fisheries, Government of Japan, is stated as follows: "As a research institution representing Japan in the field of international agriculture, forestry and fisheries, JIRCAS aims to enhance agriculture, forestry and fisheries technology in the world including Japan and to contribute to the advancement of sustainable agriculture, forestry and fisheries, towards the accomplishment of the government policy on the Basic Plan for Food, Agriculture and Rural Areas." The target also specified two priority tasks: the effective and intensive implementation of research and development to contribute to solving global food and environmental issues, and the enhancement of function for collecting and analyzing multi-dimensional information related to the issues and for its broader dissemination.

To meet the target, JIRCAS selected its main research and development activities and organized them into two programs — "Environment" and "Food" — so that intensive implementation can be assured. Each program covers six research projects, and all of these projects aim to achieve better outcomes by providing solutions to global issues related to agriculture, forestry, and fisheries. Also, activities that enhance its function as an information center on the complex and diverse global environment and food systems were gathered and classified into four projects under the "Information" program.

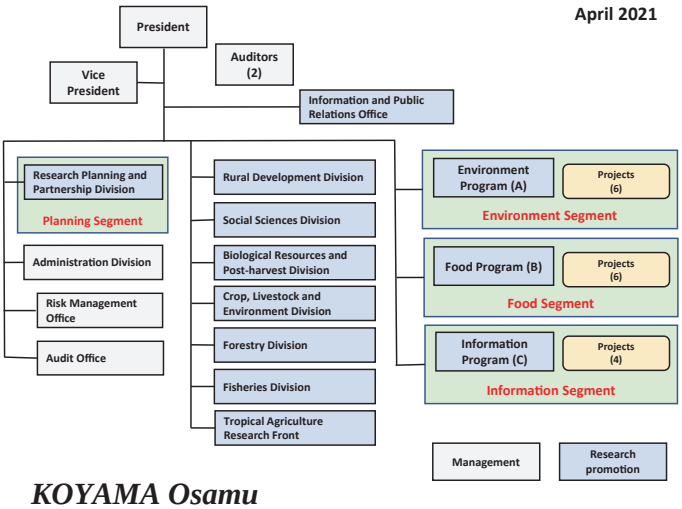
These 16 projects in total were planned in an internal ad hoc conference through discussions, based on both the basic guidelines made by executives and the specific research proposals made by researchers. Many of these projects have a multidisciplinary nature. As in previous periods, researchers will continue to belong to their respective divisions (in Tsukuba HQ) or to the Tropical Agriculture Research Front (to those in Okinawa), which are organized according to academic fields and research targets for long-term human development and accumulation of expertise, and each researcher will be participating in several projects.

As JIRCAS pursues the above tasks, we will pay particular attention to providing a swift and flexible

response to the changing situation in target regions and the consequences of the COVID-19 crisis etc., as well as cooperate with various domestic and international partners and promote public relations using various media and communication tools. In addition, using advanced digital technologies, we will also strive to further enhance productivity and efficiency, improve the quality of our outputs, and promote openness and transparency. To handle managerial issues, the Research Planning and Partnership Division was reorganized, and the Information and Public Relations Office was relocated directly under the President in order to centralize all related activities.

JIRCAS celebrated its 50th anniversary last year and entered a new stage with the slogan "Together for our food and planetary health." Guided by long-term principles such as the Sustainable Development Goals of the United Nations (SDGs) and the new policy "Measures for Decarbonization and Resilience with Innovation" of the Japanese Ministry of Agriculture Forestry and Fisheries, we will unite ourselves and work together to uphold and create new values based on our common humanity. The new Medium to Long-Term Plan of JIRCAS provides the most appropriate framework for us to fulfill our mission.

Organization Chart



KOYAMA Osamu
President

(Program A: Environment)

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

In October 2020, the so-called “carbon neutral” challenge began in Japan when it announced its aim to achieve zero greenhouse gas (GHG) emissions by 2050 and realize a decarbonized society. In May 2021, the Ministry of Agriculture, Forestry and Fisheries formulated the Strategy for Sustainable Food Systems (MeaDRI) to actively contribute to this effort. To achieve carbon neutrality, it is important to reduce GHG emissions from agricultural production. Accelerated GHG emissions through crop cultivation, livestock production, and extractive forest resource use can amplify the burden on people's lives and society. Many farmers in developing regions that rely heavily on agriculture, forestry, and fisheries are small-scale farmers; thus, reduced production due to floods and droughts can threaten their daily livelihoods. Clearly, the increase in atmospheric concentrations of GHGs can directly and indirectly hurt people's lives. We need a carbon-neutral society in order to realize the 17 Sustainable Development Goals. The Japan International Research Center for Agricultural Sciences (JIRCAS) is working with national agricultural research institutes and other organizations in such countries, through cooperation, to develop technologies needed by small-scale farmers who are exposed to the effects of climate change, and for each country to achieve its own nationally determined contribution (NDC) target to reduce its GHG emissions. In addition, as part of the “MeaDRI,” which is the culmination of Japan’s science and technology innovation and a model for initiatives in the Asian monsoon region, we are promoting international joint research with countries in the region.

The Environment Program of JIRCAS aims to achieve the twin goals of ensuring sustainability in the agriculture, forestry, and fisheries sectors and establishing appropriate resource management by maximizing resource use efficiency in developing regions that are heavily dependent on agriculture, forestry, and fisheries. To achieve these goals, we will develop water management technologies that reduce GHG emissions, agricultural management technologies for livestock use, carbon recycling technologies that convert agricultural waste into resources, low-impact agricultural production systems that use biological nitrification control to reduce the environmental impact of nitrogen compounds, silvicultural technologies that enhance the forestry productivity and environmental adaptability of tropical forests, and environmental conservation technologies that link mountains, villages, and oceans in the tropics and islands. We are also working on the development of environmental conservation technologies through Yama-Sato-Umi connectivity in the tropics and islands, soil conservation technologies in arid regions, and technologies to reduce the risk of drought (Fig. 1).

Fig. 1. Outline of the Environment Program

Development of comprehensive agricultural technologies for climate change mitigation and adaptation in monsoon Asia【Climate Change Measures in Monsoon Asia Project】

JIRCAS has been working on the development of climate change measures technologies applicable to small-scale farmers in the Asian monsoon region. For example, we have been conducting research and development on mitigation measures, among them GHG emissions reduction from paddy fields and livestock, soil carbon storage, and adaptation measures such as water-saving cultivation and improvement of water management. In the 5th Medium to Long-Term Plan, we aim for social implementation and dissemination of these technologies. We plan to accumulate evidence that these technologies are easy for local farmers to accept and can lead to various co-benefits, and we will make policy recommendations to the governments of partner countries. For example, intermittent irrigation in a paddy field is generally known to reduce soil GHG emissions and increase rice yield; however, it is a difficult technique for farmers to manage on large fields. In addition, appropriate water management is required to adapt for water scarcity under climate change. Therefore, we will develop a method of paddy water management optimized for higher rice yield and supported by information and communications technology（ICT)-based tools to reduce soil GHG emissions, and we will establish a decision-making tool for efficient water use by water users' associations. Furthermore, we will assess the vulnerability of agricultural areas to climate change using remote sensing technology. Soil fertility in the tropical zone is low, hence, development of management technologies to improve soil fertility is an urgent issue for achieving sustainable food production and for increasing soil organic matter, which plays a role in carbon sequestration for climate change mitigation. We will conduct field experiments on biochar application, organic matter input, and conservation tillage, and evaluate the effects of management strategies on carbon sequestration and crop production. Furthermore, we will study the determinants of carbon storage potential as well as evaluate the carbon storage capacity of soils in tropical humid regions using new techniques and approaches (e.g., physical fractionation and microbial carbon use efficiency). Subsequently, we will reveal the best technology to store carbon in tropical soils by pot experiments and then, confirm its performance by on-farm trials. It is also important to mitigate GHG emissions from livestock production. In this project, we will develop GHG mitigation technologies from both enteric fermentation and manure management through utilization of locally available resources. We will aim for social implementation and disseminate the technologies developed under this project. These technologies will be evaluated using GHG Life Cycle Assessment and improved through action research to make them more applicable to farmers. We will also utilize a method to generate carbon credits (emissions reduction) used in GHG emissions trading.

Photo 1. Measurement of GHG emissions from a paddy field in Vietnam

Development of carbon recycling technologies to address global issues caused by agricultural waste 【Carbon Recycling Project】

Agriculture produces a lot of agricultural waste. In developing countries, agricultural waste is used as livestock feed and compost, but it also negatively impacts society and the environment when it is abandoned on farmland or burned. In tropical plantations, it is desired to build technologies and social systems that promote agricultural waste recycling. Therefore, in this project, we will develop a microbial saccharification-gasification bioreactor to generate methane, carbon dioxide, and hydrogen from agricultural waste with high efficiency. In addition, we will work on the development of nutritional pigments and fuel production technologies using the various gases generated, and the development of production technologies for producing high value-added substances such as bioplastics.

On the other hand, understanding agricultural waste's global environmental impact on recycling is crucial. Therefore, we will propose utilization and management methods for agricultural waste by

promoting GHG data conversion and crop impact assessment generated when agricultural waste is abandoned on agricultural land. Furthermore, we will promote the spread of carbon recycling technologies jointly with private companies, government agencies, local governments, and agricultural cooperatives, with the aim of facilitating social implementation.

Development of planet-friendly agricultural production systems using biological nitrification inhibition (BNI) technology【BNI-system Project】

Modern agriculture relies on massive inputs of nitrogen fertilizer derived from industrial nitrogen fixation. However, 50%-70% of the nitrogen fertilizer applied to farmland is not utilized by crops. Excess nitrogen remaining in the soil is converted to nitrate (by nitrification) by soil microorganisms and then leaks into groundwater, polluting the water. Furthermore, nitrate is converted into nitrous oxide — a GHG nearly 300 times more potent than carbon dioxide — and is emitted into the atmosphere, becoming largely responsible for GHG emissions from agriculture.

JIRCAS discovered biological nitrification inhibition (BNI), the natural ability of certain plant species to reduce environmental burden resulting from nitrogen fertilization, which has already far exceeded the buffering capacity of the planetary ecosystem (i.e., the planetary boundary). BNI activity is stimulated by genetic exploitation of a naturally occurring plant function, playing an important role in maintaining high productivity and in advancing modern agriculture. We had formed a BNI international consortium with institutions from different parts of the world, and are working to develop technologies to utilize BNI in agriculture.

JIRCAS is currently focusing on four crops, i.e., wheat, maize, sorghum, and *Brachiaria* pasture grass, which account for about 500 million ha of cultivated area globally. Wheat is the world's second largest crop. For this reason, we have developed BNI-enabled elite-wheat lines, which are presently undergoing field-evaluations for possible deployment in major wheat-growing regions such as the IGP (Indo-Gangetic Plain), a major wheat-producing area in India, where there is a growing demand for wheat. BNI research for maize, the most widely grown crop, had been initiated, and BNI compounds are being elucidated. We are further utilizing this clue to establish a maize production system with BNI. Sorghum, the fifth largest crop, is utilized in semi-drylands where many developing countries are located, and the behavior of BNI compounds in soil and crop-soil microflora interactions are being elucidated. JIRCAS is working on marker-assisted selection for BNI-trait components (such as sorgoleone production from root systems) as part of its efforts to develop BNI-enabled sorghum elite-varieties. Also, we are establishing a DeNitrification-DeComposition (DNDC) model as the foundation of a sustainable crop rotation system with *Brachiaria* pasture grass.

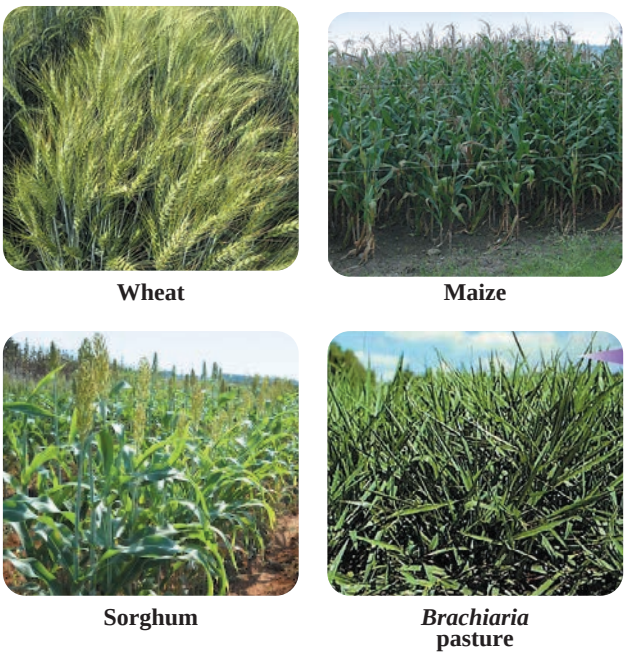


Photo 2. BNI research by JIRCAS is currently focused on the above crops.
Our target crops cover huge farmlands all over the world, and we are aiming at achieving a planet-friendly food system.

Evaluation of genetic resources for strengthening productivity and adaptability of tropical forests【Adaptive Forestry Project】

Tropical forests have a particularly large carbon storage and play an important role in the global greenhouse gas balance. At the same time, the growing impact of climate change on the health of tropical forests is becoming a major concern. Timber is an important export item in Southeast Asia but the decrease in natural forest resources has led to a rapid shift to plantation timber production. To promote effective forest restoration, JIRCAS is conducting the following research activities on native tree species in Southeast Asia: (1) Evaluation of the growth and properties of wood, as well as their adaptability to environmental changes such as higher temperature and drought, to propose tree species and land suitable for

planting, (2) Application of genomic selection to the breeding of teak in Thailand and dipterocarps in Malaysia and Indonesia to significantly shorten the breeding cycle, (3) Development of silvicultural techniques with growth prediction based on the evaluation of the physiological characteristics of tree species in order to plant an appropriate combination of tree species and strains that can adapt to the environment of the planting area, (4) Evaluation of the impact of tree planting on ecosystem functions and the proposal of operational guidelines for recovering these functions, and (5) Promotion of international networks to share the obtained information on tropical forest genetic resources.

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 Project】

The Coral Triangle (CT) is an area in the tropical waters around the Philippines and Indonesia, with a variety of coral species which account for 80% of the world. Precisely, CT is playing a critically important role in the absorption of greenhouse gases from around the globe. As tropical islands are vulnerable to the impacts of climate change and natural disasters, environmental conservation for mountains and villages as a connecting ecosystem to the coastal area can save precious marine resources such as coral reefs. Based on this idea, we aim at the development of a rural livelihood system that improves water-soil conservation function and rural livelihood based on the Japanese Satoyama-management method, thereby leading to the mitigation of soil erosion and improvement of material circulation. In the village, we will work on the development of a sustainable technology which consists of an underground irrigation technology to reduce the use of chemical fertilizers, an organic matter application technology using unutilized biomass resources, and an improved fertilizer application technology, as well as the development of a sugarcane cultivation technology and potential breeding lines to reduce the environmental impacts. Furthermore, we will focus on mangroves and macro- and microalgae in the hydrosphere environment so as to develop a water quality conservation technology based on their biological functions. Since eventually the technologies that JIRCAS develops need to be utilized appropriately and sustainably, we will also conduct an environmental impact assessment and clarify the applicable conditions for the introduction of our technologies.

Photo 3. Technology development for an environmentally sustainable sugarcane production

Development of sustainable land management technologies under extreme weather conditions in drylands 【Sustainable Land Management in Drylands Project】

Global warming due to increased GHG threatens the lives of farmers in developing countries. Especially in the drylands of Africa and Asia where desertification has progressed due to soil degradation, extreme weather events such as drought and heavy rain have risen markedly in recent years, threatening food and nutrition security. To achieve sustainable agriculture and food and nutritional security, we are developing a sustainable land management (SLM) strategy that conserves soil resources while maximizing the efficiency of soil and water resource utilization.

In West Africa where soil erosion and drought are major problems, we will improve soil conservation technologies, create soil conservation standards, and develop technologies to maximize soil resource utilization. Furthermore, we will develop an effective dissemination method for these soil conservation technologies.

On the other hand, in northern India where salinization and heavy rain are major problems, we will develop low-cost technologies that mitigate salinization and maximize water resource utilization. Furthermore, we will evaluate the local applicability and dissemination potential of the technologies.

HAYASHI Keiichi
Program Director
Environment Program

(Program B: Food)

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

The global food system has been facing problems due to the effects of population growth and climate change, with the ongoing COVID-19 pandemic revealing a vulnerability in this food system and exacerbating the situation. It is therefore essential to strengthen the resilience of the food system in order to deal with not only pandemics but also various problems that are occurring or may occur in the future. To increase the resilience of food systems in developing regions, it is necessary to address the diverse needs (i.e., social, economic, and biosphere needs) related to food systems. "Social needs" include quantitative and qualitative nutritional improvement and realization of health through food. "Economic needs" include labor reduction / productivity improvement, maximum utilization of local resources, or promotion of agriculture that is resilient to risks such as climate change. "Biosphere needs" include reduction of chemical fertilizers and pesticides, and conservation and regeneration of biodiversity. In order to solve these needs, we expect to utilize advanced technologies such as ICT, IoT, and biotechnology.

In this program, through technological development and utilization in response to such diverse needs related to food systems, we will build a "new food system that achieves improved food productivity and improved nutrition" to contribute to stable food production in the target area, international food supply and demand, and food and nutrition security (Fig. 1). For this purpose, we will promote six projects for improving productivity, sustainability, and resilience. These projects are classified into "Crop and food processing technology development," "Environment-friendly production base," and "Food and nutrition security in Africa," and they all contribute primarily to Goal 2 (Zero Hunger) of the Sustainable Development Goals (SDGs).

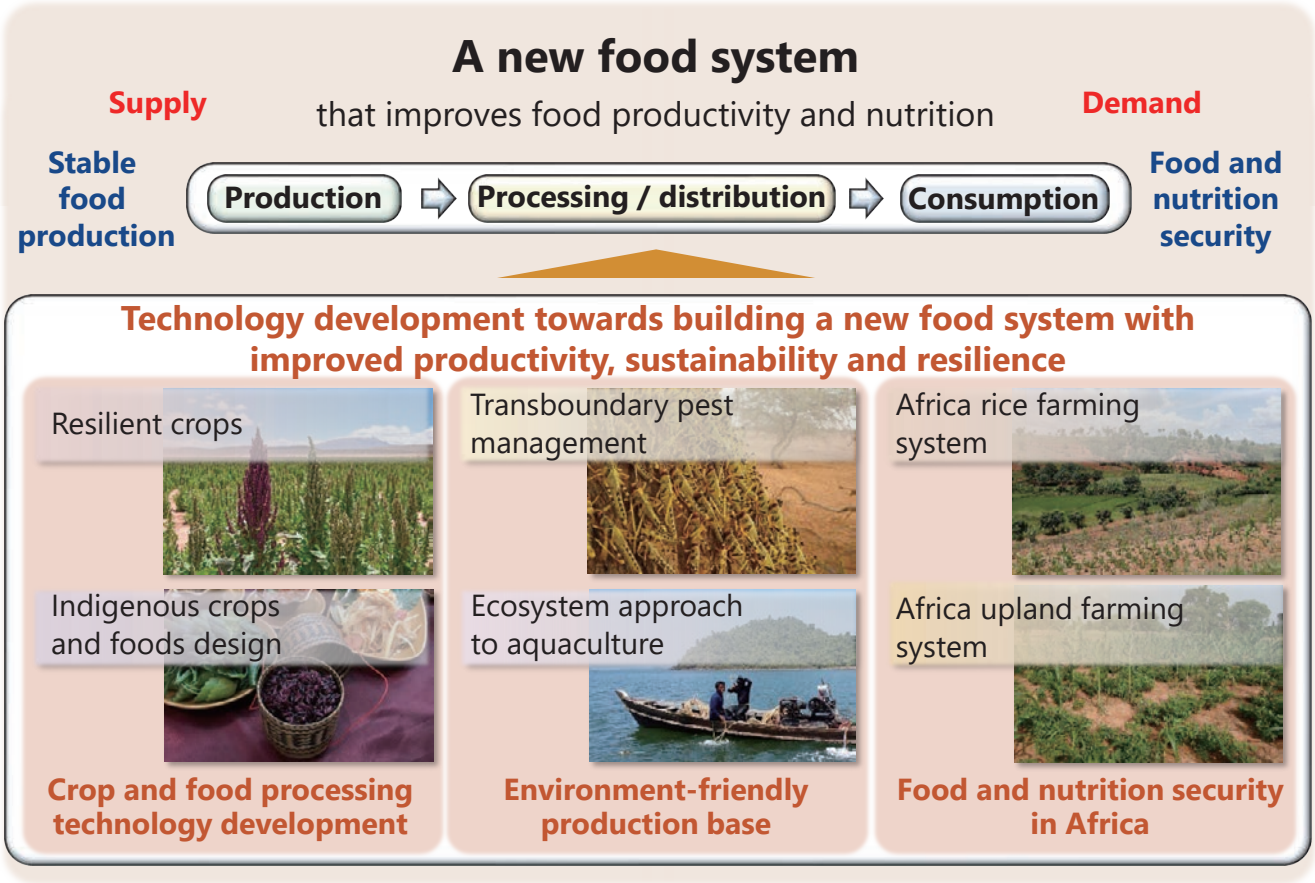


Fig. 1. Outline of the Food Program

Development of resilient crops and production technologies【Resilient Crops Project】

This project aims to contribute to reducing global hunger and malnutrition and strengthening food and nutrition security on a global scale by enabling resilient crop production, even in adverse environmental regions around the world. To this end, we will utilize cutting-edge technologies to develop breeding materials and production technologies that contribute to strengthening resilience to external disturbances such as environmental stresses of the main crops (rice and soybean) and the low-use crop (quinoa) (Photo 1).

Photo 1. Rice and soybean (the main crops) and quinoa (the low-use crop)

Design of crop breeding and food processing of indigenous resources to create new and diversified demands【Indigenous Crops and Foods Design Project】

The environment surrounding “food” and “agriculture” in the world is changing due to climate change, globalization, and infectious diseases. The way food is produced, distributed, and consumed is entering a period of change. Improvement of nutrition in developing regions can be achieved through cross-disciplinary research activities on the quality of indigenous crops and traditional foods. Currently, technological innovations observed in IoT-related fields and next-generation sequencers have made it possible to comprehensively analyze the functionality and processing characteristics of indigenous crops and traditional foods at the molecular level. In this project, we will clarify the functionality and processing characteristics of indigenous genetic resources (rice, ginger, yam, etc.) and traditional foods (fermented foods, etc.) (Photo 2) in Laos, Myanmar, Nigeria, and Japan with advanced technology for the development of production technologies, breeding materials, and food processing techniques that contribute to solving the global challenges of food and nutrition.

Photo 2. Various native crop genetic resources and traditional foods

Development of environment-friendly management system against transboundary plant pests based on ecological characteristics【Transboundary Pest Management Project】

This project aims to contribute to the stable supply of food and nutrients with low environmental impact, which is the SDGs' target, by contributing to the establishment of an international management system for transboundary plant pests whose damage is expanding. To this end, we will collaborate with organizations including international organizations on efficient and environmentally friendly control technologies against desert locust, rice planthoppers, and fall armyworm (Photo 3), which are global problems. In addition, we will present an economic evaluation model that will guide the development of a comprehensive control technology efficiently when a new transboundary plant pest problem becomes apparent.

Photo 3. Transboundary plant pests causing widespread damage

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

This project will strategically revitalize the tropical fisheries sector by developing and disseminating sustainable aquaculture technologies through an ecosystem approach to the aquaculture industry, and by socio-economic analysis of the community. Furthermore, we aim to contribute to the formation of a healthy community by improving the nutritional status of the residents. To this end, we will revitalize the fishery industry and improve nutrition by continuously developing aquaculture technologies and disseminating them through a community-based approach, based on the management of aquaculture grounds that maintain the ecosystem (Photo 4).

Photo 4. Community-based aquaculture ground management that maintains ecosystem functions

Development of sustainable rice cultivation and food production system in Africa【Africa Rice Farming System Project】

In sub-Saharan Africa, where food security is the most lagging in the world, one in four people suffer from chronic hunger. In order to secure stable food in the region and eradicate hunger as listed in the SDGs, food production technologies that can adapt to the destabilizing cultivation environment and effectively utilize limited resources, such as water and nutrients, are required. In this project, we will create new technologies and knowledge that will lead to increased production of rice, which is the key crop of the region, and improvement of people's nutrition, and aim to build a sustainable food production system centered on rice cultivation (Photo 5).

Photo 5. Construction of a sustainable food production system centered on rice cultivation for Africa

Technology development towards supporting farmers' decision-making to boost sustainable upland farming system in Africa【Africa Upland Farming System Project】

In Africa, small-scale farmers make up the majority of the rural population. To support small-scale farmers and achieve agricultural revitalization, activities that improve agricultural productivity and resilience as well as commercialization are necessary. In particular, in order to activate upland farming, it is essential not only to improve productivity but also to utilize technologies that could lead to balanced profitability and sustainability, such as the introduction of high-value-added crops and soil conservation technologies. In this project, we will develop and promote technologies to improve productivity, profitability, and sustainability of small-scale upland crops and livestock production in a well-balanced manner. In addition, we will contribute to enhancing the small-scale upland farming system in Africa by ensuring farmers' access to the information needed to make the right decision on their best-bet combination of crops and production technologies (Photo 6).

Photo 6. Supporting food and nutrition security for the African people

NAKASHIMA Kazuo
Program Director
Food Program

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

Today, global food systems are exposed to multiple challenges including climate change, transboundary pests and diseases, and pandemics. Risks inherent in imbalances in the demand and supply of globally traded agricultural commodities can be instantly transmitted through global food systems, adversely impacting the economic performance of importing countries and regions, and worsening inequality through the disproportionately affected socio-economically vulnerable groups. Furthermore, the projected acceleration of changes in food demand, both in quantity and quality, with the population growth and urbanization prospects in some developing countries, can bring about disruptive impacts on all stages of global food systems from production, distribution, and consumption. This could potentially threaten global food security if the global communities stay uninformed and unprepared.

It is therefore essential for policy makers to access the latest, systematically compiled information on global food system development and trajectories based on scientific knowledge, so as to participate in opportunities to set global agendas. Similarly, it has become increasingly important for scientists to access the latest information on the challenges and drivers affecting global food systems, in order to identify opportunities for science, technology, and innovation to play a role in providing solutions.

The Information Program aims at collecting, analyzing, and providing strategic and evidence-based information on the challenges affecting the agriculture, forestry, and fisheries sectors and global food systems in increasingly more complicated and multi-faceted societies, and to disseminate this information widely, as an opinion leader, in order to guide and mobilize collective actions to solve global issues. The Program (Fig. 1) consists of the following four research projects.

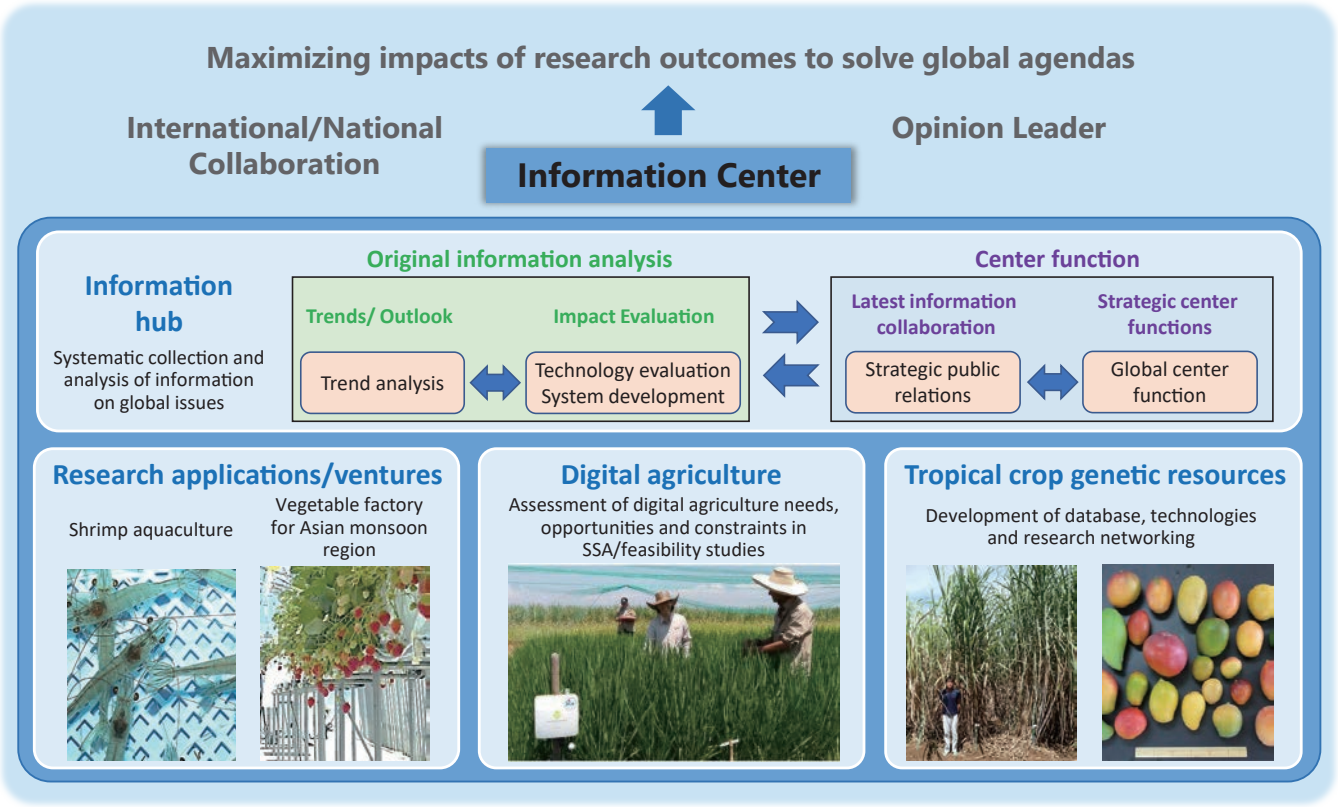


Fig. 1. Outline of the Information Program

Strategic information hub for international agricultural research【Information Hub Project】

In recent years, with the acceleration of the speed at which new developments in science, technology, and innovation are transforming our societies, the readiness of inter-disciplinary collaboration to adopt advanced technologies defines the competitiveness of a country. Information collection and analysis of global megatrends affecting food and nutrition security will play an important role in the transformation of global food systems into a sustainable one for both human and planetary health.

The 'information hub' project is engaged in the systematic collection and analysis of information on new developments in the agriculture, forestry and fisheries sectors, in order to derive recommendations over the role of science, technology, and innovation in the transformation of global food systems (Fig. 2).

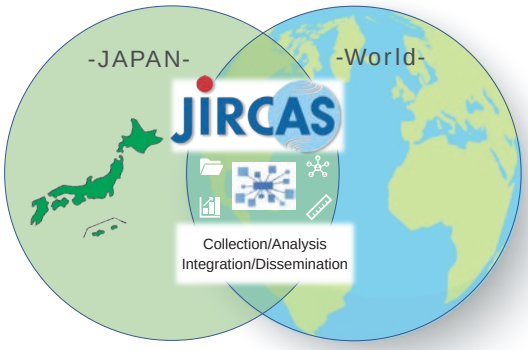


Fig. 2. Global Information Center

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 Project】

Most of JIRCAS's outputs in its 50-plus years of experience conducting research in developing countries have been disseminated through its joint research project counterparts (i.e., national agricultural research institutes and/or government agencies); thus, it was rather rare for the research outputs to be widely scaled out through private sectors/markets.

This project specifically aims at scaling out JIRCAS's research outputs through establishment of a new business model to tailor and optimize technologies to local contexts through collaboration with private sectors in Japan as well as in developing countries.

Towards the development of digital agriculture technologies in Sub-Saharan Africa【Digital Agriculture Project】

These days, there has been an increased expectation for digital agriculture to solve the compounded challenges affecting food security in developing countries, including climate change and agricultural labor constraints, by improving efficiency in resource use. However, the lack of critical information on enabling vs. constraining conditions for the application of digital agriculture in locally specific contexts has hindered the realization of its potentials.

This project collects and analyzes evidence-based information on the opportunities and constraints of the application of digital agriculture in the sub-Saharan Africa region, in order to assess potentials and barriers and subsequently formulate strategies to promote its development.

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

JIRCAS possesses a diverse collection of tropical crop genetic resources, including sugarcane, indica-type (long grain) rice, tropical fruits, and *Brachiaria* (tropical grass for forage). With the increasing threats posed by global climate change, it is imperative to ensure sustainable production of such tropical crops, which can contribute to the stable production of food and biomass crops and promote food diversification and nutrition both in developing countries and in Japan.

This project aims at advancing the management and utilization of diverse tropical crop genetic resources through development of databases, technologies, and research networks with domestic as well as international partners so as to contribute to sustainable production and utilization under adverse agricultural environments in tropical and sub-tropical areas including Japan.

IIYAMA Miyuki
Program Director
Information Program

JIRCAS TODAY

【JIRCAS Research Highlights】

Elucidating the behavior of desert locust survival in the desert — Realization of predicting behavior using a constructed model —

JIRCAS, in collaboration with the Mauritanian National Desert Locust Centre (CNLA), the French Agricultural Research Center for International Development (CIRAD), and the University of Melbourne, has clarified previously unknown behavior of desert locust to survive in harsh desert environments, and used the results to construct a model that can estimate the body temperature and predict the behavior of desert locust.

The body temperature and the surface temperature of the surroundings were measured at various times using a thermal infrared camera for desert locusts that were actively moving in groups. At low temperature, it was clarified that the gregarious nymphs tend to aggregate and bask in the sun to raise the body temperature, whereas at high temperature, they tend to move away from the hot ground surface to regulate the body temperature. When the temperature is low, gregarious nymphs maintain a higher body temperature than the surroundings. It is thought that digestion can be promoted by maintaining about 40°C even when the temperature is high. An investigation of the condition of the feeding pattern showed that the foreguts of the locusts on the move were almost full of food. We therefore assumed that food is digested quickly so the migratory bands tend to starve easily and can efficiently forage and promote growth by using new feeding areas while moving. Furthermore, we constructed a biophysical model of thermoregulatory behavior that incorporates the relationship between the obtained body temperature and activity at a remote site, and confirmed that it is possible to estimate the body temperature and predict the behavior of desert locust using globally available weather information. These results will be useful in predicting the behavior of desert locust and improving the accuracy of locust outbreak prediction.

The results were published in the online version of the journal *Ecological Applications* on April 9, 2021 (Press release date: April 14, 2021).

"More ammonium" in farmlands is key to mitigate nitrogen pollution and boost crop yields

JIRCAS, in collaboration with the School of Public and International Affairs, Princeton University, USA, has proposed "ammonium-based solutions" to reduce nitrogen pollution and improve crop productivity. The "use of ammonium" also infers utilization of biological nitrification inhibition (BNI) and application of synthetic nitrification inhibitors (SNI) in agriculture production, by retaining and utilizing soil-N as ammonium reduces nitrogen leakage while improving crop productivity. Soil-ammonium does not move out of farmlands (unlike nitrate) or cannot produce nitrous oxide (N_2O) (unlike nitrates), the powerful greenhouse gas (which is 310 times more potent than CO_2) emitted from agricultural soils. While SNI is a known technology to control soil-nitrification, JIRCAS has focused on BNI-technology to control soil-nitrifier activity and soil-nitrate levels. JIRCAS has established an International BNI Consortium with 17 organizations and provides leadership in leading and promoting BNI research worldwide. BNI has the potential to overcome the limitations of SNI and to improve the nitrogen use efficiency (NUE) of food production systems by combining BNI-capacity in root systems with an ability to utilize ammonium. The effective utilization of ammonium in the global food production system is expected to be a new solution to reduce nitrogen pollution and increase food production.

This 'opinion' article was published in the *Proceedings of the National Academy of Sciences of the USA*, one of the most prestigious journals in the world (Press release date: June 1, 2021).

JIRCAS TODAY

World's first discovery of a biological nitrification inhibitor in maize roots — First step to reducing nitrogen fertilization application and making the earth healthier

A joint research group led by Drs. OTAKA Junnosuke, Guntur V. Subbarao, and YOSHIHASHI Tadashi of JIRCAS and Dr. ONO Hiroshi of the National Agriculture and Food Research Organization, has succeeded for the first time in identifying a biological nitrification inhibitor (BNI) produced from maize roots.

The results of this research are expected to pave the way for the construction of earth-friendly agricultural production systems that utilize the BNI-producing ability (BNI capacity) of maize. In modern agriculture, large amounts of industrially produced ammonia nitrogen fertilizer are applied to farmlands and converted (nitrified) by soil bacteria, causing various problems caused by nitrogen loss, such as greenhouse gas emissions and water pollution.

JIRCAS aims to reduce nitrogen loss from agricultural lands by utilizing the BNI effect of compounds produced in the roots of crops. The research group conducted a search for BNI compounds from the surface extract of maize roots and succeeded in discovering one new highly active compound, and also identified one highly active compound and two active compounds. The compound with the strongest BNI activity (the ability to suppress nitrification by nitrifying bacteria) was named "zeanone" because it was the first BNI compound to be discovered in nature. The four compounds, including the newly discovered zeanone, were found to have an activity equivalent to 45% of the total BNI activity of maize roots. Enhancing the BNI capacity of maize, the most widely produced field crop in the world, based on the BNI compounds obtained in this study will reduce nitrogen fertilizer loss and environmental pollution, and improve the global nitrogen cycle.

The results of this research were published in the online edition of the scientific journal *Biology and Fertility of Soils* on June 17 (June 18, Japan time) (Press release date: July 29, 2021).

Evaluating the effectiveness of greenhouse gas reduction in the Mekong Delta, Vietnam — Integrated rice and beef production systems reduce GHG emissions by 22% —

JIRCAS, in collaboration with the National Agriculture and Food Research Organization (NARO), the University of Miyazaki, and Can Tho University in Vietnam, has conducted a life-cycle assessment (LCA) to evaluate the effects of reducing greenhouse gas (GHG) emissions, which contribute to global warming, and reducing environmental impact in the rural areas of the Mekong Delta.

In the rural areas of southern Vietnam, it is common to have specialized farming systems in which rice cultivation and beef cattle production are conducted independently. However, these specialized farming systems do not effectively utilize local resources and may have a negative impact on the environment. The research group found that an integrated system that combines paddy rice cultivation and beef cattle production with biogas production can reduce GHG emissions by 22% compared to a specialized system. It was also found that energy consumption could be reduced by 22% through the use of biogas, and that emissions of ammonia and other substances derived from livestock manure that affect the water quality of rivers and other bodies could be reduced by 14%.

In the Asian monsoon region, including Vietnam, as in the Mekong Delta, agriculture, mainly paddy rice cultivation, is an important industry. In recent years, the demand for livestock products such as meat has been increasing in line with economic development, and it is expected that the combined system of rice farming and beef cattle production will be adopted in the Asian monsoon region in the future, thereby contributing to the achievement of GHG reduction targets.

The results of this research have been published in the electronic edition of the *Journal of Environmental Management* on June 8, 2021 (Japan time).

JIRCAS TODAY

【JIRCAS Open House 2021 held online】

JIRCAS organized and held its 2021 Open House online last April 12 to 18 (Mon-Sun), in conjunction with Japan's Science and Technology Week. The annual event, which showcases JIRCAS's various research activities to the general public, was conducted online for the first time this year as a precaution to prevent the spread of coronavirus (COVID-19) infection. A dedicated webpage was set up for the event, featuring audio-visual presentations by research staff plus a special mini-lecture livestreamed via Webex and YouTube on April 17.

JIRCAS expresses its gratitude to the people who took part and watched. For those who missed the event, the presentations may still be viewed on the JIRCAS YouTube channel (https://www.youtube.com/c/JircasGoJp).

【JIRCAS is now on Twitter!】

To coincide with our founding anniversary on June 10, we have created and activated our official Twitter account. Please follow us. Thank you.

@jircas_direct

JIRCAS Mail Magazine (English) Registration Guidance

JIRCAS Mail Magazine, the online quarterly publication of JIRCAS, provides information on the latest topics, events, seminars and workshops, as well as new technologies, research highlights, and guidance publications. To subscribe online, please use the following link. Thank you very much in advance.

https://www.jircas.go.jp/en/public_relations/jircas_mailmagazine

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