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Tunupa Volcano, ascending to an altitude of 5,432m, overlooks the Uyuni Salt Flat and a vast quinoa field in Bolivia. (Photo by Dr. Keisuke Katsura, TUAT)

Special Feature:
JIRCAS and the Science and Technology Research Partnership for Sustainable Development (SATREPS) Program: Addressing Four Challenges

JIRCAS

JAPAN INTERNATIONAL RESEARCH CENTER FOR AGRICULTURAL SCIENCES

In This Issue

JIRCAS Addresses Global Issues through Project Activities under the SATREPS Program

The Japan International Research Center for Agricultural Sciences (JIRCAS), covering almost all fields of the natural and social sciences related to agriculture, forestry and fisheries, conducts research with the aim of solving problems affecting developing countries, e.g., in tropical and subtropical regions, and achieve sustainable development. We carry out joint research projects with international research institutes and research agencies in the target countries, and we are also working to expand research exchanges and cooperation networks, including human resource development.

Now, many problems facing Earth are becoming apparent. These include climate change, environmental degradation, resource depletion, and transboundary infectious diseases and pests, aggravating the already tight food supply-demand situation and pushing over 800 million poor people to the brink of starvation. These issues can have significant impacts on sustainable production especially in developing regions, and can threaten livelihoods and human security. In addition, many of the problems that often occur in developing countries are on a global scale, and their solutions can only be made possible through global cooperation. Therefore, JIRCAS considers global problems as issues to be solved, and conducts research utilizing its expertise through close cooperation with joint research institutes, among others.

Meanwhile, the Japan Science and Technology Agency (JST) and Japan International Cooperation Agency (JICA) have been jointly promoting the Science and Technology Research Partnership for Sustainable Development (SATREPS) Program since 2008. This program consists of joint research projects between Japan and developing countries, and aims to achieve the following: (1) Strengthening international science and technology cooperation between two countries, (2) Acquiring new knowledge and technologies that will lead to solving global-scale issues, improving science and technology standards, and creating innovation, and (3) Capacity development. Social implementation of the research results is planned while working toward goal achievement. These aforementioned goals and schemes of SATREPS are consistent with those of JIRCAS. Therefore, we strategically and proactively apply for SATREPS projects and strongly advance scientific research aimed at solving global issues, making full use of JIRCAS researchers' diverse expertise and experience.

Four SATREPS projects are currently being implemented through JIRCAS, each for a 5-year research period, as follows (Project name [Target country, Year of adoption]): 1) Establishment of the model for fertilizing cultivation promotion using Burkina Faso phosphate rock [Burkina Faso, 2016], 2) Breakthrough in nutrient use efficiency for rice by genetic improvement and fertility sensing techniques in Africa [Madagascar, 2016], 3) Sustainable replantation of oil palm by adding value to oil palm trunk through scientific and technological innovation [Malaysia, 2018], and 4) Strengthening of resilience in arid agro-ecosystems vulnerable to climate change through research on plant resources and technological applications [Bolivia, 2019]. This special feature introduces the efforts being taken on these projects.

YAMASAKI Seishi
Director
Crop, Livestock and Environment Division

(Project Summary: Burkina Faso)

Toward “Local Production for Local Consumption”: Aiming at Production and Distribution of Fertilizers Manufactured from African Indigenous Phosphate Rock

Phosphorus is extremely important in crop cultivation as a major plant nutrient. In 80% of Sub-Saharan Africa (SSA), soil phosphorus deficiency is an obstacle to improving agricultural productivity. Imported commercial fertilizers in SSA are extremely expensive for farmers and the amount of applied fertilizer is not sufficient, which is one of the main reasons for low crop yields. Although phosphate rock (PR) deposits of various sizes exist in many countries of SSA, many of these are so-called low-grade PRs, say, with low phosphorus content, low solubility, and siliceous properties, which is why they are not often utilized in SSA. In Burkina Faso where low-grade PR is abundant (estimated around 100 million tons), JIRCAS started the SATREPS project called “Establishment of the model for fertilizing cultivation promotion using Burkina Faso phosphate rock (2017-2021)” together with the Institute of Environment and Agricultural Research in Burkina Faso (INERA), a reliable research partner for over 10 years, and we are currently implementing collaborative research focusing on the development of low-cost and locally applicable methods to manufacture phosphate fertilizers with local PR as a raw material.

In this project, we have been studying about a technology that enhances P solubility of the PR with application of the calcination method (baking PR powder with auxiliary materials at a temperature of around 1,000°C) and the partial acidulation method (adding acid to PR). To date, the technology for enhancing P solubility using these methods has been essentially established and transferred to counterpart scientists (Photo 1). A demonstration plant for fertilizer production was installed and turned over to INERA Kamboinsé station (Photo 2), and domestic production of phosphate fertilizers has commenced.

We verified the effectiveness of the locally developed phosphate fertilizers in three regions of Burkina Faso with different agricultural environments, and it was revealed that they have almost the same effect as the prevailing imported phosphate fertilizer, although they vary somehow depending on regional conditions. We are also developing the most effective fertilization technologies for these local fertilizers. Going forward, we will study the feasibility of distributing local fertilizers to local farmers in a participatory manner.

Furthermore, we are running studies on other agricultural scenarios wherein raw PR, cheaper but less soluble, can be effectively used. Through this two-pronged approach, i.e., 1) manufacturing soluble phosphate fertilizers from low-grade PR and 2) PR direct utilization, we will propose a comprehensive and efficient utilization plan for PR, which is a valuable natural resource of the country.

Burkina Faso is currently constructing a manufacturing plant that blends all imported raw materials (nitrogen, phosphorus, and potassium) to produce compound fertilizers. If the phosphorus component, which is the highest priced among imported raw materials, could be domestically produced with the technology proposed by the project, it would be possible to provide farmers with cheaper fertilizers than those produced by relying entirely on imports. We believe that it will make a significant contribution in the transition toward intensive agriculture with high productivity in the country.

Moreover, in parallel with the above-mentioned activities in Burkina Faso, we are collecting and analyzing PRs in other deposits throughout the African continent with the cooperation of researchers in each country. We hope that this development strategy (which we call the “Burkina Model”) of utilizing indigenous PR resources will be adopted by other African countries in the near future through new collaborations, leading to the diffusion of domestic phosphate fertilizer production and PR direct utilization technology, and consequently turning our dream of an “African Fertilizer Revolution” into reality.

NAGUMO Fujio
Crop, Livestock and Environment Division

Photo 1. Dr. Jacques Sawadogo (center), counterpart researcher at INERA in Burkina Faso, during his visit to Japan to learn how to operate a phosphate fertilizer production plant by calcination (December 2018)

Photo 2. Turnover ceremony for the demonstration plant (October 2019, INERA Kamboinsé Station). Commemorative photo taken in front of the newly prepared fertilizer production room.

(Project Output:Burkina Faso)

Toward Expansion of Fertilized Cultivation using a New Fertilizer Composed of Burkina Faso Phosphate Rock

In Burkina Faso, crops are grown chiefly without fertilizers, and this is one of the major factors underlying limited agricultural productivity. To expand fertilized cultivation, it is necessary to understand the current fertilizer distribution across the country along with related policies, and to investigate farmers' access to fertilizer and their capacity to scale up its application.

We interviewed farmers who currently use commercially available chemical fertilizers to trace their distribution channels. It was found that the availability of cheap, government-subsidized fertilizers is limited and that the private sector plays a major role in fertilizer supply in Burkina Faso. At this moment, there are no fertilizer manufacturing plants, but only fertilizer blending factories in this country, so 100% of chemical fertilizers are being imported. However, non-licensed or non-authorized importers aligned with regular routes may provide uninspected fertilizers at import/wholesale stage. This is why we find poor-quality fertilizers occasionally in the market, with pebbles as in Photo 1 for a typical case. To solve these problems, the Government of Burkina Faso has been enforcing regulations on fertilizer distribution and strengthening inspections, but these measures are not yet fully implemented due to budget constraints. Therefore, domestic production of chemical fertilizers is needed to advance as soon as possible to improve quality and affordability for local farmers.

Actually in the field, the shortage of alternative organic fertilizers also prevents the expansion of fertilized cultivation. Around Saria town, one of our project sites in the Central-West Region, some farmers apply dried animal dung and manure, but these are applied only to about 1/5 of the total cultivated land due mainly to limited quantity and transportation means. In this area, about 1/3 of farmers still cannot purchase chemical fertilizers, and although the remaining farmers purchase them, the average amount is only about 50 kg per year, covering only about 1/4 of the total cultivated land. If the price of chemical fertilizers declines by about 20%, farmers who currently cannot afford them are willing to buy, while those who are already using them are willing to increase purchase. Therefore, the development of a new, less expensive fertilizer could lead farmers to use more chemical fertilizers and expand fertilized cultivation in Burkina Faso.

Currently, we are conducting data collection through participatory appraisal on farmers (Photo 2) and analyzing them to examine the effects of reducing fertilizer prices on farmer's income. In addition, we will demonstrate the effect of newly developed chemical fertilizers in on-farm experiments and show its advantages over conventional fertilizing techniques, which will allow farmers to understand the practical benefits of the novel fertilizers. Based on the results of the experiments, the optimal cropping system will be proposed to farmers to maximize the effect of the new fertilizers. Promotion of fertilized cultivation may subsequently help transform the current crop cultivation system from extensive, low-yielding agriculture to an intensive, high-yielding one.

KOIDE Junji and KOBAYASHI Shintaro
Social Sciences Division

Photo 1. Stone-mixed chemical fertilizer purchased by a farmer

Photo 2. Data collection (Interview with farmers)

(Project Summary: Madagascar)

Contributing to Food Security in Madagascar by Developing a Rice Cultivation Technology that Improves Nutrient Use Efficiency

Rice is the most important crop in Madagascar. Per capita rice consumption in the country exceeds 100 kg per year, more than double that of Japan. According to estimates, more than 60% of the population are rice farmers; however, rice productivity has remained stagnant, hindering food security and poverty reduction for the majority of the populations in rural areas. As a result, Madagascar is one of the world's poorest countries, with 77% of its population living on less than $1.90 a day. To overcome this situation, Madagascar is working on various policies, and one of its most important national strategies is to achieve rice self-sufficiency by 2023.

Factors that impede rice productivity in Africa include the limited capacity of poor farmers to purchase fertilizers and soils that are characteristically highly weathered and nutrient-poor. Therefore, JIRCAS, in collaboration with the Ministry of Agriculture, Livestock and Fisheries and other research institutes in Madagascar, started the project “Breakthrough in Nutrient Use Efficiency for Rice by Genetic Improvement and Fertility Sensing Techniques in Africa” under the framework of SATREPS (Science and Technology Research Partnership for Sustainable Development). The project is commonly known as the FY VARY Project and aims for the development of technologies that can improve rice productivity in a stable manner even with low nutrients from fertilizers and soils (Photo 1).

This project involves not only researchers in technological development on soil science, remote sensing, breeding, crop management and molecular biology, but also experts in agricultural economics and psychology. This is because the project also aims to evaluate the impact of increased rice productivity on farmers’ income and nutrition, the interest among farmers in adopting the new technology, and the network between farmers to which the technologies are transmitted. In addition, we are striving to develop technologies in line with local needs and the environment by promoting activities centered on experiments and surveys on farm fields, and by holding farmers’ meetings to reflect the opinions of farmers. Although experiments and surveys in rural areas of developing countries have various difficulties, we believe that these efforts will lead to the smooth transfer of the developed technologies to the beneficiaries, which in turn will lead to an impact on the local community.

As a recent research highlight, we issued a press release regarding the results of phosphorus-dipping treatment on improving fertilizer use efficiency and rice yield in Madagascar (see p.13). This technology involves dipping the roots of rice seedlings for about 30 minutes in a mud-like mixture (slurry) of phosphorus fertilizer and paddy soil, and is easy to practice even for small-scale farmers. On-farm field trials in Madagascar showed that rice yield can be significantly improved with less fertilizer. In addition, the number of days from transplanting to maturity is shortened, thereby avoiding low-temperature stress during reproductive growth stage (Photo 2). This achievement has been widely covered by the local media in Madagascar, and increased the interest among farmers, government agencies, fertilizer companies, etc. In the future, we would like to promote activities for disseminating the technology while strengthening cooperation with these parties.

TSUJIMOTO Yasuhiro
Crop, Livestock and Environment Division

Photo 1. Conducting selection trials to develop new high-yielding varieties even under nutrient-deficient conditions

Photo 2. A rice farmer dipping rice seedlings in P-enriched slurry

(Project Output: Madagascar)

SATREPS Madagascar Output 4: Elucidation of Factors Affecting the Dissemination of Rice Cultivation Technology and Impact Evaluation

To disseminate the technology that we have researched and developed, it is crucial that the actual farm management and livelihood conditions as well as technical requirements are understood. In addition, farmers' comprehension of the logic of technology and confirmation of its merits stimulate a sense of ownership, resulting in sustainable adoption after the completion of the project.

Output 4 of SATREPS Madagascar studies the impacts of technology on socio-economic development, with the aim of providing an effective and efficient diffusion strategy for the technologies developed in Outputs 1-3. By conducting an interview survey with farmers, we capture the current situation and clarify the factors that influence technology selection. To advance practical diffusion strategies, psychological factors on adoption motivation are examined. Also, to propose evidence-based policy recommendations, we estimate the impacts of technology on income and nutrition improvements quantitatively.

In Vakinakaratra region in the central highlands of Madagascar, which is the target area, we have been conducting a household survey for 600 randomized farmers (Photo). The survey includes questionnaires regarding basic household information, farm production, consumption, income, land, and technology. To capture the seasonal changes, we repeat the survey on the same household three times a year: immediately after rice harvest, in the lean season, and in the middle of the season.

As the potential for paddy field expansion is limited, upland rice cultivation has been increasing since around 2000. In addition, various kinds of vegetables have been grown for a long time, taking advantage of the cool climate. Diversification of farm production to lowland rice, upland rice, and vegetables contributes to the seasonal stability of food supply, income growth, and nutrition improvement. We also found that the farmers selectively apply chemical fertilizers to crops that have a high response.

A dietary survey revealed the nutritional imbalance due to the rice-based diet, with a marked deficiency in micronutrients such as calcium and vitamin A. We found seasonal differences in dietary diversity, which shows significant reduction during lean season. As for the preferences of rice producers and consumers, productivity is particularly important for producers, whereas various qualities such as taste (sweetness, etc.), appearance (color, shape, etc.), and ease of cooking are valued by consumers.

We also conduct surveys on participant farmers of a development assistance project, concerning farmer-to-farmer information flow and motivation for project participation. There are two types of voluntary information transmission among farmers: "close neighbors/relatives" in which information is exchanged continuously with relatives and acquaintances, and "remote unknown people" in which a resource person teaches outside his residence. These two types of communication are expected to have complementary functions. Psychological research suggests that the extension officers who have frequent contact with farmers and are highly evaluated for their teaching skills are supportive of farmers' psychological needs, thus promoting active project participation.

We plan to implement a social experiment on fertilizer management examining farmers' responses to the provision of information on soil fertility, in order to investigate the effects of increased rice production on diet and nutritional improvement, and to elucidate extension support methods that facilitate intrinsic motivation.

YOKOYAMA Shigeki, Research Planning and Partnership Division

SHIRATORI Sakiko, Research Strategy Office

Photo. Conducting household surveys to grasp current income levels and nutrition status in the target area

(Project Summary: Malaysia)

Sustainable Land Management Technologies in Oil Palm Plantations and the Future of the Palm Oil Industry

Palm oil extracted from palm fruits is the most consumed vegetable oil in the world and is used as a raw material for producing cooking oil, margarine, and shortening. It accounts for about 30% of total vegetable oil production of 200 million tons. Demand for palm oil is expanding rapidly with the economic growth of developing countries. In Indonesia and Malaysia, where 80% of the world's palm oil is produced, approximately 3.6 million ha of tropical rainforest have been converted to oil palm plantations over the past 20 years, and there are substantial concerns about their impacts on the natural environment and ecosystems (Photo 1).

Oil palms are replanted when they reach an economical age (25-30 years after planting). In Indonesia and Malaysia, approximately 63 million oil palm trunks (OPTs) are felled annually (Photo 2), and reforestation is carried out in approximately 440,000 ha per year. Not only OPTs but also oil palm fronds (OPFs) and empty fruit bunches are discarded from palm oil mills. The plantation is like a waste dump for biomass, leading to the failure of replantation due to the spread of pests. It also has a significant impact on the environment, causing not only groundwater and river pollution (due to excess fertilizers that were added to compensate for poor growth caused by palm diseases) but also greenhouse gas emissions (due to the decomposition of OPTs and OPFs). New plantations need to be established to compensate for the failure of replantation, even as tropical forests are being cut down and disappearing at an alarming rate. In order to break this vicious cycle, it is necessary to develop OPT applications, take OPTs and OPFs out of the plantation, and promote recycling at the plantation.

JIRCAS has developed a technological system that enables efficient production of renewable energy and chemical materials from OPT through field surveys and research on OPT at a palm plantation in Malaysia. The development of OPT utilization technologies forms incentives for OPT utilization, creates new industries, and promotes sustainable management of palm plantations. In 2018, we started the SATREPS project titled "Sustainable Replantation of Oil Palm by Adding Value to Oil Palm Trunk through Scientific and Technological Innovation." In this project, we are developing activities for dissemination and social implementation through the development of an OPT high sugar content technology, a technology for manufacturing high value-added products from OPT, and sustainable land use and regeneration methods by replanting. To continue using palm oil, the palm oil industry must prioritize sustainability. Through the SATREPS project, we hope to implement sustainable oil palm plantation management and contribute toward achieving a sustainable palm oil industry.

KOSUGI Akihiko
Biological Resources and Post-harvest Division

Photo 1. Oil palm plantation

Photo 2. Felling of OPT

(Project Output: Malaysia)

Development of High Value-adding Technologies for Oil Palm Trunk and its Social Implementation

The SATREPS Oil Palm Trunk (OPT) Project aims to develop OPT utilization and high value-added technologies in 2018 through collaboration between Japanese and Malaysian industry-government-academia. In 2014, JIRCAS began field surveys and research on biomass at palm plantations in Southeast Asia. We discovered that OPT sap contains a lot of free sugars such as glucose and that the sugar content rises when stored for a certain period. The juice contained in OPT is a useful resource for biofuels and biochemical materials such as ethanol and plastic. However, the sugar content of juice obtained from felled OPT was not constant, and it was necessary to elucidate the factors contributing to fluctuations in sugar concentration. We carried out monitoring for three and a half years at an oil palm plantation in the northern part of Malaysia (Photo 1), focusing on the relationship between OPT starch and free sugars, palm bunch, temperature, and precipitation. As a result, we found that there is a strong relationship between the accumulated rainfall and the amount of OPT free sugar and starch, and that the increase in the amount of free sugars and starch in OPT depends on the increase in accumulated rainfall. This suggests that OPT with high sugar content can be harvested by cutting down the tree around the period when accumulated rainfall increases from October to December.

We are also advancing the commercialization of OPT fuel pellets with IHI Co., Ltd., a member of the SATREPS project, from the pilot plant in Johor, Malaysia (Photo 2). The juice of OPT contains a lot of ash (calcium and potassium), which causes combustion problems such as agglomeration inside the furnace. For it to be classified as a high-quality fuel material, a manufacturing process that reduces ash is required. Hence, we developed a powerless juice extraction system in which the OPT chip is soaked in water, and the ash component and sugar are extracted 100% without power by utilizing the osmotic pressure difference between water and juice. The OPT fuel pellets made by this process have the same quality and ash content as the wood pellets. Moreover, it is possible to supply all the electric power and drying energy required for pellet production because methane gas can be generated from the extracted juice. The OPT pellets produced by the process are expected to expand as a clean energy source. Based on these technologies, the project is currently developing new value-added products such as liquid fertilizers from phosphorus and potassium recovered from sap, algae (as a protein source), and biodegradable plastics. We aim to solve various environmental problems caused by oil palm plantations through development of a comprehensive process to utilize OPT while creating new industries.

KOSUGI Akihiko
Biological Resources and Post-harvest Division

Photo 1. Monitoring survey at the oil palm plantation

Photo 2. Demonstration/ Pilot plant for OPT commercialization (Johor, Malaysia)

(Project Summary: Bolivia)

Strengthening of Resilience in Arid Agro-ecosystems Vulnerable to Climate Change through Research on Plant Resources and Technological Applications

Quinoa, a pseudocereal crop that originated in the Andes of South America, is becoming popular among health-conscious people worldwide due to its exceptionally nutritious properties (Photo 1). The United Nations has recognized quinoa as an important crop with the potential to contribute to food and nutrition security worldwide due to its high nutrient value and great tolerance to a wide range of abiotic stresses such as drought and high salinity (International Year of Quinoa, 2013). Although quinoa is grown mostly in Bolivia and Peru, its cultivation has expanded to more than 95 countries in recent years.

Our SATREPS project entitled "Strengthening of resilience in arid agro-ecosystems vulnerable to climate change through research on plant resources and technological applications" was adopted by the Japan Science and Technology Agency (JST) and the Japan International Cooperation Agency (JICA) after meeting the required conditions. Our purpose is to develop and promote technologies that enhance resilience for sustainable management of the quinoa-based Bolivian Altiplano agro-ecosystems, and our goal is to strengthen the resilience and sustainability of Bolivian Altiplano agro-ecosystems. Our project, whose members are scientists from Japan and Bolivia (Photo 2), consists of 4 outputs as follows:

1. Genetic resources are collected, consolidated, and conserved for genome-based breeding. 1-1. The genetic and phenotypic diversities of quinoa lines and its wild relatives are evaluated. 1-2. A database of quinoa and its wild relatives is constructed based on phenotype and genotype information. 1-3. Nested Association Mapping (NAM) population is established for accelerating the identification of genes involved in enhanced resilience in the quinoa-based agro-ecosystems. 1-4. The long-term seed storage system for quinoa, its wild relatives, and NAM population is developed.

2. Breeding lines for enhanced resilience and early ripening are developed. 2-1. Early-ripening quinoa lines are developed. 2-2. DNA markers for breeding to enhance resilience in quinoa production are developed. 2-3. Useful genes are identified, and their functions related to enhanced resilience in quinoa production are elucidated.

3. Technology for sustainable management of agro-ecosystems based on quinoa is developed. 3-1. Cultivation techniques to enhance sustainability of agroecosystems and quinoa production are developed in the model sites. 3-2. Bioactive compounds of at least two native plants are identified to increase the value of Altiplano agro-ecosystems. 3-3. New eco-friendly fertilizers and new biopesticides to improve quinoa production are identified. 3-4. Integrated quinoa-llama system is improved at the model site. 3-5. Average quinoa yield is raised on the experimental fields in the target area.

4. Extension network system is established in Bolivian Altiplano. 4-1. The Altiplano Agro-ecosystem Information Platform (AAIP), including a social network system (SNS), workshops, and demonstration fields, is developed to improve access to information technologies. 4-2. Farmers of the Altiplano access the agro-ecologic technologies developed in the project through AAIP.

FUJITA Yasunari
Biological Resources and Post-harvest Division

Photo 1. A dish of boiled quinoa and llama meat served at a hotel near Uyuni Salt Flat in Bolivia

Photo 2. SATREPS project members enjoying their meal at the Universidad Mayor de San Andrés (UMSA) in La Paz, Bolivia

(Project Output: Bolivia)

SATREPS Bolivia Output 2: Development of Breeding Lines for Enhanced Resilience and Early Ripening

The area of Altiplano in south Bolivia, the target site of our SATREPS project, is exposed to harsh environments associated with extreme climate conditions that bring strong winds and cause high soil salinity and long-term droughts. Quinoa, which has been cultivated for more than 7,500 years in the Andes region, is one of those rare crops that can grow in this area, and the locals have relied on cultivating quinoa and raising llamas as their main sources of income. Recently, however, the basis of their livelihood is being threatened by the reduction in quinoa yield owing to soil erosion due to agricultural land expansion and drought due to climate change. Back in the 16th century, quinoa was worshipped and considered the sacred “mother grain” of the Incas, thus the Spanish conquerors forbade its cultivation. Quinoa consequently remained as a neglected crop in South America for about 500 years until the 20th century, which explains why the studies on improved breeding methods to stabilize quinoa yield did not progress, even though it has high environmental adaptability and great potential to be a major global crop.

Based on our research knowledge and technology about molecular analysis of plant environmental stress using model plants and crops including soybean and rice, JIRCAS will develop quinoa breeding lines suitable for their needs in Bolivia. In addition, we will clarify the molecular mechanism that enables quinoa to adapt to severe environment and climate conditions. We will seek answers as to why quinoa can grow under drought and high salinity conditions, like at areas around Uyuni Salt Flat where annual rainfall is about 200 mm (Photo 1). We believe that unraveling these mysteries through plant science would enable us to develop more productive and useful crop varieties that are required to enhance global food security.

So far, in collaboration with universities, research institutes, and private companies, JIRCAS has succeeded in deciphering the complete genome of quinoa for the first time in the world, which should help accelerate studies and efforts to breed improved varieties of quinoa. We have also constructed the free-access Quinoa Genome DataBase (QGDB; http://quinoa.kazusa.or.jp), which is essential for advancing quinoa studies. Based on the database, we are proceeding with the development of early-ripening quinoa lines that are in high demand locally (Photo 2). In addition, we will develop DNA markers for efficiency and to accelerate breeding of quinoa. At our target site in Uyuni, Bolivia, the impact of drought at the early growth stage of quinoa during the cultivation season has intensified. The early-ripening quinoa lines, which enable reseeding after drought damage, would contribute to yield stability in the area. Furthermore, we are screening and observing the variation among quinoa lines in order to detect tolerance to environmental stresses such as droughts, high salinity, low temperatures, and diseases. Using the characterized quinoa lines, we will also identify the key genes involved in the phenotype to understand the molecular mechanisms of stress tolerance. Our study would enable us to develop not only more productive and useful varieties of quinoa but also other crops.

NAGATOSHI Yukari
Biological Resources and Post-harvest Division

Photo 1. Quinoa cultivation near Uyuni Salt Flat in Bolivia

Photo 2. Quinoa is grown in a temperature-controlled chamber at JIRCAS.

Central Soil Salinity Research Institute

Although India is attracting attention for its rapid economic growth, many people are still suffering from poverty. A large part of India is exposed to dry climate conditions, resulting to the wide distribution of saline soils. In addition, excessive irrigation and fertilization have accelerated salt accumulation in the soil. Many crops cannot grow well in fields where soils accumulate high concentrations of salt. To address these challenges, the Indian government established the Central Soil Salinity Research Institute (CSSRI) in 1969 in Karnal, Haryana state, 125 km from the Indian capital of New Delhi (Photo 1). CSSRI has developed many saline- and alkaline-tolerant varieties of crops such as rice, wheat, and mustard. The institute also successfully developed methods to improve sodic soils (alkali soils) through addition of chemical amendments, and to improve saline soils through subsurface drainage.

JIRCAS signed a Memorandum of Understanding (MoU) for research cooperation with the Indian Council of Agricultural Research (ICAR) in February 2018, and thereafter started collaborative research with CSSRI and the Indian Agricultural Research Institute. Both institutes are under the umbrella of ICAR. CSSRI organized an international conference in February 2019 in commemoration of its 50th anniversary, with JIRCAS President IWANAGA Masa in attendance to give a congratulatory speech at the opening session for CSSRI's great achievements. Dr. Iwanaga and Dr. Suresh K. Chaudhari, assistant director general of ICAR, also took the opportunity to present the MoU at the conference. The research cooperation is written in the fact sheet that was summarized at the Japan-India Summit Meeting in October 2018.

JIRCAS and CSSRI are currently trying to develop low-cost techniques to remove salt from saline soil. The "Cutsoiler" machine, which was developed in Japan, was introduced to India for the first time (Photo 2). The "Cutsoiler" cuts a ditch down to 40–60 cm below the ground surface. At the same time, it collects crop residues scattered on the ground surface and puts them into the ditch that works as a subsurface drainage. Compared to the subsurface drainage systems that CSSRI had developed for public infrastructure, "Cutsoiler" can construct shallower and smaller drainages at a smaller cost per unit area, which makes it affordable for individual farmers to introduce in their farmlands. CSSRI is trying to standardize this technique as a low-cost desalination method for individual farms by the end of June 2021. Moreover, collaborators are trying to develop more efficient irrigation methods as well as low-cost and labor-saving techniques to monitor salt movement in soil by using sensors.

Although JIRCAS's research collaboration with Indian institutes has only a short history, we expect it to expand and deepen, and hopefully lead to the development of sustainable and resilient food production systems that contribute to improving the lives of people in India and other countries.

WATANABE Takeshi
Tropical Agricultural Research Front

Photo 1. The main building of CSSRI

Photo 2. The "Cutsoiler" machine

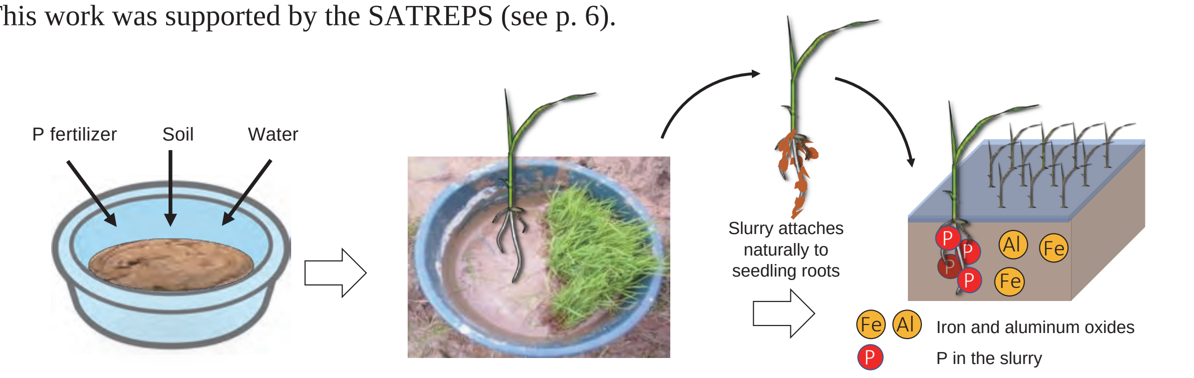
【Research Highlight】

Phosphorus-dipping treatment of rice seedlings increases yield and avoids cold damage —Towards stable rice production in Africa with minimal fertilizer input—

A joint research collaboration of JIRCAS and the National Center for Applied Research on Rural Development (FOFIFA) of Madagascar has shown that phosphorus-dipping treatment of seedlings, so-called "P-dipping," can significantly improve the fertilizer use efficiency and yield of rice. In this technology, the rice seedlings are dipped in a mud-like mixture of phosphorus fertilizer and paddy soil before transplanting. On-farm field trials in Madagascar have clarified that the P-dipping shortened days from transplanting to maturity and avoided cold stress during the reproductive stage. In addition, the P-dipping also increased the yield by 9%~35% as compared to the conventional method of fertilizer broadcasting. In Sub-Saharan Africa including Madagascar, the productivity of rice is severely limited due to the poor supply of nutrients such as phosphorus, and the unstable production environment due to water shortage and low temperature and high temperature stresses during the growing season. The dissemination of this technology is expected to contribute to stable rice production in the Sub-Saharan region, and to further enhance food security.

The results of this research were published online in *Field Crops Research*, an international scientific journal, on 24 April 2020.

This work was supported by the SATREPS (see p. 6).

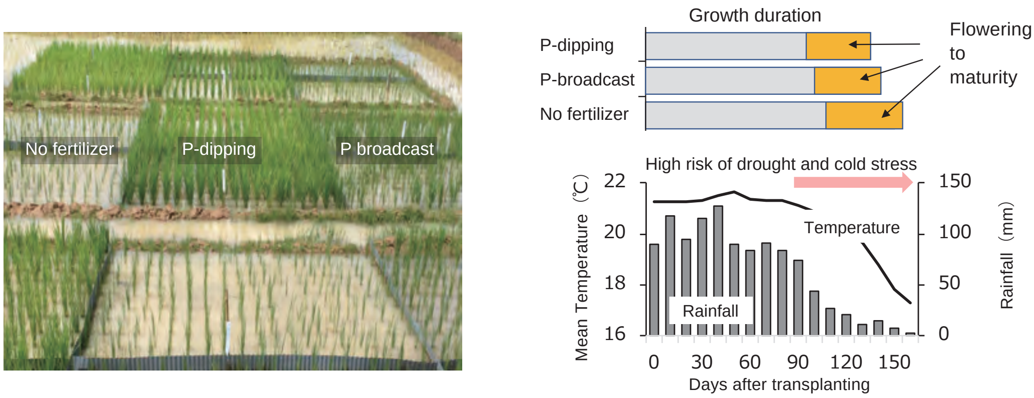


1. Preparation of P-enriched slurry
P concentration = 1.3~2.3%

2. Dipping of rice seedlings
Less than 4h of dipping duration to avoid chemical injury

3. Transplanting
Positioning of P close tp the roots facilitates efficient uptake even in high P-fixing soils with abundant iron and aluminum oxides.

Fig. 1. Phosphorus-dipping treatment of seedlings (P-dipping)



1. P-dipping enhances fertilizer use efficiency in P-deficient fields resulting in increased grain yield.

2. P-dipping shortens the growth period avoiding environmental stress in later growth stages.
*Mean temperature and rainfall for transplanting in mid December based on the average weather data in Antananarivo in 1981-2010

Fig. 2. Effects of P-dipping

【Announcement】

JIRCAS Commemorates its 50th Founding Anniversary

The Japan International Research Center for Agricultural Sciences (JIRCAS), which was first established as the Tropical Agriculture Research Center (TARC) in 1970, celebrates its 50th anniversary this year.

Throughout its 50 years of existence, JIRCAS has been a front-runner in Japan in carrying out international collaborative research in agriculture, forestry, fisheries, and related industries in developing regions.

The global community is currently facing huge challenges, including climate crisis, the rapid spread of transboundary pests such as desert locust and fall armyworm, and zoonotic disease transmission due to environmental degradation. These problems are evolving too fast, becoming increasingly too complex, and affecting too many dimensions of our planet as well as our lives.

JIRCAS will deal with the above challenges, while also keeping an eye on emerging global issues, by taking advantage of its strength based on its 50-year research experience. At the same time, in order to achieve the United Nations' Sustainable Development Goals (SDGs), JIRCAS will keep looking for an even more effective, impact-oriented mode of international research collaboration. Smart tools will be adopted while working with cross-disciplinary teams, and technologies will be developed/disseminated/scaled-up swiftly and widely while strengthening ties with implementing partners.

To celebrate the 50th founding anniversary of JIRCAS, a specially designed commemorative logo has been created to be used throughout 2020. The logo is designed to symbolize a better future for our planet, with the two-colored circles (representing Earth at sunrise) symbolizing hope for the future of JIRCAS. In addition, the SDG color wheel icon is used as the number zero to show our commitment to contribute in achieving the SDGs.

Japan International Research Center for Agricultural Sciences 50th 1970-2020

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.
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Information and Public Relations Office
1-1 Ohwashi, Tsukuba, Ibaraki 305-8686, JAPAN
Phone: +81-29-838-6313 Fax: +81-29-838-6316 https://www.jircas.go.jp/
https://www.jircas.go.jp