Contents of the Project Completion Report

I. Basic Information of the Project

1. Country

Republic of Madagascar

2. Title of the Project

Project for Breakthrough in Nutrient Use Efficiency for Rice by Genetic Improvement and Fertility Sensing Techniques in Africa (SATREPS)

3. Duration of the Project (Planned and Actual)

Planned: May 16, 2017 to May 15, 2022

Actual: May 16, 2017 to Sep 30, 2022

*The Project period was extended to complete all the activities under the circumstance of COVID-19.

4. Background (from Record of Discussions(R/D))

Agriculture, including fishery and forestry, is a mainstay of the economy that accounts for 23% of GDP and employ 70% of the labor force in Madagascar. In the agricultural sector, rice cultivation is important not only as production of the staple food of the nationals but also as the major occupation or income resource in the rural livelihoods. However, the rapid population increase has out-speeded the increase of domestic rice production. As a result, import of rice has been currently inevitable to meet the domestic demands. The stagnant rice productivity risks the national food security and deprives the poor farmers in rural areas of chances to improve their livelihoods. This situation has prevented the country of escaping from poverty, where nearly 80% of people still live on less than 1.25 USD per day.

In the country, 70% of the rice cropping area is categorized as “irrigated” and mostly managed by smallholder farmers. Irrespective of the relatively favorable water conditions, the average yield level has been stagnated at less than 3t/ha level. The restricted yield is primarily due to inadequate fertilizer application and poor nutrient supplying capacity of the highly weathered soils, e.g. Ferralsols that prevails particularly in the central to eastern part of the island, corresponding to the major rice-producing areas. Previous studies indicate that various nutrient deficiencies such as phosphorus, nitrogen, sulfur, and silicate restrict the rice productivity. However, few appropriate soil and fertilizer management practices have been developed for the rice cultivation in these nutrient deficient conditions. In addition, the capacity for rice breeding to date has been weak to develop any promising varieties that can increase rice yields adapting to the local environments.

The effective and further utilization of fertilizer resources including domestic products is highly expected to contribute to the improvement of rice productivity as well as the development of varieties suitable to low fertility conditions in Madagascar.

Given these circumstances in the agricultural sector, development of varieties and efficient soil and fertilizer management techniques in rice production under the low-input and low–fertility soil conditions, is a key challenge to improve the rice productivity in Madagascar.

In addition, the capacity building in rice research is needed to continuously improve the rice production and rural development of the country. The development of these techniques and associated capacity building will contribute not only to Madagascar but also to the other regions of Africa where rice productivity is largely restricted by the low-input and low-fertility soil conditions.

1) Agricultural development policy in Madagascar

The National Development Plan (PND, 2015-2019) highlighted the importance of the development of the agricultural sector, in particular the sustainable growth of rice production. Provisions for improving rice productivity under the National Rice Development Strategy (NRDS) and the Coalition for African Rice Development (CARD) include the development of the seed sector and the effective use of fertilizer with strengthening the interactions between research and extension to ensure the widespread dissemination of agricultural technologies and knowledge.

2) Japanese Aid policy for the agricultural sector in Madagascar

Based on the agricultural sector development policy of Madagascar described in Chapter I, paragraph (1) above, Japan is increasing its support to the agricultural sector, in particular for the development of rice culture. The Japanese Fund for Policy and Human Resources Development, established jointly by Japan and the World Bank, began technical support for the promotion of rice culture using irrigation infrastructure and seeds production. In addition, a new JICA Technical Cooperation project entitled "Project for Rice Productivity Improvement and

Management of Watersheds and Irrigated Areas (PAPRIZ Phase 2) (2015-2020)", aimed to the extension of rice culture started. The Project with the objective of research for development should be articulated with these ongoing supporting projects for the overall development of the rice sector of Madagascar.

5. Overall Goal and Project Purpose (from Record of Discussions(R/D))

Overall Goal

Developed techniques are used by farmers in the target area.

Project Purpose

Rice production techniques to improve nutrient use efficiency under low-input and low-fertility soil conditions for dissemination are developed.

6. Implementing Agency

Madagascar

Ministry of the Agriculture and Livestock (MINAE), National Center of Applied Research and Rural Development (FOFIFA), Radioisotopes Laboratory of University of Antananarivo (LRI), and National Nutrition Office (ONN)

Japan

Japan International Research Center for Agricultural Sciences (JIRCAS), Kyoto University (Kyoto U, ~March 2020)*, Kochi University (Kochi U, Apr 2020~)*, The University of Tokyo (Tokyo U), Yamashi Eiwa Univ. (Yamanishi U)

*The implementing agency was changed due to the transfer of participating researcher.

II. Results of the Project

1. Results of the Project

1-1 Input by the Japanese side (Planned and Actual)

Dispatch of Experts

Planed

Long-term expert: One (1) long-term expert will be dispatched as the Project Coordinator who shall be responsible for day-to-day operation of the Project activities in collaboration with the Malagasy counterparts.

Short-term experts: Short-term experts will be dispatched for collaborative research and technology transfer several times a year during the Project period.

Actual

One long-term expert as the Project Coordinator was consistently dispatched to

Madagascar from Aug2017 to Sep2022 except the period of evacuation due to the COVID-19 pandemic from Apr2020 to Jan2021. Short-term experts in each output group were frequently and consistently dispatched except the trip-restricted periods from Mar2020 to Sep2021 and from Jan2022 to Mar2022 due to the COVID-19 pandemic. Short-term experts were dispatched in total of 118 times with the duration of 2,806 days throughout the Project period (See details in the below table and Annex1).

Table 1. The short-term experts in the number (days) of dispatchment

	Output1	Output2	Output3	Output4	All
2017	2 (36)	6 (171)	4 (153)	6 (75)	18 (341)
2018	5 (112)	15 (323)	10 (289)	10 (177)	40 (775)
2019	5 (99)	10 (248)	10 (307)	7 (99)	32 (717)
2020	0 (0)	5 (56)	2 (48)	3 (76)	10 (131)
2021	1 (33)	3 (95)	4 (122)	0 (0)	8 (250)
2022	1 (24)	3 (90)	4 (121)	2 (52)	10 (235)
Total	14 (304)	42 (983)	34 (1040)	28 (479)	118 (2806)

Training

Planed

JICA will provide the Malagasy counterparts with necessary trainings in Japan or in third countries.

Actual

For the enhancement of research partnership and capacity development, malagasy researchers including 2 output leaders were invited to Japan in total of 23 times and 910 days consistently except the period of Oct2019 to Jun2022 due to the COVID-19 pandemic (See the Table2 below). Through the trainings, scientific and technical knowledge in the area of respective outputs: Soil analysis and remote sensing (Output1); Crossing, phenotyping and genetics (Output2); Crop physiology and fertility management (Outptu3); Socioeconomy and nutrition (Output4) were transferred to Malagasy researchers. Apart from these trainings, the Project dispatched a total of 9 Malagasy researchers to the JICA training Program of "Development of Core Agricultural Researcher for Promotion of Rice Production in Sub-Saharan Africa". In addition, a total of 3 Malagasy researchers received the JST-MEXT (1) and JICA Agri-Net (2) scholarship programs and have been implementing the Ph.D. studies in Japan as of today.
(See the list of training in the Annex1 and the reports in the Annex6)

Table 2. The short-term trainings in the number (days) of trips to Japan

	Output1	Output2	Output3	Output4	All
2017	2 (80)	1 (42)	0 (0)	1 (11)	4 (122)
2018	2 (40)	2 (118)	4 (239)	0 (0)	8 (397)
2019	2 (45)	1 (40)	2 (80)	2 (24)	7 (189)
2020	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
2021	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
2022	0 (0)	3 (144)	1 (47)	0 (0)	4 (191)
Total	6 (165)	7 (344)	7 (366)	3 (35)	23 (910)

Machinery and Equipment

Planed

JICA will provide such machinery, equipment and other materials including those for Molecular Biology Laboratories in FOFIFA and laboratories in LRI, (hereinafter referred to as “the Equipment”) necessary for the implementation of the Project.

Actual

For the enhancement of research capacity in the Malagasy side, necessary research equipment/facility and the technical skill were provided for each output group or counterpart institutes to promote the respective objectives throughout the Project. In summary, Output1 has improved to implement remote-sensing and soil analysis. Output2 has improved to implement crossing and genetic analysis for rice breeding. Output3 has improved to implement field monitoring and crop growth analysis. Output4 has improved to implement socioeconomic survey and analysis. The inauguration ceremony for the genetic analysis laboratory and crossing greenhouse for rice breeding developed at FOFIFA and remote sensing and soil analysis facilities developed at LRI were implemented in May 2019 in the presence of Minister of MINAE.

(See the list of equipment in the Annex1 and the media disclosure on the inauguration ceremony and use of facilities in the Annex7).

Necessary recurrent cost

Planed

Both parties upon mutual consultations will share running expenses necessary for the implementation of the Project such as consumables for laboratory analysis and field experiments.

Actual

For the implementation of the Project, a total of 2,494,511,011 Ar (414,238,998 Ar in

2017FY, 478,048,513 Ar in 2018FY, 427,902,525 Ar in 2019FY, 430,112,531 Ar in 2020FY, 505,898,578 Ar in 2021FY and 238,309,867 Ar in 2022FY) was provided for the running costs including transportation, consumables, maintenance of project cars, employment of technicians and administrative staff etc.
*FY indicates the fiscal year of Japan, i.e. from April to March

1-2 Input by the Madagascar side (Planned and Actual)

Counterpart personnel and technical and administrative staff members

Planed

The MPAE (MINAE), FOFIFA, LRI, and ONN will take necessary measures at its own expenses for the assignment of counterpart personnel as follows:

MPAE (MINAE)

(a) Assignment of Project Director (PD)

PD will be responsible for the overall administration and implementation of the Project.

(b) Assignment of the Project Manager (PM)

PM will be responsible for operation of the Project activities.

(c) Assignment of the Technical (Project) Coordinator (TC)

PC will assist the Project Manager and JICA Experts in managerial and technical matters for smooth operation of the Project.

(d) Assignment of the counterpart personnel in Analamanga and Vakinankaratra Regions

FOFIFA

(a) Assignment of the TC

(b) Assignment of the Output Leaders

Output Leaders from FOFIFA will be responsible for the implementation of the designated outputs of Output 2, 3 and 4 on PDM.

(c) Assignment of the counterpart personnel

LRI

(a) Assignment of the TC

(b) Assignment of the Output Leader

Output Leaders from LRI will be responsible for the implementation of the designated outputs of Output 1 on PDM.

(c) Assignment of the counterpart personnel

ONN

(a) Assignment of the TC

(b) Assignment of the counterpart personnel Both parties upon mutual consultations will share running expenses necessary for the implementation of the Project such as consumables for laboratory analysis and field experiments.

Actual

The Madagascar side consistently assigned and allocated necessary amounts of human resources together with PD, PM, TC, and Output leaders for the smooth operation and coordination throughout the Project. The assigned members were yearly confirmed at JCC. We have changed the PD, PM, and TC for several times due to the personal shift within the Ministry and Output2 and Output3 leaders one time due to their retirements. However, little operational difficulties or confusions occurred because the aims and issues of the Project had been shared and taken over at the institutional level. It should be noted that the Madagascar side enhanced the human resources in particular the extension officers to promote the pilot-scale test and dissemination of P-dipping technique at the latter stage of the Project and at the absence of Japanese experts during the COVID-19 safety measure. In addition, FOFIFA and LRI consistently provided the drivers for the Project cars.

(See the list of counterpart personnel with their efforts to the Project confirmed at the 5th JCC on Oct12, 2021 in the Annex1).

<u>Facilities necessary for the implementation of the Project (laboratories, experimental fields, project offices, greenhouses etc.)</u>

Planed

The MPAE (MINAE), FOFIFA, LRI, and ONN will take necessary measures at its own expenses for the provision of:

-suitable office and meeting spaces with necessary equipment

-suitable laboratories, glasshouses and experimental fields

-machinery, equipment, instruments, vehicles, tools, spare parts and any other materials necessary for the implementation of the Project other than the equipment provided by JICA.

Actual

The Madagascar side consistently provided necessary administrative and laboratory facilities as well as vehicles for the smooth operation of the Project. The facilities to be provided were yearly confirmed at JCC. The facilities that were confirmed at the 5th JCC on Oct12, 2021, is shown in the below Table 3.

Table 3. Key admin/lab facilities provided by the Madagascar side

	MINAE	FOFIFA	LRI

Research Facility/Equipment	Glasshouse, driver, vehicles, extension officers (DRAE-Vakinankaratra)	1 driver, car parking, PHRD lab and technicians (Ampandriniomby), Molecular biology lab and greenhouse (Ambatobe)	1 driver, technicians, Soil analysis lab, greenhouse, NC analyzer room, dark room for Hyperspectral sensor (FieldSpec)
Offices/room	1 project office (DRAE)	1 Project office; 1 Output2 sub office, 1 storage room (Ambatobe); Output4 sub office (Tsimbazaza); Output3 sub-office, Oven room, Motor-bike parking (FOFIFA-Antsirabe)	Output1&3 sub-office, storage room, meeting room
Field	-	Tsararano-station (off-season evaluation and seed multiplication).	-

<u>Other financial and operational inputs</u>

Planed

The MPAE (MINAE), FOFIFA, LRI, and ONN will take necessary measures at its own expenses for the provision of available data and information related to the Project and necessary recurrent cost including the customs clearance and taxation for the installed equipment and counterpart fund for the smooth operation of the Project.

Actual

The Madagascar side had consistently taken necessary measures and secured the counterpart funds for the tax exemption of the provided equipment, for the trips of counterpart researchers, and for the utility costs to run the laboratories and other facilities. The budget plan for the counterpart funds were annually confirmed at JCC. In summary, a total of 155,878,745 Ar (2,556,000 Ar in 2018, 52,828,678 Ar in 2019, 100,494,067 Ar in 2020) was provided as counterpart funds for the Project from Jan 2018 to Dec 2020 plus the utility expenses of the laboratories and other facilities (data is unknown). Necessary documentations were consistently issued by the Madagascar side to facilitate the operations of the UAV (e.g., drone), implementation of the soil sampling and socioeconomic surveys (interviews to farmers and anthropometric measurements) in the target regions, field trips during the COVID-19 movement restrictions, custom clearance for the equipment installation, and others. In addition, MINAE had taken an initiative via the activities of SOC and DRAE for the dissemination of the P-dipping technique and registration of new varieties.

Two issues in this section 1.2 should be noted for the improvement of the collaborative operation:

- Although the customs clearance and tax exemption on the installed equipment were properly handled by the MINAE, internal procedure within the Ministry and between the Ministry and Customs sometimes took months to be clueared, during which the warehousing costs were increased and incurred to the Project.
- While the per diam of Malagasy counterparts were financially and annually secured by the MINAE, its execution procedure required a number of documents and took months which deprived the daily and smooth operation of the Project.

1-3 Activities (Planned and Actual)

Planed

See the Plan of Operation (PO) and PDM attached to the RD.

Actual

The activities were operated based on the Plan of Operation (PO) which was reviewed annually at JCC. The major changes from the Planned activities were that the dispatchment of long-term and short-term experts of the Japan side was suspended during the period of COVID-19 safety measure and that the Project period was extended for 4 months to recover the delay of activities caused by the pandemic. Apart from these changes and minor alterations of members and merges of sub-activities, there were no major changes, and all the Planned activities were completed accordingly (See the PO of monitoring sheet ver.8 in the Annex5).

Specific changes from the PO ver.0 that were approved in each JCC were:

1st JCC meeting

- Two researchers, Dr. Nobuo Sayanagi (Yamanashi Eiwa U) and Dr. Ralandison Tsilavo (Kyoto U) both for Output4 were added as Japanese experts.
- Sub-activity 1.2.2 and 1.2.3 shall be combined for the simplification.
- Sub-activity 1.2.5 and 1.2.6 shall be combined for the simplification.

2nd JCC meeting

- A new research member, Dr. Tomohiro Nishigaki (JIRCAS) joined Output1 group with a specific subject for the characterization of P-deficient soils and improvement of P use efficiency for rice.

3rd JCC meeting

- No specific PO changes occurred.

4th JCC meeting

- "1.4.3 To simplify the nutrient omission trials in pots with farmers' participation to enhance the knowledge on the nutrient deficiency of their rice fields" shall be deleted because 1. Results in pot experiments did not perfectly reflect the fertilizer responses in farmers' fields; 2. We have identified appropriate soil analytical indicator to assess response of rice to P fertilizer in field scale.
- "3.4.4 To incorporate several genetic resources in the activity of 3.3.4" shall be combined with 3.4.3. because these activities are closely interrelated.

5th JCC meeting

- No specific PO changes occurred.

2. Achievements of the Project

2-1 Outputs and indicators

(Target values and actual values achieved at completion)

Output1: Evaluation techniques and geographical maps of field nutrient fertility characteristics are developed.

Objectively Verifiable Indicators for the Output1

- *1-1. Soil and spectral analytical methods that are applicable to the rice fields in the target area are established.*

➔ **Achieved 120%**: A total of 11 peer-reviewed papers and 1 review article were published related to prediction for carbon, phosphorus, nitrogen and other properties of soils. In particular, the detection of relevant wavelength to the available phosphorus (oxalate-extractable P) contents of soils and development of prediction model for P deficiency across lowlands and various agroecosystems is a novel and practical achievement of this activity. The number of methodologies developed exceeded the plan.

- *1-2. Inter-field scale maps for the fertilizer application are developed.*

➔ **Achieved 90%**: Based on the survey on a total of 699 lowland fields using unmanned aerial vehicle (UAV) and interview to farmers, geographical parameters and farmers management practices that affect spatial differences in total carbon contents and available P contents in soils were identified. With these parameters, spatial maps of total carbon contents and available P contents in soils were developed at the resolution of 10 m (controllable) in the target sites. However, the prediction accuracy of the model was relatively low and not applicable for farmers' soil management practices because the study found that these spatial differences were affected by various unknown factors.

- *1-3. The developed evaluation methods are transferred to at least 20% of extension service in the target regions of Madagascar.*

➔ **Achieved 100%**: From the products of 1-1, three most practical soil evaluation methods were selected and compiled as technical manuals for "Quick assessment of bioavailable P in soils: Method and algorithm with FieldSpec", "Estimation of rice response to P fertilizer application using soil P retention capacity", and "Estimating soil organic matter content by visual assessment of soil color". On-site demonstration and workshop was held to hand over these techniques to the beneficiaries, namely agricultural extension officers in the target regions, research technicians of agricultural research institutions, and farmers. The manuals were made openly available at the LRI website.

Output2: Breeding materials to improve grain yield and nutrient use efficiency under low-input and low-fertility soil conditions are developed.

Objectively Verifiable Indicators for the Output2

- *2-1. At least two breeding lines to improve nutrient acquisition capacity and utilization efficiency by 20% relative to the conventional varieties in the target area (or recurrent parents) are developed.*

➔ **Achieved 120%**: A total of 8 breeding lines derived from the crossing populations between IR64 and DJ123 and the Pup1 locus introgression lines with the background of IR64 were selected as promising lines that showed consistently high yields than the local high-yielding variety X265 and recurrent parent IR64 under poor nutrient lowlands in the target region. Further, with the multiple year-site production tests and tasting tests supervised by SOC, two varieties (FyVary32 and FyVary85) were officially released as new lowland rice varieties in Madagascar on Nov4, 2021. FyVary85 showed on average >20% greater grain yields than X265 and IR64 under low fertilizer input and low-yielding lowlands. The stage of selection exceeded the indicator.

- *2-2. At least two DNA markers for QTLs related to nutrient acquisition capacity and utilization efficiency of rice are developed.*

➔ **Achieved 100%**: >300 varieties with a range of genetic diversity and genetic or single nucleotide polymorphism (SNP) data were imported from the gene bank of International Rice Research Institute (IRRI). Based on the multi-site-year trials of these >300 varieties on poor nutrient fields in Japan and in Madagascar, 3 new donors, i.e., AZ-97, GP1103, and GP91 and 2 new QTLs (*qLFT5* and *qLFT11*) were identified that can be used for breeding in the target environment. Relevant DNA markers to distinguish these donors and X265 were also developed. Further, development of breeding populations and initial field evaluations were started by crossing these donors and X265.

- *2-3. At least two genes and their mechanisms related to nutrient acquisition capacity and utilization efficiency of rice are identified.*

➔ **Achieved 80%**: On-farm trials using near isogenic line with the QTL of MP3 and controlled chamber trials using the gene-edited mutant lines indicated that use of *MP3* candidate gene may increase rice yields under tillering-restricted and phosphorus deficient lowlands. The target gene was cloned and the functional mechanism to control tillering of rice was identified. However, gene closing and identification of functional mechanism of the QTL (*PUE1*, *PUE11*) conferring to phosphorus use efficiency of rice were not achieved. The by-products of this activity include genetic transformation protocols for the major Malagasy varieties (X265 and Nerica4) and complete DNA sequencing of DJ123. These by-products can be used for gene identifications and advanced breeding for improving the performance of rice under poor nutrient environments.

Output3: Fertilizer management techniques using genetic resources for nutrient-efficient rice production are developed.

Objectively Verifiable Indicators for the Output3

- *Fertilizer management practices that improve nutrient use efficiency by 20 % are developed.*

➔ **Achieved 120%**: On-farm trails and pot experiments identified that P-dipping efficiently increase rice yields with minimal fertilizer inputs on P-deficient lowlands as well as cold-stress and flood-stress prone environments. The P-dipping is a simple manipulation to dip rice seedlings into muddy soils added with a small amount of phosphorus fertilizer, whereby the seedling roots are coated with the P-enriched slurry and transplanted in the main field. Further, the pilot-scale test in >300 farmers identified that P-dipping achieved on average 100% greater fertilizer use efficiency (yield gain per unit of fertilizer input) than conventional phosphorus application via broadcasting under farmers' management practices in the region of Vakinankaratra. The study also identified that the efficiency of farmyard manure (FYM) for lowland rice production is increased by >100% with the consecutive and selective application to P-deficient fields compared to the uniform application. The effectiveness of this new FYM management was confirmed by 40 farmers' participatory trials. The efficiency of developed technologies and the stage of implementation exceeded the indicator.

- *3-2. At least two varieties that show high performance responding to the field nutrient conditions are selected.*

➔ **Achieved 100%**: Two varieties/lines were identified to have superior performance under P-deficiency (AZ-97 and NIL-*MP3*). The aboveground morphological traits of AZ-97 and NIL-*MP3* to have superior performance under P-deficiency were characterized. In adding, the pot experiment using near-isogenic lines differing in root cone angle indicated that the combination of P-dipping and shallow-root genotype or NIL-qsor1 had a positive interaction for rice growth and P uptakes. The findings were all published in peer-reviewed papers.

- *3-3. The developed fertilizer management techniques are transferred to at least 20% of extension service in the target regions of Madagascar.*

➔ **Achieved 120%**: The manuals of P-dipping technique and effective FYM application were developed. Further, a small-dose fertilizer package for the P-dipping technique was produced in collaboration with a local fertilizer company. Using the manual and fertilizer package, the technique was transferred to extension officers and >3,000 farmers not only in the target regions but also other regions in the central highlands in collaboration with JICA technical cooperation Project or Papriz. The technical transfer scale exceeded the indicator.

Output 4: A policy recommendation is compiled to promote the extension of developed techniques for rice production in the target area.

Objectively Verifiable Indicators for the Output4

- *Socioeconomic factors for the dissemination of fertilizer management techniques and varieties in the target area are identified.*

➔ **Achieved 90%**: The randomized-controlled trials identified that the provision of soil nutrient information or P deficiency and expected effectiveness of nitrogen application can help farmers to use more urea fertilizer and gain more rice yields. The semi-structured interviews and group discussion on the farmer-to-farmers technology dissemination or cascade scheme of Papriz found that two complemental types of farmers—informal leaders who are influential in a small neighbor group and outgoing transmitters to outside communities—play pivotal roles for increasing dissemination efficiency beyond the initial farmer-trainer and that inefficient farmer-trainers are characterized by poor understanding of the training program and techniques and weak relationships with the official extension officers. Based on the finding, we proposed that quality assurance of farmer training and follow-up support of the agent ensures the efficacy of the cascade model. However, the number of samples and repetition as well publications were too weak to make this proposition into action because of the activity restrictions by the COVID-19 pandemic confirmation. As a by-product, the activity developed a more suitable scale for psychometrics in the target region.

- *The effect of improved rice cultivation techniques on household income and human nutrition are quantified based on 500 or more household survey in the target area.*

➔ **Achieved 100%**: A panel data across 3 seasons by 4 years on socioeconomic status, agricultural technologies and productions, and anthropometric & nutrition status were developed for randomly selected 596 lowland rice farmers in 60 villages in the region of Vakinankaratra. The analysis of panel data revealed the following findings: 1. The adoption of upland rice cultivation increases household income; 2. Higher lowland rice yields improves human nutrition status via the increased intakes of energy, zinc, iron, and vitamin A; 3. Market-oriented vegetable production increases household income and dietary diversity; 4. Cropping diversity positively correlates dietary diversity, and the dietary diversity improves children's weight-for-height Z (wasting) score.

- *The policy recommendation is reflected in the implementation plan to promote the extension of developed techniques or knowledge in the target area.*

➔ **Achieved 90%**: The policy recommendations were summarized based on the obtained results (See the Annex 2). In addition, the obtained knowledge on the relationship between agricultural production and human nutrition status are adopted to and taken into action of the JICA technical cooperation Project for the food and nutrition or PASAN.

2-2 Project Purpose and indicators

(Target values and actual values achieved at completion)

Project purpose: Rice production techniques to improve nutrient use efficiency under low-input and low-fertility soil conditions for dissemination are developed.

Objectively Verifiable Indicators for the Project purpose

- *Developed breeding materials and fertilizer management practices based on field nutrient characteristics are appreciated by 50% of rice farmers that participate in adoption trials in the target area.*

➔ **Achieved 100%**: Interviews to farmers in the pilot-scale test and dissemination activities of P-dipping identified that >80% of farmers found the technique easy-to-practice and had a willingness to continue. Two rice varieties were officially released by passing the farmers' participatory production and tasting tests.

- *User manuals of developed techniques and recommendation for the extension policies are compiled.*

➔ **Achieved 100%**: The manuals for soil evaluation methods, P-dipping, effective FYM application, variety catalogues, and policy recommendations were developed and compiled in the Annex 2. The manuals and catalogues were made openly available at LRI and FOFIFA websites.

- *Over 25 research articles including 5 top-authored ones by the Malagasy researchers related to the project outputs are published.*

➔ **Achieved 120%**: A total of 40 peer-reviewed papers including 12 malagasy top-authored ones were published. The number of achievements were far above the target indicator.

- *Developed fertilizer management practice(s) are tested >500 farmers' fields, and the factors of farmers' adoption and effect under farmers' management practices are identified.*

➔ **Achieved 120%**: The P-dipping technique was distributed to >3,000 farmers in 5 regions of the central highlands of Madagascar. The trials identified that the technique was effective even under farmers' management practices and the effectiveness is particularly high in P-deficient and low-yielding fields as well as cold-stress and flood-stress prone environments. The number of farmers and regions of dissemination were far above the target indicator.

Overall goal: Developed techniques are used by farmers in the target area.

Objectively Verifiable Indicators for the Overall goal

- *Developed breeding materials and/or fertilizer management practices are used by 500 or more farmers in the target area.*

➔ **Achieved**: The target was already achieved as described in the achievement of Project purpose.

- *Developed breeding materials are officially released as varieties in Madagascar.*

➔ **Achieved**: The target was already achieved as described in the achievement of Project purpose.

3. History of PDM Modification

The targets of each objectively verifiable index (OVI) were quantified in the 1st JCC meeting. In the 4th JCC meeting, one more OVI for the Project purpose was added (upward revision) by which the Project received extra budget allocation from JICA to ensure the wide-scale dissemination of developed technology or P-dipping because the development of effective fertilizer management technique in the Output 3 was achieved much earlier than planned. The specific changes from the PDM v1 (at RD signing) that were approved in each JCC were:

1st JCC meeting

- Alaotra-Mangoro region was added to the Target area. The revised Target areas are Vakinankaratra Region, Analamanga Region, and Alaotra-Mangoro Region.
- Yamanshi Eiwa University, Dr. Nobuo SAYANAGI, was added in the Implementing Agencies (Japan) for Output4.
- Objectively verifiable indicators were specified.

2nd JCC meeting

- No specific PDM changes occurred.

3rd JCC meeting

- No specific PDM changes occurred.

4th JCC meeting

- One OVI (Objectively verifiable indicators) for the Project purpose "Developed fertilizer management practice(s) are tested >500 farmers' fields, and the factors of farmers' adoption and effect under farmers' management practices are identified" was added to ensure the wide-scale dissemination of developed technology.

5th JCC meeting

- The wording of the OVI 4.3. was modified by adding 'or knowledge' as "The policy recommendation is reflected in the implementation plan to promote the extension of developed techniques or knowledge in the target area.

(See all the PDM versions in the Annex 3)

4. Others

4-1 Results of Environmental and Social Considerations (if applicable)

Not applicable.

4-2 Results of Considerations on Gender/Peace Building/Poverty Reduction (if applicable)

Not applicable.

III. Results of Joint Review

1. Results of Review based on DAC Evaluation Criteria

2. Key Factors Affecting Implementation and Outcomes

3. Evaluation on the results of the Project Risk Management

4. Lessons Learnt

IV. For the Achievement of Overall Goals after the Project Completion

1. Prospects to achieve Overall Goal

Overall goal: Developed techniques are used by farmers in the target area.

Objectively Verifiable Indicators for the Overall goal

- *Developed breeding materials and/or fertilizer management practices are used by 500 or more farmers in the target area.*
- *Developed breeding materials are officially released as varieties in Madagascar.*

As described in the section **2. Achievements of the Project**, both indicators were already achieved. For sustainable scale-outs and impacts of the achievements, the following strategies and recommendations can be raised.

2. Plan of Operation and Implementation Structure of the Madagascar side to achieve Overall Goal

- MINAE will try necessary measures as listed below for the dissemination of P-dipping technique and new varieties FyVary32 and FyVary85.

  For the P-dipping technique

  Based on the experiences in the 2021-2022 campaign and those learned from the PAPRIZ activities, the following 6 points shall be considered in 2022-2023 campaign:

  1) Approach by irrigated perimeters (IP): Three (3) IPs per District will be selected per year and preferably IPs outside the PAPRIZ intervention; in the choice of PI, it is necessary to consider the success criteria P-dipping technique (result of evaluation of the 2020/2021 campaign in Vakinankaratra) and prioritized PIs where producers have low fertilizer use.
  2) Selection of lead farmers (LF): The lead farmers (in the same way as the PFs of Papriz) will be selected in each IP: 30 LF per IP. They will benefit free TSP and training. Then, they are expected to share the training with farmers in the surrounding area. Type of training and support to promote: collect of data base (general information of farmers practice), operating account training, general training in the P-dipping technique, assisted training in transplanting, monitoring at flowering time, harvesting (with yield survey), etc.
  3) Enhancement of extension workers: Continue to work with extension technicians by district. DRAE agents can carry out this task. Also, select support technicians

at the regional level to ensure the coordination of activities.

4) Installation of rice emergence site based on the P-dipping technique (SMER FYVARY): In contribution to the objective of MINAE, SMER is an effective strategy in terms of agricultural extension. In this sense, an action and support package will be made: use of FYVARY variety seeds (depending on pedoclimatic conditions), P-dipping sac and manual, modern agricultural equipment, etc. The site will be under the direct supervision of the DRAE.
5) Provision of TSP input (P-dipping sac) dealers at the District/Commune level + Provide General training on the P-dipping technique to sellers: Only Lead farmers will have free P-dipping sac (for the first year). Thus, it is necessary that the TSPs be available at the level of the local resellers so that the surrounding farmers can also get the sac and thus copy the technique. This will also ensure the sustainability of the use of the technique by farmers. Surveys have already been undertaken in Vakinankaratra to assess the possibility of this extension method through input dealers.
6) Strengthening Communication: Visual support will have to be developed such as tarpaulin, banner, T-shirt, documentary film, radio/TV program, technical sheet, etc. the stronger the communications, the more the technique will attract the interest of the farmers.

<u>For the new rice varieties</u>

In order to promote these new seeds, three strategies can be raised:

1) Collaborate with GPS (Group of seed producers) and PMS (Seed producer and multiplier). Seeds can only be widely disseminated if local PMS and GPS are interested in its production. This will ensure the permanent availability of seeds. For Vakinanakaratra, 1 PMS in Antsirabe I and 1 GPS in Ankazomiriotra have expressed their interest in producing FYVARY seeds for this next campaign; however, this will depend on the availability of basic seed at FOFIFA.
2) In addition to P-dipping, install SMERs (Rice Emergence Site with FYVARY seed)

- ONN in collaboration with PASAN plans to unitize the evidenced information about the positive relationship between rice yield and human nutrition intake in their activities.
- FOFIFA will continuously allocate researchers manpower to enhance the activities using the developed breeding labs and greenhouse in the topics of (i) extraction of DNA of plant or soil, (ii) selection activity using SSR marker, (iii) using continuously green house for breeding or other activities/tests. A system of cost sharing principles

shall be put in place beside the consumables required for each activity being conducted.

- FOFIFA will ensure continuous training of young researchers in collaboration with Ministries, international research partners such as JIRCAS, CIRAD, AfricaRice as well as international development agencies such as JICA, FAO, etc.
- FOFIFA rice breeding program with the allocation of breeders shall be put in place in collaboration with national or international partners such as JIRCAS, CIRAD, AfricaRice or IRRI via Excellence in breeding platform.
- FOFIFA will contribute to the certified seed production by continuously producing high-quality foundation seeds of new varieties developed by the project: e.g FOFIFA Kianjasoa have already produced basic seeds of the 2 new varieties this season 2021-22 and by this coming season 2022-23, FOFIFA DRR will start to produce also the basic seeds of the new varieties.
- FOFIFA will closely work with SOC/MINAE to ensure high quality foundation seed production.
- LRI shall organize annually 1 training session on the evaluation techniques developed in the project following DRAE or NGO's request.
- LRI shall develop short movies for each developed soil evaluation techniques and share them on LRI, MINAE websites or SNSs.
- LRI and MINAE shall include the developed soil evaluation techniques in the training courses of schools for rural/agricultural development technicians or agents, decision makers, students, professionals.

3. Recommendations for the Madagascar side

- Both MINAE and MeSUPRES should continue the research capacity enhancement including budget allocation and recruitment of young researchers for agricultural development.
- FOFIFA should strengthen the capacity for retaining breeder seeds and providing high-quality foundation seeds of developed new varieties in collaboration with Papriz to attract more seed producers and the quantity of certified seed production.
- FOFIFA should implement the adaptation tests of new varieties in other rice-producing regions to extend the recommendation areas in collaboration with Papriz, JIRCAS, and other research or development aid agencies.
- MINAE should strengthen the institutional partnerships to facilitate the delivery of certified seeds to farmers.
- In addition to the activities within the Papriz project, MINAE should strengthen the

extension activities and institutional partnerships in particular with private fertilizer companies to scale-out the dissemination of P-dipping technique.

- ONN in collaboration with PASAN can use the evidenced information about the positive relationship between rice yield and human nutrition intake in their activities.
- LRI should strengthen the partnership to implement the developed soil evaluation techniques for improving farmers' fertilizer management practices and their rice yields.

4. Monitoring Plan from the end of the Project to Ex-post Evaluation

Not applicable.

(If the Project will be continuously monitored by JICA after the completion of the Project, mention the plan of post-monitoring here.)

ANNEX 1: Results of the Project

(List of Dispatched Experts, List of Counterparts, List of Trainings, List of equipment)

ANNEX 2: List of Products (Peer-reviewed papers, manuals, variety catalogues, policy recommendation etc.) Produced by the Project

ANNEX 3: PDM (All versions of PDM)

ANNEX 4: Short-term training reports

ANNEX 5: Media Coverage

Annex1. Results of the Project

1.1.List of dispatched experts

Name	Affiliation	Output and research area	Start date	End date	Duration (days)
Yasuhiro Tsujimoto	JIRCAS	Project leader, Output3: Crop and fertility management	2016/9/18	2016/10/1	14
			2017/9/11	2017/10/7	27
			2017/11/26	2017/12/24	29
			2018/2/12	2018/3/12	29
			2018/4/21	2018/5/18	28
			2018/6/25	2018/7/6	12
			2018/9/13	2018/9/28	16
			2018/11/12	2018/11/17	6
			2018/11/26	2018/12/23	28
			2019/2/11	2019/2/28	18
			2019/4/20	2019/5/24	35
			2019/7/6	2019/7/13	8
			2019/8/31	2019/9/11	12
			2019/11/21	2019/12/22	32
			2020/2/15	2020/2/29	15
			2021/9/12	2021/10/16	35
			2021/11/21	2021/12/17	27
			2022/4/15	2022/5/22	38
			2022/8/26	2022/9/15	21
Naoki MORITSUKA	Kochi University	Output1 leader: evaluation techniques and nutrient characteristics	2017/9/11	2017/9/25	15
Tomohiro Nishigaki	JIRCAS	Output1: evaluation techniques and nutrient characteristics	2017/11/25	2017/12/15	21

			2018/2/2	2018/3/7	34
			2018/9/14	2018/10/10	27
			2018/12/7	2018/12/26	20
			2019/2/9	2019/2/24	16
			2019/4/10	2019/5/8	29
			2019/11/9	2019/12/5	27
			2021/11/12	2021/12/14	33
			2022/4/15	2022/5/8	24
Kensuke KAWAMURA	JIRCAS	Output1: evaluation techniques and nutrient characteristics	2018/2/19	2018/3/3	13
			2019/2/16	2019/2/28	13
			2019/11/23	2019/12/6	14
Kenta Ikazaki	JIRCAS	Output1: evaluation techniques and nutrient characteristics	2018/9/13	2018/9/30	18
Matthias Wissuwa	JIRCAS	Output2 leader: Breeding and plant nutrition	2017/9/29	2017/10/8	10
			2018/2/19	2018/3/9	19
			2018/4/11	2018/4/27	17
			2018/12/3	2018/12/16	14
			2018/12/21	2018/12/23	3
			2019/4/9	2019/4/19	11
			2019/9/2	2019/9/27	26
			2019/12/7	2019/12/16	10
			2020/2/28	2020/3/9	11
			2021/10/3	2021/11/6	35
			2022/4/8	2022/5/12	35
Pariaska Juan TANAKA	JIRCAS	Output2: Breeding and plant nutrition	2017/5/15	2017/6/16	33
			2017/10/31	2017/11/28	29

			2018/3/21	2018/4/26	37
			2018/10/15	2018/11/21	38
			2019/5/6	2019/6/14	40
			2019/10/28	2019/12/6	40
			2021/11/19	2021/12/17	29
			2022/4/22	2022/5/22	31
Katsuhiko Kondo	JIRCAS	Output2: Breeding and plant nutrition	2017/12/4	2017/12/24	21
			2018/4/16	2018/5/20	35
			2018/11/26	2018/12/23	28
			2019/4/15	2019/5/18	34
Toshiyuki TAKAI	JIRCAS	Output2: Breeding and plant nutrition	2018/2/19	2018/3/3	13
			2018/4/21	2018/5/13	23
			2018/9/17	2018/10/1	15
			2018/11/19	2018/12/8	20
			2019/2/11	2019/3/3	23
			2019/4/6	2019/4/17	12
			2019/4/29	2019/5/15	17
			2019/11/11	2019/12/15	35
			2020/2/22	2020/3/15	22
			2021/11/14	2021/12/14	31
			2022/4/22	2022/5/15	24
Takuma ISHIZAKI	JIRCAS	Output2: Breeding and plant nutrition	2018/2/19	2018/3/1	11
			2020/2/22	2020/2/28	7
Kyonoshin MARUYAMA	JIRCAS	Output2: Breeding and plant nutrition	2018/2/19	2018/2/28	10
			2020/2/22	2020/2/28	7
Yusaku Uga	NARO	Output2: Breeding and plant nutrition	2020/2/22	2020/2/28	9
James Douglas Morrison	University of Tokyo (JST)	Output2: Breeding and plant nutrition	2017/4/17	2017/5/31	45

King					
	(JST)		2017/11/17	2017/12/19	33
	(JST)		2018/5/7	2018/6/15	40
Hidetoshi ASAI	JIRCAS	Output3: Crop and fertility management	2018/4/9	2018/5/4	26
			2018/11/7	2018/12/11	35
			2019/2/16	2019/2/28	41
			2019/4/13	2019/5/12	30
			2019/11/18	2019/12/18	31
			2021/11/14	2021/12/14	31
			2022/4/15	2022/5/8	24
Aung Zaw Oo	JIRCAS	Output3: Crop and fertility management	2019/4/20	2019/6/2	44
			2019/10/28	2019/12/22	56
			2020/2/1	2020/3/4	33
			2021/11/19	2021/12/17	29
			2022/4/15	2022/5/22	38
Atsuko Tanaka	JIRCAS	Output3: Crop and fertility management	2017/8/1	2017/9/1	32
			2017/10/23	2017/12/26	65
			2018/1/17	2018/3/29	72
			2018/4/11	2018/5/17	37
Shigeki Yokoyama	JIRCAS	Output4 leader: Impact analysis	2017/8/23	2017/9/6	15
			2017/9/30	2017/10/7	8
			2018/2/17	2018/2/27	11
			2018/8/22	2018/9/4	13
			2019/3/11	2019/3/23	13
			2020/11/30	2020/12/15	16
Nobuo SAYANAGI	Yamanashi Eiwa University	Output4 : Impact analysis	2018/2/16	2018/3/3	16
			2018/8/22	2018/9/4	14
			2019/2/25	2019/3/11	15
			2019/8/24	2019/9/5	13

			2020/2/27	2020/3/8	11
Sakiko SHIRATORI	JIRCAS	Output4 : Impact analysis	2017/8/6	2017/8/15	10
			2018/6/2	2018/6/9	8
			2019/12/7	2019/12/13	7
			2022/6/24	2022/716	23
Ralandison Tsilavo	Kyoto University	Output4 : Impact analysis	2017/7/29	2017/8/13	16
Takeshi SAKURAI	University of Tokyo	Output4 : Impact analysis	2017/11/19	2017/11/28	10
			2018/6/4	2018/6/20	17
			2018/12/12	2018/12/23	12
			2019/9/7	2019/9/21	15
Ryosuke Ozaki	University of Tokyo (JST)	Output4 : Impact analysis	2017/7/29	2017/8/13	16
	(JST)		2018/1/17	2018/3/14	57
	(JST)		2018/6/4	2018/6/20	17
	(JST)		2018/12/12	2018/12/23	12
	(JST)		2019/5/13	2019/5/24	12
	(JST)		2019/9/6	2019/9/29	24
	(JST)		2020/1/27	2020/3/15	49
	JIRCAS		2022/6/22	2022/7/20	29

Summary statistics

	Number of trips (duration)				
	Output1	Output2	Output3	Output4	All
2017	2 (36)	6 (171)	4 (153)	6 (75)	18 (341)
2018	5 (112)	15 (323)	10 (289)	10 (177)	40 (775)
2019	5 (99)	10 (248)	10 (307)	7 (99)	32 (717)
2020	0 (0)	5 (56)	2 (48)	3 (76)	10 (131)
2021	1 (33)	3 (95)	4 (122)	0 (0)	8 (250)
2022	1 (24)	3 (90)	4 (121)	2 (52)	10 (235)
Total	14 (304)	42 (983)	34 (1040)	28 (479)	118 (2806)

1.2.List of invited researchers for short-term training

Name	Affiliation	Output and training area	Start date	End date	Duration (days)
Andry Andriamananjara	LRI, Researcher	Output1: GIS, Remote sensing, Soil science	2017/7/25	2017/9/2	40
Michel Rabenarivo	LRI, Researcher	Output1: GIS, Remote sensing, Soil science	2017/7/25	2017/9/2	40
Sarah Tojo Mandaharisoa	FOFIFA, Researcher	Output2: Molecular breeding, plant nutrition	2017/9/26	2017/11/6	42
RABESON RAYMOND	FOFIFA, Director	Output3: Management	2018/1/23	2018/1/31	9
TANTELY RAZAFIMBEL	LRI, Director	Output1: Management	2018/1/23	2018/1/31	9
Tovohery Rakotoson	LRI, Researcher	Output3: fertility management	2018/6/5	2018/9/2	90
Seheno Rinasoa	LRI, Doctoral course student	Output3: fertility management	2018/6/5	2018/9/2	90
Njato Michaël RAKOTOARISOA	FOFIFA, Researcher	Output3: fertility management	2018/7/22	2018/9/9	50
Mbolatantely Fahazavana	FOFIFA, Researcher	Output2: Molecular breeding, plant nutrition	2018/8/5	2018/10/2	59
Harisoa Nicole RANAIVO	FOFIFA, Researcher	Output2: Molecular breeding, plant	2018/8/5	2018/10/2	59

		nutrition			
Michel Rabenarivo	LRI, Researcher	Output1: GIS, Remote sensing, Soil science	2018/8/19	2018/9/18	31
RAZAFIMANANTSOA Marie-Paule Mbolanirina	LRI, Laboratory chief manager	Output1: GIS, Remote sensing, Soil science	2019/6/30	2019/7/16	17
RAKOTONINDRINA Hobimiarantsoa Nantenaina	LRI, Doctoral course student	Output1: GIS, Remote sensing, Soil science	2019/6/30	2019/7/27	28
Njato Michaël RAKOTOARISOA	FOFIFA, Researcher	Output3: fertility management	2019/8/6	2019/9/14	40
ANDRIANARY Haja Bruce	LRI, Doctoral course student	Output3: fertility management	2019/8/6	2019/9/14	40
Viviane RAHARINIVO	FOFIFA, Researcher	Output2: Molecular breeding, plant nutrition	2019/8/6	2019/9/14	40
Jules RAFALIMANANTSOA	ONN, Responsible of research and development	Output4: Socioeconomy, Nutrition	2019/6/3	2019/6/14	12
Harisoa Sahondra Andriamanana RAZAFIMBELONAINA	FOFIFA, Researcher	Output4: Socioeconomy, Nutrition	2019/6/3	2019/6/14	12
Harisoa Nicole RANAIVO	FOFIFA, Researcher	Output2: Molecular breeding, plant nutrition	2022/7/1	2022/8/30	61

Mbolatantely Fahazavana	FOFIFA, Researcher	Output2: Molecular breeding, plant nutrition	2022/7/1	2022/8/30	61
Andry Andriamananjara	LRI, Lecturer researcher	Output3: fertility management	2022/7/15	2022/8/30	47
Viviane RAHARINIVO	FOFIFA, Head of Seed Laboratory	Output2: Molecular breeding, plant nutrition	2022/8/11	2022/9/1	22
Andriamialison Herinirina RAMAROSON (JST)	University of Antananarivo, Lecturer	Output4: Socioeconomy, Nutrition	2017/10/2	2017/10/12	11

Summary statistics

	Number of trips (duration)				
	Output1	Output2	Output3	Output4	All
2017	2 (80)	1 (42)	0 (0)	1 (11)	4 (122)
2018	2 (40)	2 (118)	4 (239)	0 (0)	8 (397)
2019	2 (45)	1 (40)	2 (80)	2 (24)	7 (189)
2020	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
2021	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
2022	0 (0)	3 (144)	1 (47)	0 (0)	4 (191)
Total	6 (165)	7 (344)	7 (366)	3 (35)	23 (910)

In addition, a total of 9 Malagasy researchers (3 in 2017, 3 in 2021, and 3 in 2022) participated to the JICA training Program of “Development of Core Agricultural Researcher for Promotion of Rice Production in Sub-Saharan Africa”.

A total of 3 Malagasy researchers received the JST-MEXT and JICA (Agri-Net) scholarship programs and have been implementing the Ph.D. studies in Japan.

1.3.List of counterparts (at 5th JCC meeting on Cot12, 2021)

1. Administration of the Project

(1) Malagasy Side

Project director: SG, TILAHY ANDRIANARANINTSOA Désiré Gabriel

Project Manager/Project leader: DGA, Lantonirina RAMAROSON

Project coordinator-MAEP: DAPV, Harivony RAMANANJANAHARY

Project coordinator-ONN: Chief of Survey and Evaluation, Andriantsarafara Lalaharizaka

Project coordinator-LRI: Director of LRI, Tantely Razafimbelo

Project coordinator-FOFIFA: Director of Rice Research, Raymond Rabeson

2. Researcher list

*Project Leader, **Output Leader

(1) Malagasy Side

Name	Position/Organization	Related outputs	Effort (%) As of Aug31, 2020
Dr. Tantely Razafimbelo**	Professor/LRI	1	10
Dr. Razakamanarivo Herintsitohaina	Professor/LRI	1	15
Dr. Rafolisy Tovonarivo	Senior Researcher/LRI	3	10
Dr. Rakotoson Tovohery	Researcher/LRI	3, 1	60
Dr. Andriamananjara Andry	Researcher/LRI	3, 1	30
Dr. Rabenarivo Michel	Researcher/LRI	1, 3	40
Ms. Razafimanantsoa Marie-Paule	Laboratory Chief/LRI	1, 3	25
Dr. Razafindrakoto Malalatiana	Researcher/LRI	1, 3	10
Ms. Rinasoa Seheno	Ph.D. student/LRI	3	100
Ms. Rakotonindrina Hobimiarantsoa	Ph.D. student/LRI	1	100
Mr. Haja Bruce	Ph.D. student/LRI	1, 3	100
Mrs. Andrianofidinjanahary Mialy	MSc student/LRI	3	100

Dr. Raharinivo Viviane**	Researcher/FOFIFA	2	50
Ms. Ranaivo Nicole	Researcher/FOFIFA	2	80
Ms. Rakotondramanana Tantely	Researcher/FOFIFA	2	80
Dr. Rabeson Raymond**	Director of Rice Department/FOFIFA	3	20
Ms. Razafiarivo Ny Toky	Researcher/FOFIFA	3	25
Mr. Rakotoarisoa Njato	Researcher/FOFIFA	3	60
Ms. Ranjakason Anny	Researcher/FOFIFA–	3	50
Ms RAHARIMANANA Vololonirina	Researcher/FOFIFA	3	25
Dr. Rolland Razafindraibe	Director of Research and Development Department/FOFIFA	4	25
Dr. Henri Lucien Abel-Ratovo**	Senior Researcher/FOFIFA	4	25
Mr. Nirina Rabemanantsoa	Researcher/FOFIFA	4	25
Mr. Jean Fidele Randrianjatovo	Researcher/FOFIFA	4	25
Ms. Razafimbeloniaina Harisoa Andriamanana	Researcher/FOFIFA	4	25
Mr Randriamanana Tsinjo	Researcher/FOFIFA	4	25
Mr. Andriantsarafara Lalaharizaka	Chief of Survey and Evaluation/ONN	4	25
Dr. Ravelonarivo Harinaivo	Regional Coordinator, Vakinankaratra/ONN	4	15
Mr. Rafalimanantsoa Jules	Investigator of Research and Development/ONN	4	60
M. Rabemanantsoa Andry	Chargé de la base des données	4	25
Mme Andriamahefazafy Liselle Aina	Responsible de suivi-évaluation	4	25
Dr Rajaomaloson José	Regional Monitoring and	4	25

	Evaluation responsable of Vakinankaratra/ONN		
Mr. Randriakotomihaja James Odon	Regional Coordinator Analamanga/ONN	4	15

Director and Extension officers of DRAE in the target regions are also included in the project. SPDR shall be newly joined for the dissemination of research outputs.

1.4. List of equipment provided

Equipment Name	Brand	Model	Quantity	Location Name
Laptop PC	ASUS	Sonic Master V455L	1	FOFIFA Ambatobe Lab.
Projector	EPSON	EB-W04	1	FOFIFA Ambatobe Lab.
Projector	EPSON	EB-S05	1	LRI
Color copy machine	CANON	IR ADV-C255i	1	FOFIFA Ambatobe Lab.
Grain moisture meter	Kett	Riceter 512	1	LRI
Grain moisture meter	Kett	Riceter 512	1	FOFIFA Ambatobe Lab.
pH meter benchtop	Hanna	Edge pH HI 2002	1	FOFIFA Ambatobe Lab.
Analytical electronic balance	AND	HR-150 AZ	1	FOFIFA Ambatobe Lab.
Micro test tube mixer (hands-free, 1.5ml)	TOMY	MT-400	1	FOFIFA Ambatobe Lab.
Seed cleaning machine	PSS	PS-100/110	3	FOFIFA Ambatobe Lab.
Trace high-speed refrigerated centrifuge, legend Micro 21R	Thermo Scientific	Legend Micro 21R	1	FOFIFA Ambatobe Lab.
Grain Counter	DAIDEX	IC - Vai	1	FOFIFA Ambatobe Lab.
Thermal Cycler (PCR)	Thermo Fisher Scientific	SimpliAmp Thermal cycler	1	FOFIFA Ambatobe Lab.
Water bath for crossing	OZAWA	OZAWA 702	1	FOFIFA Ambatobe Lab.
Lab bench	N/A	N/A	1	FOFIFA Ambatobe Lab.
Water bath	Thermo Scientific	Precision GP 05	1	FOFIFA Ambatobe Lab.
Magnetic stirrer	Thermo Scientific	S88850105	1	FOFIFA Ambatobe Lab.

Liquid nitrogen container (25L)	Statebourne cryogenics	196° C Extreme Cold	1	FOFIFA Ambatobe Lab.
Liquid nitrogen container (2L)	Thermo Scientific	2/23	1	FOFIFA Ambatobe Lab.
Refrigerator	SHARP	SJ.F7 0 PC.SL	1	FOFIFA Ambatobe Lab.
Portable EC/Ph meter	HANNA	HI98131	4	LRI
Simple soil analytical Kit (Rq flex 10)	Merk KGaA	RQ flex 10	2	LRI
Portable meter for soil pH, nitric acid and EH (PRN-41＋EH electrode set)	FUJIWARA	PRN-41	2	LRI
Portable TDR soil moisture sensor	Campbell Scientific	HydroSenseII	2	LRI
Small unmanned aerial vehicle (UAV), batteries and iPad (controller)	DJI	Phantom 3-W322B	3	LRI
Susceptibility and conductivity measuring instrument	GEORDDIS	KT-10	1	LRI
Multi-spectral camera for drone	Parrotx	Sequoia	2	LRI
Software Pix Dmapper Pro Non-profit organization OT license	PIX4DMapper	Pix4DMapperpro	1	LRI
Mathematical software, MATLAB	Matlab online	Software professional	1	LRI
Precision GPS	in Japan TRIMBLE	in Japan Geo 7X handheld (H-Star, Floodlight, NMEA) – WEHH 6.5	1	LRI
Filed Spec 4 (ASD), full-range spectroradiometer	ASD inc	FieldSpec4HRNG	1	LRI
Hi-Spec PC (workstation)	FUJITSU	CELCIUS R940	1	LRI

Refrigerator	SHARP	SPSJF70PCSL	1	LRI
Micro plate reader - Spectrophotometer µDrop Plate (cat N12391)	Thermo Scientific	Multiskan GO (1) µDrop Plate (cat N12391) (2)	2	FOFIFA Ambatobe Lab.
Sample grinder. TissueLyser II Tnx Qiagen,	Qiagen	Tissue Lyser II	1	FOFIFA Ambatobe Lab.
Two set of adapter plates (96 well) for Mixer Mill	Qiagen	Adapter Set 2 plates 96 wells for MM400 (cat 69984)	1	FOFIFA Ambatobe Lab.
Two sets adapter plates (24 x 2 mL tubes) for Mixer Mill	Qiagen	QIAGEN Tissue Lyser Adapter Set 2 x 24 (cat 69982)	1	FOFIFA Ambatobe Lab.
Stainless steel beads - set of 200, suitable for Mixer Mill	Qiagen	Stainless steel beads, 5mm (cat 69989)	1	FOFIFA Ambatobe Lab.
Mini Centrifuge MySPIN 12	Fisher Scientific	GUSTO	1	FOFIFA Ambatobe Lab.
Micro Centrifuge MySPIN 6	Thermo Scientific	MySPIN6	1	FOFIFA Ambatobe Lab.
MD-MINI Dry Bath	Major Science	MD-MINI	1	FOFIFA Ambatobe Lab.
pH meter, Hana Instruments HI991001	Hana Instruments	HI991001	1	FOFIFA Ambatobe Lab.
Gel electrophoresis, Mupid - one, 088900	Mupid - one,	one, 88900	1	FOFIFA Ambatobe Lab.
Gel electrophoresis, Mupid-2 plus	Mupid	2 plus	1	FOFIFA Ambatobe Lab.
FAS-Digi Gel documenting system with Illuminator	Nihon genetics	FD3421	1	FOFIFA Ambatobe Lab.
Pippete Eppendorf Reference 2	Eppendorf	Reference 2, , 0.1-2,5µl	1	FOFIFA Ambatobe Lab.

Pippete Eppendorf Reference 2	Eppendorf	Reference 2, 2-20µl	1	FOFIFA Ambatobe Lab.
Pippete Eppendorf Reference 2	Eppendorf	Reference 2, 10-200µl	1	FOFIFA Ambatobe Lab.
Pippete Eppendorf Reference 2	Eppendorf	Reference 2, 100-1000µl	1	FOFIFA Ambatobe Lab.
Pippete Eppendorf Xplorer	Eppendorf	Xplorer, single, 0.5-10	1	FOFIFA Ambatobe Lab.
Pippete Eppendorf Xplorer	Eppendorf	Xplorer, single, 5-100	1	FOFIFA Ambatobe Lab.
Pippete Eppendorf Xplorer	Eppendorf	Xplorer, 8 channel, 0.5-10	1	FOFIFA Ambatobe Lab.
Multipette stream (1µL - 50ml)	Eppendorf	Multipette stream	1	FOFIFA Ambatobe Lab.
Pipette stand	Eppendorf	for 6 pippete	1	FOFIFA Ambatobe Lab.
Charger stand	Eppendorf	for 4 pippete	1	FOFIFA Ambatobe Lab.
Deep Freezer	LG	GR.B404 ES NV 75 1B1055	2	FOFIFA Ambatobe Lab.
N/C Analyzer	PerkinElmer	2400 Series II CHNS/O System	1	LRI
Air Compressor for N/C Analyzer	TECHPOWER	EAC50L	1	LRI
Block digester with accessories	Velp Scientifica	F30100360	1	FOFIFA Ambatobe Lab.
Refrigerated centrifuge with rotors and parts	Thermo Scientific	Multifuge X1R	1	FOFIFA Ambatobe Lab.
Microwave oven	GEEPAS	GMO 1886-48LD	1	FOFIFA Ambatobe Lab.
Electrophoresis apparatus	Nihon Eido	NB 1017C	1	FOFIFA Ambatobe Lab.
Ventilated Oven （Air Performance Universal Oven)	Air Performance	AP240	1	FOFIFA Ambatobe Lab.
Centrifuge	Thermo Scientific	Sorvall ST16	1	LRI
Autoclave	ALP	KTR-30S	1	LRI
Water distilling apparatus			1	LRI

Fumehood	KIT LAB	(WxDxH) 1500x800x1520 mm	1	LRI
Canopy Analyzer	Li-Cor	LI2200	1	LRI
Cathode lamps	Fisher Scientific	Lead Data, Copper Data, Potassium Data Coded Hollow Cathod Lamps	3	LRI
Soil colorimetric sensor	NixPro	NixPro 2	1	LRI
Spectroradiometer	PELICAN	MS-720	1	LRI
Accurate balance (620g)	METTLER TOLEDO	PL602E	1	LRI
EC tester	HANNA	GroLine EC Tester (HI98331)	4	LRI
Soil color chart	FHK, Munsell Color	44011100, Munsell soil color book	4	LRI
pH meter	HANNA	HI5221	1	LRI
Micro pipet	Eppendorf	200/1000	2	LRI
SPAD meter	KONICA MINOLTA	Spad-502	2	LRI
Battery for UAV	PHANTOM	PH3-4480mAh-15.2V	10	LRI
Greenhouse	None	None	1	FOFIFA Ambatobe Lab.
Dark Room	None	None	1	FOFIFA Ambatobe Lab.
Root Scanner	EPSON	WinRHIZO STD4800	1	LRI
A3 Color Ink-jet printer	HP	Officejet 7612 All-in-One	1	LRI (FY VARY's room)
Solar panel set	TOP CHARGE	UE07002	22	FOFIFA Tsimbazaza, under the responsibility of Mr. Herinirina (034 03 299 06)
Windows10 Professionnel	MICROSOFT	Windows 10 Professionnel	5	FOFIFA Tsimbazaza

Laptop PC	ASUS	ASUS	2	FOFIFA Tsimbazaza (Used by all the Output 4 members) / Under the responsibility of Mr. Tsinjo (034 09 661 60)
Office desks	NONE	Without drawers	6	FOFIFA Ambatobe Lab.
Meeting table	NONE	Oval	1	FOFIFA Ambatobe Lab.
Office chairs	NONE	Rotating model with wheels	6	FOFIFA Ambatobe Lab.
Lab. Stools	NONE	Rotating model	6	FOFIFA Ambatobe Lab.
Shelves	NONE	With Glass Sliding Doors	2	FOFIFA Ambatobe Lab.
Meeting chairs	NONE	Rotating model with wheels	2	FOFIFA Ambatobe Lab.
Locker	NONE	Vertical	5	FOFIFA Ambatobe Lab.
White Board	NONE	With stand	1	FOFIFA Ambatobe Lab.
Voltage Stabilizer	VMARK POWER	RE23-3000	1	FOFIFA Antsirabe
Transformer for Thermal Cycler	Suwaro denki	Transpal 1500	1	FOFIFA Ambatobe Lab.
Ventilated Oven （Air Performance Universal Oven)	FROILABO	Air Performance AP240	1	FOFIFA Antsirabe
Platinum electrodes for Eh measurements	FUJIWARA	EP-201	1	LRI
Height scale	TANHA	seca 213	10	FOFIFA Tsimbazaza / Under the responsibility of Mr. Tsinjo (034 09 661 60)
height scale for infant	TANHA	seca 210	10	FOFIFA Tsimbazaza / Under the responsibility of Mr. Tsinjo (034 09 661 60)
pH meter, Hanna Instruments	Hanna Instruments	H15221	1	FOFIFA Ambatobe Lab.
UPS	PROLINK	PRO 700SFC	2	FOFIFA Ambatobe Lab.

Hard disk (PC), 1TB	TOSHIBA	DTP210	2	FOFIFA Ambatobe Lab.
UPS 1050 VA	INTEX	THUNDER	3	FOFIFA Ambatobe Lab.
Photography camera	Canon	PowerShot SX610 HS, white color	1	FOFIFA Ambatobe Lab. (lost)
Vacuum cleaner	VISTA	Multi cyclone VC-78C, 1600 W	1	FOFIFA Ambatobe Lab.
Wireless network router	Huawei	B310S-22	1	FOFIFA Ambatobe Lab.
Telephone set	HUAWEI	ETS5623	1	FOFIFA Ambatobe Lab.
Air conditioner	TCL	Split mural 24 000 BTU/h	3	FOFIFA Ambatobe Lab.
		Split mural 24 000 BTU/h		
		Split mural 18 000 BTU/h		
Color Inkjet Printer (A3)	HP	Officejet 7612	1	DRAEP Antsirabe, used by Ms. Harimenja
Color Inkjet Printer (A3)	HP	Officejet 7612	1	FOFIFA Ambatobe Lab. (currently at LRI)
UPS 3 KVA	Light Wave	LW UPS 3000	1	LRI (out of order)
Ventilated Oven （Air Performance Universal Oven)	Air Performance	AP240	1	FOFIFA Ambatobe Lab.
Multimeter	Benning	MM 1-1	1	FOFIFA Ambatobe Lab.
Small refrigerator	FUJITA	One-door 120 L Locked with key	1	FOFIFA Ambatobe Lab.
Hand tools set	TOTAL	101 parts with electric drill	1	FOFIFA Ambatobe Lab.
Foldable ladder	N/A	N/A	2	FOFIFA Ambatobe Lab.
Electric socket adaptors	N/A	N/A	8	FOFIFA Ambatobe Lab.
Thermal Cycler	Bio-Rad	C1000	1	FOFIFA Ambatobe Lab.
Cutting Mill	RETSCH	SM100	1	LRI
Cutting Mill / Ultra-centrifugal Mill	RETSCH	ZM200	1	LRI

Ventilated Oven （Air Performance Universal Oven)	Air Performance	AP240	1	LRI
Speakerphone	JABRA	Speak 510	1	LRI
Used media pads	HUAWEI	MediaPad M5 Lite	3	Used by Ms. Hobimiarantsoa at LRI (034 15 035 58)
Air conditioner	TCL	CHSA/JAI 9000 BTU	1	FOFIFA Ambatobe Greenhouse
Air extractor	TECHPOWER	EF 400	3	FOFIFA Ambatobe Greenhouse
Water softener with connector set	EYELA	MK-n4αUW	1	LRI
Transformer box	EYELA	AC200	1	LRI
Compact scale	HT-5000	1g-5kg	4	LRI
Compact scale	HT-500	0,1g-510g	4	LRI
Water distilling apparatus	EYELA	SA-2100A	1	FOFIFA Ambatobe Lab.
Laptop PC for FieldSpec	DELL	Latitude 5400	1	LRI - Shall be handed over
Autoclave	ALP	KTR-2322	1	FOFIFA Ambatobe Lab.
X-ray Fluorescence Analyzer	VANTA	VMR-CCC-S3-J-JA	1	LRI
Water distillation apparatus	EYELA	SA-2100A	1	FOFIFA Ambatobe
4X4 VEHICLE	TOYOTA	LX HZJ76L	1	Coordinator Office (FOFIFA)
4X4 VEHICLE PICK UP	FORD RANGER	DBL CAB	1	Coordinator Office (FOFIFA)
DIRT BIKES	YAMAHA	XTZ125E	1	FOFIFA Antsirabe / Used by Mr. Henintsoa (034 54 938 90)
DIRT BIKES	YAMAHA	XTZ125E	1	Behenjy / Used by Mr. Liva (034 76 669 72)
Laptop PC	DELL	VOSTRO 15 3000 Series	1	Coordinator Office (FOFIFA) / Used by Ms. Nathalie

Laptop PC	DELL	Inspiron 15-3567 15.6TM core i3	1	Coordinator Office (FOFIFA) / Used by Mr. Ando
Safe Box	NONE	BGX-A/D-63	1	Coordinator Office (FOFIFA)
Water Pump	TECHPOWER	AGP017 / WP20D	2	1 in Behenjy, 1 in Ankazomiriotra
Working Desk	NONE	With drawers	3	Coordinator Office (FOFIFA)
MS Office	MICROSOFT	Office 2016	5	* 02 installed on the two laptops in FOFIFA Tsimbazaza * 01 installed on the high spec. PC at LRI * 01 installed on the laptop at FOFIFA Ambatobe Lab. * 01 installed on the laptop which is used by Mr. Ando at the Coordinator Office
TELMA Modem	HUAWEI	Wingle 4G	6	5 at the Coordinator Office (FOFIFA) 1 at DRAEP Antsirabe / used by Ms. Harimenja (034 04 259 91)
Meeting Table	NONE	Round	1	Coordinator Office (FOFIFA)
Meeting chairs	NONE	Fixed model	4	Coordinator Office (FOFIFA)
Office chairs	NONE	Rotating model with wheels	3	Coordinator Office (FOFIFA)
Small office desk	NONE	Without drawers	3	Coordinator Office (FOFIFA)
Office shelves	NONE	Without door	1	Coordinator Office (FOFIFA)
Office Shelves	NONE	With glass doors	2	Coordinator Office (FOFIFA)
Office Cupboards	NONE	With Sliding Doors	2	Coordinator Office (FOFIFA)

White Board	NONE	Walled	3	Coordinator Office (FOFIFA)
Office desks	NONE	With drawers	3	Coordinator Office (FOFIFA)
Color Inkjet Printer (A3)	HP	Officejet 7612	1	Coordinator Office (FOFIFA)
Color Inkjet Printer (A3)	HP	Officejet 7612	1	Coordinator Office (FOFIFA)
Speakerphone	JABRA	Speak 710	1	DGA - MAEP
Speakerphone	JABRA	Speak 510	1	Coordinator Office (FOFIFA)
Speakerphone	Anker	Portable conference speakerphone	1	DRAEP Antsirabe
Camera tripods	JOBY	N/A	2	DRAEP Antsirabe
Used hard disks	BUFFALO	1,8 TO	3	Antsirabe / Under the responsibility of Ms. Harimenja (034 04 259 91)
Motorcycle	SYM	X-WOLF F5	6	1 used by Kenny in Behenjy (0343679318) ; 1 used by Toky in Antanifotsy (0347860646) ; 1 used by Patrick in Ambohibary (0344049140) ; 1 used by Crysanthe in Faratsiho (0344659884) ; 1 used by Anderson in Betafo (0342777889) ; 1 used by Dauphin Ankazomiriotra (0347073390)
Wifi Router	Huawei	Domino 4G	1	DRAEP Antsirabe, used by Ms. Harimenja
Safe Box	Honeywell	5115	1	DRAEP Antsirabe, used by Ms. Harimenja
Laptop PC	ASUS	X509	1	DRAEP Antsirabe, used by Ms. Harimenja
Fumehood	AS ONE	Compact	1	FOFIFA Ambatobe
Greenhouse			1	LRI
Air-dried oven	FROILAB	AP240	1	DRAE Antsirabe

Published products of FyVary Project

Breakthrough in Nutrient Use Efficiency for Rice by Genetic Improvement and Fertility Sensing Techniques in Africa

Japan-Madagascar International Research Collaboration Project under the framework of SATREPS

Preface

Rice cultivation is an important part of the economy that provides the staple food of the country and is a major source of income for the rural citizens of Madagascar. However, the stagnant rice productivity risks national food security and deprives poor farmers of the chance to increase their livelihood. This has prevented the country from escaping poverty of which nearly 80% of people still live with less than 1.9 USD per day in the country.

In Madagascar, 70% of the rice agricultural area is categorized as “irrigated” and mostly managed by smallholder farmers. Irrespective of the relatively favorable water conditions, the average yield is stagnated at 2,7 tons/hectare (t/ha). The restricted yield is primarily due to inadequate fertilizer application and poor nutrient supplying capacity of the highly weathered soils. For example, Ferralsol spreads across the central to the eastern part of the island, corresponding to the major rice-producing areas. The deficiency of nutrients like phosphorus, nitrogen, sulfur, and silicate restricts rice productivity. However, few appropriate soil and fertilizer management practices have been developed for rice cultivation in these nutrient deficient conditions. Till now, the capacity for rice breeding has been weak, hindering the development of promising varieties that can increase the yields and adapt to the local environments.

Optimizing the use of fertilizers, including local products like farmyard manure, and developing crop varieties suitable for less fertile soils can improve rice productivity in Madagascar. Such strategies can be applied to the other parts of Africa where the production level is restricted by nutrient-deficient soils and poor fertilizer management. Therefore, in 2017, we launched the Madagascar-Japan Research Collaboration Project titled “Breakthrough in Nutrient Use Efficiency for Rice by Genetic Improvement and Fertility Sensing Techniques in Africa” or FyVary Project in short. We abbreviated the project as FyVary, which stands for “FertilitY sensing and Variety Amelioration for Rice Yield”, because it also means “tasty rice” in Malagasy, hoping to popularize the project among Malagasy people. The project was led by the Ministry of Agriculture and Livestock (MINAE) and Japan International Research Center for Agricultural Sciences (JIRCAS) with collaborating research institutes: le Centre National de Recherche Appliquée au Développement Rural (FOFIFA), le Laboratoire des Radioisotopes à l’Université d’Antananarivo (LRI), and Office National de Nutrition (ONN) on Madagascar’s side; and University of Tokyo, Kochi University, and Yamanashi Eiwa University on Japan’s side.

The project aimed to develop rice production techniques to realize high yields under low fertility conditions by optimizing fertilizer use suited to the soil nutrient characteristics of the field and creating new breeding lines with high nutrient use efficiency. It also aimed to evaluate the impact the adoption of such techniques has on the income and nutritional status of local farmers. For this purpose, we established four interconnected research groups: Output 1. Evaluation techniques and geographical maps of field nutrient fertility characteristics are developed; Output 2. Breeding materials to improve grain yield and nutrient use efficiency under low-input and low-fertility soil conditions are developed; Output 3. Fertilizer management techniques using genetic resources for nutrient-efficient rice production are developed; Output 4. A policy recommendation is compiled to promote the extension of developed techniques for rice production in the target area.

This book compiles a series of scientific knowledge, technical manuals, variety catalogs, and policy recommendations obtained throughout the project. We thank all the farmers and local municipalities who consistently supported our field activities, such as soil collection and analysis, on-farm experiments, household surveys, and farmer-participatory variety selection. Without their support, we could not have accomplished the project. We hope that this book will help them and contribute to sustainable rice production and poverty alleviation for smallholder farmers in Madagascar. It should be noted that many products in this book were developed by Malagasy young researchers who will play pivotal roles in the ongoing research and development in the agricultural sector of the country.

Ms. Fanja RAHARINOMENA
Secretary General, Ministry of Agriculture and Livestock, Madagascar
Dr. Yasuhiro Tsujimoto
Project leader, Japan International Research Center for Agricultural Sciences

Préface

La culture du riz, qui occupe une place importante dans l'économie de Madagascar, produit l'aliment de base du pays et est la principale source de revenu pour les populations rurales de Madagascar. Cependant, la stagnation de la productivité rizicole menace la sécurité alimentaire nationale et prive les agriculteurs à faibles revenus d'avoir la chance d'améliorer leur moyen de subsistance. Cette situation a empêché le pays d'échapper à la pauvreté dont près de 80% de la population vivent encore avec moins de 1,9 USD par jour dans le pays.

A Madagascar, 70% des surfaces rizicoles sont catégorisées comme « irriguées » et sont principalement gérées par des petits exploitants. Indépendamment des conditions hydriques relativement favorables, le rendement moyen stagne à 2,7 tonnes/hectare (t/ha). Ce rendement limité est surtout dû à une application inadéquate d'engrais et à la faible capacité d'approvisionnement en éléments nutritifs des sols très altérés. Comme exemple, les Ferralsols qui s'étendent de la partie centrale jusqu'à la partie Est de l'île, correspondent aux principales zones de production de riz. La carence en nutriments comme le phosphore, l'azote, le soufre et le silicate limite la productivité rizicole. Toutefois, peu de pratiques de gestion du sol et d'engrais ont été développées pour la culture du riz dans ces conditions de carence en nutriments. De plus, jusqu'à aujourd'hui, la capacité de sélection variétale du riz a été faible, ce qui entrave le développement de variétés prometteuses capables d'augmenter les rendements et de s'adapter aux environnements locaux.

L'optimisation de l'utilisation des engrais, y compris les produits locaux comme le fumier de ferme, et le développement de nouvelles variétés adaptées aux sols moins fertiles peuvent améliorer la productivité rizicole à Madagascar. De telles stratégies peuvent être appliquées aux autres parties de l'Afrique où le niveau de production est limité par des sols pauvres en éléments nutritifs et une mauvaise gestion des engrais. Par conséquent, en 2017, nous avons lancé le projet de collaboration de recherche Madagascar-Japon intitulé « Percée dans l'efficacité de l'utilisation des nutriments pour le riz par des techniques d'amélioration génétique et de détection de la fertilité en Afrique » ou Projet Fy Vary en abrégé. Nous avons abrégé le projet en Fy Vary, qui signifie « détection de la fertilité et amélioration de la variété pour le rendement du riz », car cela signifie aussi « riz savoureux » en malagasy[1], dans l'espoir de populariser le projet auprès des Malagasy. Le projet a été mis en œuvre par le Ministère de l'Agriculture et de l'Elevage (MINAE) et le Centre Japonais de Recherche International pour les Sciences Agronomiques (JIRCAS) en collaboration avec des instituts de recherche : le Centre National de Recherche Appliquée au Développement Rural (FOFIFA), le Laboratoire des RadioIsotopes à l' Université d'Antananarivo (LRI) et l'Office National de Nutrition (ONN) du côté malgache ; et l'Université de Tokyo, l'Université de Kochi et l'Université Yamanashi Eiwa du côté japonais.

Le projet a pour objectif de développer des techniques de production de riz pour obtenir des rendements élevés dans des conditions de faible fertilité en optimisant

[1] la langue nationale de Madagascar

l'utilisation d'engrais adaptés aux caractéristiques nutritives du sol des rizières et en créant de nouvelles lignées disposant d'une efficience d'utilisation des nutriments élevée. Il visait également à évaluer l'impact de l'adoption de ces techniques sur le revenu et l'état nutritionnel des agriculteurs locaux. Pour atteindre cet objectif, nous avons mis en place quatre groupes de recherche interconnectés : Groupe 1. Des techniques d'évaluation et une cartographie des caractéristiques de fertilité des nutriments sur le terrain sont développées ; Groupe 2. Des matériels de croisement pour améliorer le rendement en grains et l'efficience d'utilisation des nutriments dans des conditions de sol à faible apport d'intrants et à faible fertilité sont développés ; Groupe 3. Des techniques de gestion des fertilisants utilisant des ressources génétiques pour la production rizicole efficace en éléments nutritifs sont développées ; Groupe 4. Une recommandation de politique est compilée pour promouvoir la vulgarisation des techniques développées pour la production de riz dans la zone cible.

Ce livre compile une série de connaissances scientifiques, de manuels techniques, de catalogues variétales et de recommandations politiques obtenues tout au long de la mise en œuvre du projet. Nous remercions tous les agriculteurs et les communes qui ont constamment soutenu nos activités sur le terrain, telles que la collecte et l'analyse des sols, les expérimentations sur terrain, les enquêtes auprès des ménages et la sélection variétale participative des agriculteurs. Sans leur soutien, nous n'aurions pas pu réaliser le projet. Nous espérons que ce livre les aidera et contribuera à une production rizicole durable et à la réduction de la pauvreté des petits exploitants agricoles à Madagascar. Il convient de noter que de nombreux résultats dans ce livre ont été développés par des jeunes chercheurs malgaches qui joueront un rôle central dans la recherche et le développement en cours dans le secteur agricole du pays.

Ms. Fanja RAHARINOMENA
Secrétaire Général, Ministère de l'Agriculture et de l'Elevage, Madagascar
Dr. Yasuhiro Tsujimoto
Chef de Projet, Centre International de recherche pour les sciences agronomiques du Japon

FY VARY

Un projet de partenariat de recherche sur le riz

“Recherches d’aujourd’hui, production de demain”

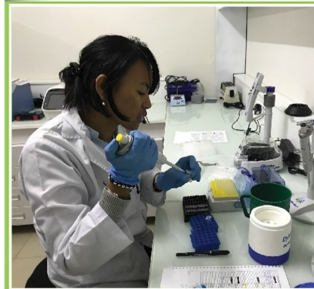
A Madagascar, la consommation de riz augmente alors que la productivité stagne, à ce jour. Cela est essentiellement dû à un manque d’apport d’engrais et à la déficience en éléments nutritifs causé par le sol dégradé, typique de l’Afrique.

Pour résoudre ce problème, le Ministère de l’Agriculture, de l’Elevage et de la Pêche (MAEP) et le Centre de Recherche International Japonais pour les Science Agronomiques (JIRCAS) mènent conjointement avec les institutions de recherche nationales un projet de coopération technique, FY VARY (2017-2022), piloté par l'Agence Japonaise de Coopération Internationale (JICA) et l'AgenceJaponaise pour la Science et la Technologie (JST), dans le cadre du programme SATREPS.

Pour un partenariat fort et durable

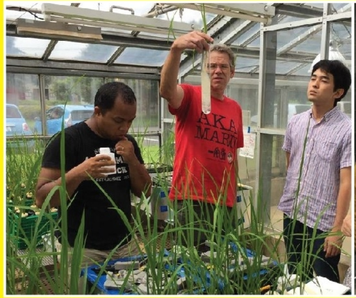
Fourniture d’équipements

Le Projet a fourni un ensemble d’équipements pour accélérer la recherche génétique, l’amélioration de variétés, l’analyse des nutriments des sols et des plantes.



Développement des capacités

Chaque année, plusieurs chercheurs Malagasy sont invités au Japon pour y suivre une formation pour appuyer les chercheurs nationaux.



Envoi d’experts à Madagascar

Chaque année, des dizaines de chercheurs Japonais de différents domaines de recherche viennent à Madagascar.

SATREPS Science and Technology Reasearch Partnership for Sustainable Development Program

Le SATREPS est un programme destiné à promouvoir la recherche internationale conjointe en utilisant les sciences et technologies avancées du Japon pour faire face aux problèmes mondiaux.

JIRCAS · MAEP · MESUPRES · Kyoto University · 東京大学 The University of Tokyo · Laboratoire des Radioisotopes Université d'Antananarivo · FIFAMANOR · Primature ONN · JICA · JST

www.jircas.go.jp/en/satreps projetfyvary_secretaire@hotmail.com

Activités

DIAGNOSTIC DU SOL ET DES PLANTES

Développer des méthodes simples et rapide pour déterminer la carence en éléments nutritifs des sols des rizières et des plants de riz

AMELIORATION DE FERTILISATION ET DE VARIETES

Développer de nouvelles variétés et techniques de gestion de fertilisation pour l’utilisation efficace des nutriments du sol et des engrais

ETUDE D’IMPACT

Clarifier l’impact de la diffusion de ces technologies sur le revenu et sur l’amélioration de la nutrition des agriculteurs

Améliorer la production rizicole des sols à faibles conditions de fertilité ainsi que son impact sur les agriculteurs

Contribuer à relever le défi de l’Etat Malagasy d’atteindre l’autosuffisance en riz en 2023

Contents

Output 2

Output 3

Output 4

Research Awards

A series of achievements of the Project received several research awards as listed below:

Awarded date	**Laureate, Affiliation**	**Award Name, Organizer**	**Awarded title**
2018.11.6	Andry ANDRIAMANANJARA (LRI)	Japan International Award for Young Agricultural Researchers (Japan Award), Ministry of Agriculture, Forestry and Fisheries	Organic matter dynamics in agroecosystems of Madagascar and its effective use for crop production
2019.4.9	Tomohiro Nishigaki (JIRCAS)	Research grant of The Japan Prize Foundation, The Japan Prize Foundation	Development of simple paddy soil fertility assessment technique to help solve food problems in Sub-Saharan Africa
2020.11.12	Yasuhiro Tsujimoto (JIRCAS)	Young Agriculture, Forestry and Fisheries Researcher Award, Ministry of Agriculture, Forestry and Fisheries	Development of efficient rice production technology in a nutrient-deficient environment in Africa
2021.2.19	Tomohiro Nishigaki (JIRCAS)	Best Presentation Award for Cross-Fertilization, Tsukuba Science Academy	Development of a rapid soil fertility assessment technique for improving rice production in Madagascar
2021.3.29	Yasuhiro Tsujimoto (JIRCAS), Tovohery Rakotoson (LRI), Atsuko Tanaka (JIRCAS), Kazuki Saito (Africa Rice Center)	18^{th} Japanese Society of Crop Science Research Award, Crop Science Society of Japan	Challenges and opportunities for improving N use efficiency for rice production in sub-Saharan Africa

2021.11.26	Yasuhiro Tsujimoto (JIRCAS)	20th Japan Prize in Agricultural Sciences, Achievement Award for Young Scientists, The Foundation of agricultural Sciences of Japan	Development and dissemination of effective rice fertilization technology suitable for cultivation environments in Africa
2021.7.31	Yasuhiro Tsujimoto (JIRCAS)	Falling Walls Award, Life Sciences, Finalists 2021, The Falling Walls Foundation	Development of efficient fertilizer management technique in Madagascar
2021.9.10	Andrianary Bruce (LRI), Yasuhiro Tsujimoto (JIRCAS), Rakotonindrina, H. (LRI), Rabenarivo, M. (LRI), Razakamanarivo, Herintsitohaina (LRI)	Best presentation award (Oral), 10th Asian Crop Science Association Conference	The effect of N and P applications on rice yield can be changed by farmers' management practices—transplanting dates and densities—
2022.3.15	Emmanuel ODAMA (Kagoshima Univ.), Yasuhiro Tsujimoto (JIRCAS), Shin Yatabe (Kagoshima Univ.), Jun-ichi Sakagami (Kagoshima Univ.)	Best presentation award, The 131th Academic Meeting of the Japanese Society of Tropical Agriculture (JSTA)	Effect of P-dipping priming on rice resilience to water and nutrient stress under rainfed lowland

A list of dissertations

The Project produced 6 MSc dissertations and 4 Ph.D. dissertations as listed below as of Aug31, 2022. In addition, 3 and 7 Malagasy researchers are continuing for the completion of their MSc and Ph.D. studies, respectively.

MSc Dissertation

- RINASOA Seheno, Application de micro-dose de phosphore sur la pépinière de la riziculture irriguée (Oryza sativa L.), UNIVERSITE ANTANANARIVO, 6 Sep, 2017
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