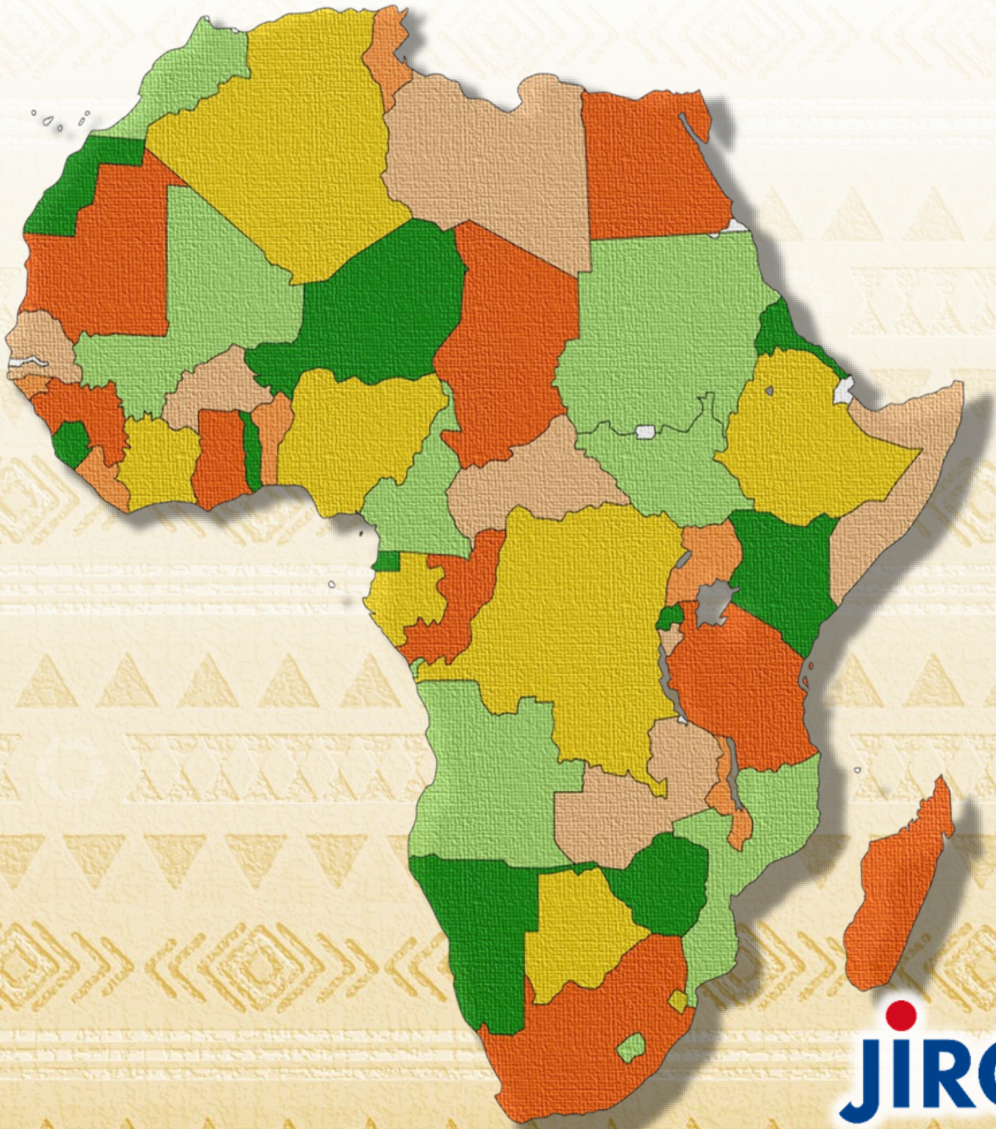
Japan International Research Center for Agricultural Sciences

Technology Showcase
for Sub-Saharan Africa



JIRCAS

Preface

The year 2022 marks the Eighth Tokyo International Conference on African Development (TICAD 8), an international conference initiated by Government of Japan in 1993 to promote high-level political dialogue on Africa's development and to strengthen partnerships between African leaders and their partners. Agriculture is among the priority topics of TICAD, as its development is fundamental for the region's sustainable growth, and this sector has been challenged by conflicts, climate change, economic disruptions and downturns aggravated by COVID-19. In order to ensure and improve food and nutrition security, the region requires not only humanitarian aid but also long-term investment in its food and agriculture sectors to build their resilience to climate variabilities, conflicts and economic shocks.

The majority of African countries have experienced stagnant growth in agricultural productivity. The underlying factors include highly weathered soil environment characterizing the region's low fertile and/or poor nutrient soils, and lack of management technologies to efficiently utilize and manage water resources. In addition, the huge diversity in locally important crops and heterogeneity in production environment – soil, climate and socio-economic condition - when combined, makes prioritization in breeding efforts difficult. As a leading Japanese national agricultural research institution, JIRCAS has long been committed to addressing challenges, including those mentioned above, through collaborative projects with national, regional and international agricultural research organizations operating in the region.

This technology showcase is a compilation of technologies and innovations that have been developed in recent years through joint research collaborations of JIRCAS, and that are expected to be utilized in African countries and contribute to sustainable agricultural intensification and food/nutrition security. Obviously, there is no one-size-fits-all solution for achieving sustainable agricultural intensification, given the extreme heterogeneity of African smallholder systems in terms of soil, climate and socio-economic conditions. Even if basic agricultural technologies have been developed, it would still be necessary to optimize and coordinate these technologies among countries and regions with different environments. We hope that this technology showcase will serve as a reference to various stakeholders in Africa, including government officials, researchers, extension officers, producers, and the private sectors.

About the Technology Showcase

The configuration of this showcase is as follows.

Title including the technology name and its advantage.

Target crop or product.

Area of contribution to social impact.

Technology Showcase for AfricaAf-2

New lowland rice varieties in Madagascar for improving yield under low-input conditions

Sustainable agriculture intensification

Production | Implementation | Crop: Rice

Outline

After several cycles of selection in farmers' field, two rice varieties, FyVary 32 and FyVary 85, with improved yield across a range of soil fertility were released in Madagascar.

Background/Effect/Note

Poor nutrient conditions such as phosphorus (P) deficiency restrict rice yield in Sub-Saharan Africa. We have identified two donor rice varieties with good adaptation to such P-limited conditions and developed breeding populations after crossing them with IR64, a major high-yielding variety in the tropics. Initial marker-assisted selection for the *Pup1* locus was followed by phenotypic selection and farmer-participatory evaluation under low-input conditions (Fig.1). The resulting varieties, FyVary 32 and FyVary 85, showed 12–20% higher grain yield compared to local recommended variety X265, and were officially released as new lowland rice varieties in Madagascar in 2021 (Fig.2). Foundation seeds of these new varieties are being disseminated to seed producers (Fig.3).

Details: https://www.jircas.go.jp/en/release/2021/press202117
https://www.jircas.go.jp/en/reports/2022/r20220520

Fig. 1. Farmer-participatory evaluation during the variety release process: Production test (left) and taste test (right)

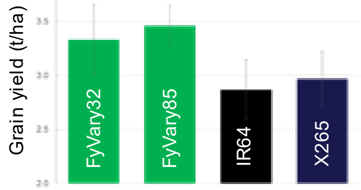


Fig. 2. Yield advantage of FyVary32 and FyVary85 over local variety X265 and parental line IR64.

Fig. 3. Seed multiplication for dissemination

Target process within the supply chain (Production, Input, Processing and distribution, Consumption) for utilization of the technology.

Present status of technological achievement (Basic, Application, Demonstration, Implementation) for the technology.

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No.	Commodities	Status	Technologies	Contribution areas
Af-1	Guinea yam	Application	Advanced utilization of Guinea yam genetic resources	Food and nutrient improvement
Af-2	Rice	Implementation	New lowland rice varieties in Madagascar for improving yield under low-input conditions	Sustainable agriculture intensification
Af-3	Rice	Demonstration	Yield Improvement by direct application of low-grade phosphate rocks in African rainfed rice	Sustainable agriculture intensification
Af-4	Rice, Maize, Sorghum	Demonstration	Fertilizer production using African local low-grade phosphate rock through calcination technology	Sustainable agriculture intensification
Af-5	Rice	Implementation	Dipping rice seedlings in phosphorus-enriched slurry or P-dipping increases yield and avoids cold stress of rice	Sustainable agriculture intensification
Af-6	Sorghum, Maize, Cowpea	Demonstration	Quick soil judging with high spatial resolution using GPR	Sustainable agriculture intensification
Af-7	Sorghum, Maize, Cowpea	Demonstration	Optimization of conservation agriculture in drylands	Soil conservation
Af-8	Rice	Implementation	Manual for low-cost irrigation facilities in Africa	Resource management
Af-9	Rice, Vegetables	Implementation	Technical manual contributes to water resource use efficiency in irrigation scheme	Resource management
Af-10	Any	Implementation	Program for creating improved farming plans for African smallholders	Livelihood improvement
Af-11	Cow	Demonstration	Improvement of milk production and profitability by feeding fermented TMR prepared with local feed resources	Livelihood improvement
Af-12	Any	Basic	Behavioral prediction technologies to improve desert locust control	Integrated pest management

Technology Showcase for Africa Af-1

Advanced utilization of Guinea yam genetic resources

Food and nutrient improvement

Production | Application | Crop: Guinea yam

Outline

The genome information, molecular tools, and representative diverse materials will facilitate the advanced utilization of Guinea yam (*Dioscorea rotundata*) genetic resources towards efficient breeding and variety improvement.

Background / Effect / Note

Guinea yam is an important regional staple food in West Africa but its breeding has remained ineffective due to its biological characteristics, regionality and locality. We are focusing to improve productivity and quality of Guinea yam through the utilization of genetic resources. The information of whole genome sequence, tool kit for variety identification, and representative diverse materials will contribute in advanced utilization of yam genetic resources for efficient breeding and variety improvement (Fig.1). Plant materials selected in this study are available for distribution through the International Institute of Tropical Agriculture (IITA).

Details : https://www.jircas.go.jp/en/publication/research_results/2017_b02
https://www.jircas.go.jp/en/publication/research_results/2019_b03
https://www.jircas.go.jp/en/publication/research_results/2020_b03

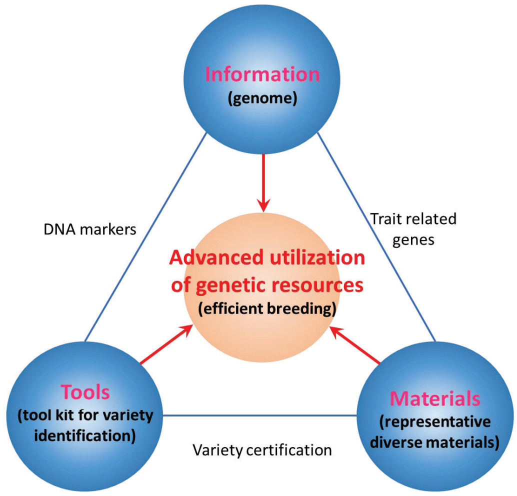

Fig.1. Information, tools and materials for advanced utilization of yam (*D. rotundata*) genetic resources.

Technology Showcase for Africa Af-2

New lowland rice varieties in Madagascar for improving yield under low-input conditions

Sustainable agriculture intensification

Production | Implementation | Crop: Rice

Outline

After several cycles of selection in farmers' field, two rice varieties, FyVary32 and FyVary85, with improved yield across a range of soil fertility were released in Madagascar.

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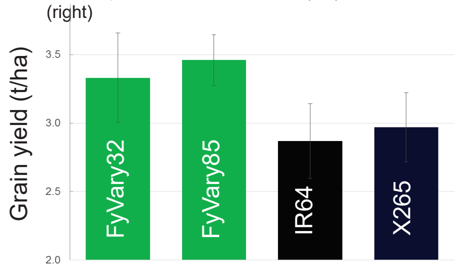

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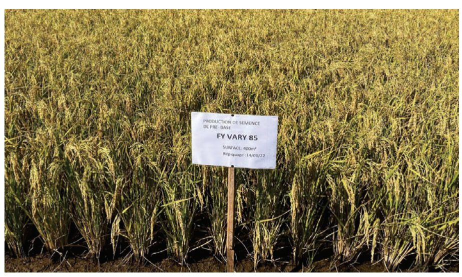


Fig. 3. Seed multiplication for dissemination

Yield improvement by direct application of low-grade phosphate rocks in African rainfed rice

Sustainable agriculture intensification

Production | Demonstration | Crop: Rice

Outline

Direct application of low-grade phosphate rock (PR) to rainfed rice is effective in West Africa. Significant differences were observed among the different agroecological zones (AEZ) in the first year. In all AEZs, residual effects of PR applied in the previous year can be expected, and the optimal application pattern depends on the level of residual effect.

Background / Effect / Note

In Africa, the use of local low-grade PR as an affordable P resource is expected to expand. Direct application of low-grade PR (PRDA) is expected to be effective in rice cultivation, but the cultivation environment of African rain-fed rice is diverse, and its application effect is not uniform. PRDA in the Sudan Savanna Zone (SS), Guinea Savanna Zone (GS), and Equatorial Forest Zone (EF), has different effects in the first year, and in addition, the residual effects are different (Fig.1). Even reducing the frequency of PR application to twice every three years in SS and GS, and once every three years in EF, PRDA can obtain similar yields to annual application (Table 1).

Details : https://www.jircas.go.jp/en/publication/research_results/2020_a10

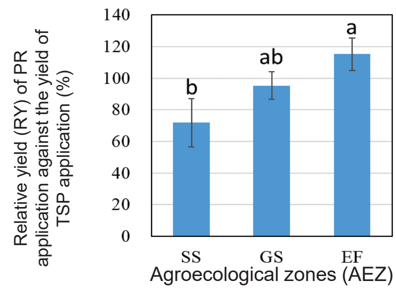


Fig.1. First-year application effect of phosphate rock under each agroecological zone

Table 1. Phosphate rock direct application effect with several application patterns under each agroecological zone

PR application patterns /Total phosphate application (kg P_2O_5 ha^{-1} 3 years^{-1})				Averaged rice grain yield (t ha^{-1} year^{-1})		
				SS	GS	EF
-P	-P	-P	0	2.42 c	2.02 c	3.63 b
+P	-P	-P	135	2.79 b	2.67 b	5.02 a
+P	+P	-P	270	3.65 a	3.13 a	4.99 a
+P	+P	+P	405	3.85 a	3.12 a	5.02 a

Fertilizer production using African local low-grade phosphate rock through calcination technology

Sustainable agriculture intensification

Production | Demonstration | Crops: Rice, Maize, Sorghum etc.

Outline

African low-grade phosphate rocks (PRs) from Africa can be fertilized by calcination with alkali addition. The application effect of the P fertilizer obtained by calcination with the addition of potassium carbonate is equivalent to that of triple super phosphate (TSP), a commercially available fertilizer.

Background / Effect / Note

Low-grade PR, which is abundant in Africa, has not been fully utilized due to its low solubility. Therefore, we developed a technology for the solubilization of Burkina Faso PRs by calcination (Fig.1). Calcination with potassium (K) or sodium (Na) carbonate can make PR soluble in citric acid to a maximum of 100% and water soluble to 38% of total P_2O_5 (Fig.2). The application effect is comparable to TSP, a commercial P fertilizer. In addition, calcination with K carbonate is expected to supply not only P but also K and calcium (Fig.3). As a slow-release alkaline fertilizer, it must be effective in tropical acidic soils. This calcination method can also be applied to the solubilization of other African low-grade PRs.

Details : https://www.jircas.go.jp/en/publication/research_results/2016_a03

Fig.1. Calcined P fertilizer (left) and the equipment for fertilizer production installed on site (right).

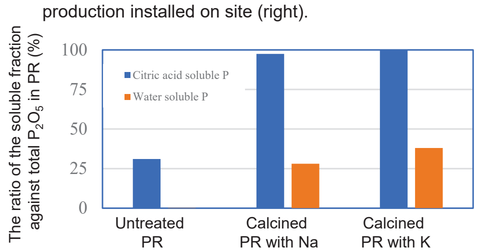


Fig.2. Solubility improvement by calcination with alkali addition.

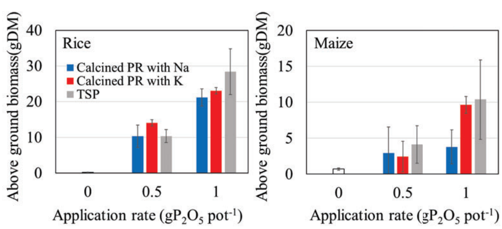


Fig.3. Effect of calcined PR application on rice and maize.

Dipping rice seedlings in phosphorus-enriched slurry or P-dipping increases yield and avoids cold stress of rice

Sustainable agriculture intensification

Production | Implementation | Crop: Rice

Outline

P-dipping at transplanting is a simple and localized phosphorus application technique to efficiently increase lowland rice yields with small amounts of fertilizer inputs.

Background / Effect / Note

P-deficient and P-fixing soils restrict rice production in the tropics. We identified that dipping seedling roots into P-enriched slurry before transplanting (P-dipping) (Fig.1), with optimal P concentration in slurry at 1.8–2.6% and dipping duration less than 2h, is a promising technique to increase rice yields with minimal fertilizer input even under high P-fixing soils. The effect was particularly large under a cool climate condition (Fig.2) because the technique shortens days to heading compared to conventional P application via broadcast, and avoids low temperature stress (Fig.3). The P-dipping technology has been already disseminated to >3,000 smallholder farmers in Madagascar.

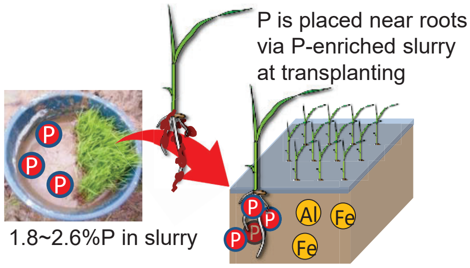


Fig.1. An illustration of the P-dipping technique

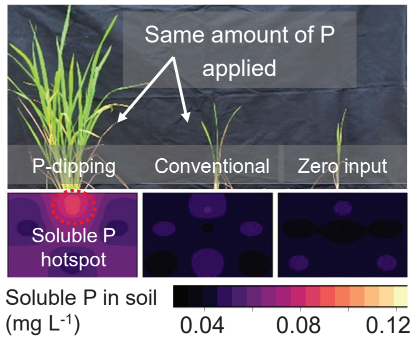


Fig.2. P-dipping effect on initial rice growth and available P content in highly P-fixing soils.

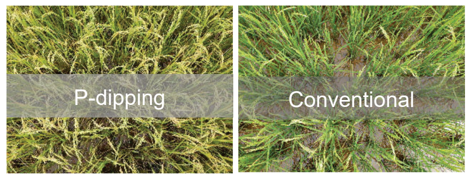


Fig.3. Effect of P-dipping on growth duration of rice.

Details: https://www.jircas.go.jp/en/publication/research_results/2020_b02

Quick soil judging with high spatial resolution using GPR

Sustainable agriculture intensification

Production | Demonstration | Crops: Sorghum, Maize, Cowpea

Outline

Use of ground-penetrating radar (GPR) has made it easier and faster to produce high-resolution soil maps in drylands of Africa. This does not require expertise.

Background / Effect / Note

Because soil mapping requires a high level of expertise and an enormous amount of time and labor, it has been difficult to develop technologies for variety improvement, better crop management, and soil conservation based on soil conditions. Using GPR has made it possible to develop such technologies based on local soil conditions, which will greatly contribute to ensuring food security and controlling desertification (Fig.1). However, the GPR is effective for major soils for which the soil type can be estimated from the depth of iron hardpan, but it is not applicable to some minor soils.

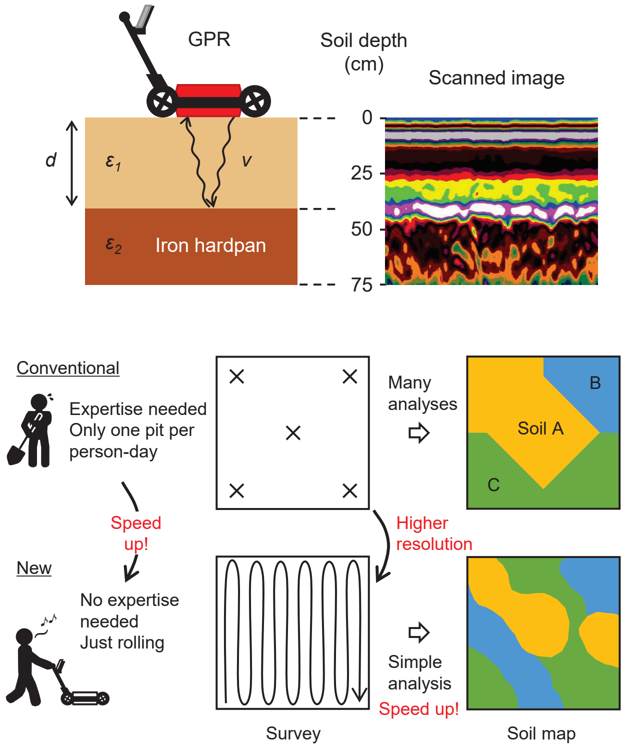


Fig. 1. Comparison of a conventional method and new method

Details : https://www.jircas.go.jp/sites/default/files/seika/2018/2018_A04_A3_en.pdf

Technology Showcase for Africa Af-7

Optimization of conservation agriculture in drylands

Soil conservation

Production | Demonstration

Crops: Sorghum, Maize, Cowpea

Outline

Conservation agriculture (CA), a farming method that combines minimum tillage, crop residue mulching, and intercropping/rotation with legumes to prevent soil erosion, was optimized in drylands, opening the possibility for its future dissemination.

Top left, Wolf spider
Top right, A hole by a wolf spider
Bottom left, Holes by termites

Bars represent 2 cm.
(From: Ikazaki *et al.* 2018)

Background / Effect / Note

CA is not widespread in sub-Saharan Africa because the burden is too heavy. This study shows that only two components, minimum tillage and crop residual mulching, can activate soil macrofauna such as spiders and termites and thereby adequately reduce soil erosion. This findings lighten the burden of adopting CA and facilitates its future promotion to the local farmers in drylands. Since this study targets CA, the effect of intercropping alone on soil erosion control was not examined. Thus, these results do not completely negate the soil erosion control effect of intercropping with legumes per se.

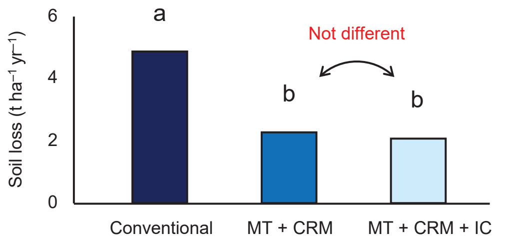


Fig.1. Soil loss (3-year average) for each farming method.
MT, minimum tillage; CRM, crop residue mulching; IC, intercropping.
Different letters indicate significant differences between treatments.
That is, if MT and CRM are employed, additional intercropping will not be effective in reducing soil erosion.

Details: https://www.jircas.go.jp/sites/default/files/seika/2018/2018_A05_A3_en.pdf

Technology Showcase for Africa Af-8

Manual for low-cost irrigation facilities in Africa

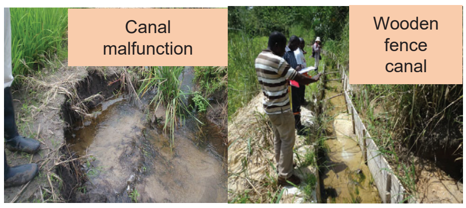
Resource management

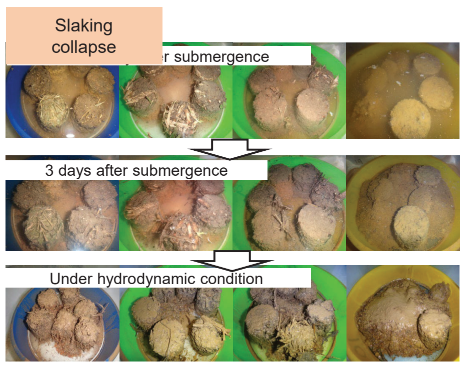
Cultivation | Implementation

Crop: Rice

Outline

In order to implement sustainable irrigated rice cultivation in Africa, water use facilities that are easy to maintain and manage are necessary. Therefore, low-cost irrigation facilities that "can be constructed with farmers' own technology and can be maintained and managed sustainably," are developed. And a manual that can be used by government engineers and extension workers was established.





Background / Effect / Note

Many of the canals in Africa that have been developed using farmer-level technology are earthen canals (trenches dug in the ground to serve as canals). Erosion of earthen canals due to water flow and rainfall reduces the function of the canal (flow of the necessary amount of water to the paddy fields), and in the worst case, the water stops flowing, making it impossible to plant rice. To address this problem, we investigated methods to strengthen the function of earthen canals that can be developed with farmers' skills and capital (funds), including the use of canals protected by wooden fence, the use of local native plants*1, and reinforcing the walls of canals with blocks. These methods were verified in Ghana (e.g., Figure 1: deterioration progression of wooden culverts), and the results were compiled into a manual*2 that (1) provides information necessary for implementation in other regions and (2) is easy for farmers and extension workers to use.

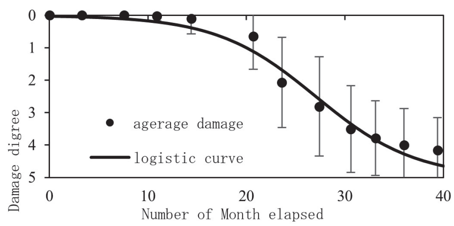


Fig. 1. Deterioration prediction of wooden fence by logistic curve (main canal, valley side)

Details : *1 https://www.jircas.go.jp/en/publication/research_results/2017_b04
*2 https://www.jircas.go.jp/en/reports/2022/r20220601

Technology Showcase for Africa Af-9

Technical manual contributes to water resource use efficiency in irrigation scheme

Resource management

Cultivation | Implementation | Crops: Rice, Vegetables

Outline

The "Technical Manual for Contributing to Efficient Water Use in Irrigation Schemes" describes several methods that contribute to improving water use efficiency in response to water resource constraints and facility degradation, which are expected to become more serious in Africa in the future.

Background / Effect / Note

In response to the growing demand for rice in Africa, development of rice paddies and irrigation facilities has been promoted, and relatively high yields have been realized in some areas. On the other hand, in many areas where irrigation has been established, the initially expected results have not been achieved due to problems such as instability of river flow and a decline in the amount of available water due to the deterioration of irrigation facilities. Therefore, irrigation areas were divided into water sources, water intake facilities, canals, and rice paddies by water conveyance route, and measures to contribute to water resource use efficiency were studied. As a result of the demonstration of the measures in the Lower Moshi Irrigation Scheme (northern Tanzania), it was shown that 2,309 ha of irrigation is possible with the implementation of the measures, compared to the actual irrigation of 1,079 ha in 2019 (Fig.1).

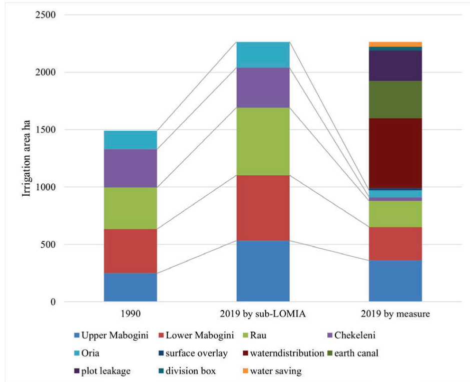


Fig.1. Comparison of actual irrigation area in 1990 with the irrigation area if the water use efficiency measures are implemented in 2019.

Details : https://www.jircas.go.jp/en/reports/2022/r20220621

Technology Showcase for Africa Af-10

Program for creating improved farming plans for African smallholders

Livelihood improvement

Farm management | Implementation | Crop: Any

Outline

The program can quickly identify cropping systems and scale of technology adoption to meet the needs of African smallholders for food self-sufficiency and risk management, and to maximize income.

Background / Effect / Note

There is a lack of tools to efficiently support African smallholders' farm decision-making, including technology adoption. We have developed a user-friendly program that quickly computes the optimal crop and technology choices to maximize income of smallholders with their principal livelihood needs satisfied. These needs include 1) ensuring the area to produce enough subsistence food crops, 2) mixed cropping to cope with production and marketing risks, and 3) ensuring non-farm activities (Fig.1).

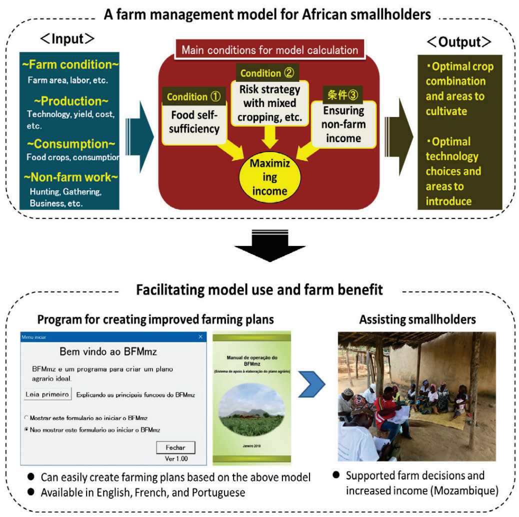


Fig.1. A newly-created program based on a farm management model

Details: https://www.jircas.go.jp/en/publication/research_results/2018_b02
https://www.jircas.go.jp/en/publication/research_results/2020_b06
https://www.jircas.go.jp/en/database/farm_management_model_for_shfa

Technology Showcase for Africa Af-11

Improvement of milk production and profitability by feeding fermented TMR prepared with local feed resources

Livelihood improvement

Production | Demonstration | Commodity: Cow

Outline

Good quality fermented TMR is prepared using locally available feed resources in southern Mozambique. TMR feeding improved the intake, digestibility, milk production and profitability of Jersey dairy cattle.

Background / Effect / Note

In Mozambique, ruminants are raised mainly by grazing in natural grasslands, and especially in the dry season, shortage of feed causes nutritional deficiencies and milk production declines. Fermented TMR (Fig.1) prepared using locally available feed resources is rich in nutrients and meets the nutritional requirements of livestock (Fig.2). TMR feeding improved the intake, digestibility, milk production and profitability of Jersey dairy cattle (Fig.3). Therefore, it is expected that the TMR preparation technology will contribute to the improvement of milk production and livelihood of local people.

Fig.1. Fermented TMR preparation (left), storage (middle) and feeding to dairy cattle (right).

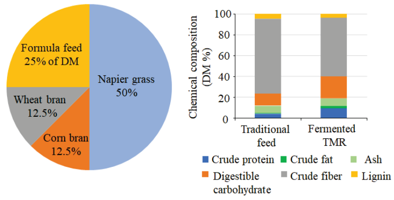


Fig.2. Fermented TMR ingredients (left) and chemical composition (right).
Digestible carbohydrate = carbohydrate – crude fiber - lignin.

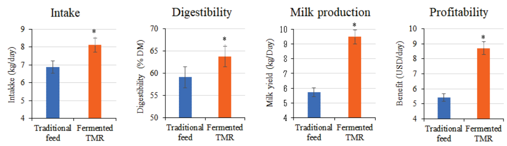


Fig.3. Performance of dairy cattle fed with traditional feed and fermented TMR.
*Means of five cattle differ significantly (p<0.05).

Details:https://www.jircas.go.jp/en/publication/research_results/2020_b05

Technology Showcase for Africa Af-12

Behavioral prediction technologies to improve desert locust control

Integrated pest management

Production | Basic | Crop: Any

Outline

Sexually mature desert locusts form groups with biased sex ratio to either males or females. Just before oviposition, females fly to the male group during the daytime and mate, and the pairs lay eggs in groups at night. By using the male group as a marker, it is possible to predict the mass oviposition site, which is a good target for pest control.

Background / Effect / Note

Desert locust outbreaks sometimes occur in Africa. Mature adult desert locusts form groups with biased sex ratio towards males or females. During the daytime, females fly to the male-biased group just before oviposition to mate (Fig.1), and the pairs lay eggs in groups at night. By using the male group as a marker, it is possible to predict the oviposition site, which is a good target for control. The application of desert locust ecology is expected to lead to natural and environment-friendly pest control that does not require the use of pesticides more than necessary.

Group of mature desert locusts

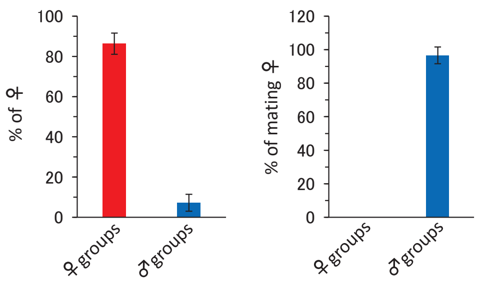


Fig.1. Sex ratios and percentage of mating females of either groups of female- or male-biased sex ratios.

Details : https://www.jircas.go.jp/en/release/2021/press202110

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