[*Jpn. J. Agric. Econ.* Vol.22, pp.74-81, 2020]

The 2019 Annual Meeting of the AESJ International Symposium

Japanese Agricultural ODA and Its Economic Impacts: Technological Assistance for the Rice Green Revolution in Sub-Saharan Africa

Yoko Kijima[1]

Since 2008, JICA has made great efforts toward doubling rice production in Sub-Saharan Africa in 10 years. This study explains JICA's approach and projects and reviews the research findings on JICA's rice training projects. The trainings on rice cultivation practices increased the rice production of the training participants, not only in the short term but also in the long term. The training benefits seem to spill over to the neighbors within the same irrigation scheme. When introducing upland rice to areas where rice was not grown, selecting areas suitable for rice cultivation is a key for sustainable adoption and production.

Key words: agricultural ODA, rice green revolution, Sub-Saharan Africa

1. Introduction

The Coalition for African Rice Development (CARD) was launched in 2008 by the Japanese International Cooperation Agency (JICA) in partnership with the Alliance for a Green Revolution in Africa (AGRA). This is an initiative to support African countries in doubling rice production in 10 years (14 million metric tons to 28 million metric tons). Although JICA has made a great effort and progress by achieving the target in 2018 (JICA 2019), it is not widely known even among agricultural economists and development economists. Therefore, this paper first briefly explains what JICA has been doing under CARD and reviews the impacts of JICA's rice training projects.

To achieve the goal (doubling rice production in 10 years), CARD's role is to coordinate projects in each member country by assiting the formulation of their National Rice Development Strategies (NRDS) (finding the problems and priotizing the areas needed first), to facilitate matching the needs with resources and opportunities (lobbying for funding), and to monitor and share the progress to ensure that the long-term goal would be achieved. CARD's approaches take into account the development of the whole rice value chain, different interventions under different agro-ecologcal conditions (irrigated, lowland, and upland), the development of the human resource capacity of farmers and extension officers, and the promotion of South-South cooperation. In the first phase of CARD, 23 countries were CARD members. By 2018, the total rice production in SSA reached the target.

According to JICA (2018a) which provides a list of CARD-labeled projects implemented, the types of the projects vary across countries. This is because the projects were selected mainly by each member country after the prioritization in NRDS. Within each country, we can identify significant differences in modality, area of intervention (sub-sector), geographical area of intervention, and type of projects by donors.

JICA's main approaches to contribute to CARD are technical cooperation to (1) conduct research for identifying and developing a rice farming system and rice varieties suitable to each country; (2) build the human resource capacity of rice research scientists and extension workers; and (3) to provide technical training to teach how to grow rice and disseminate rice varieties. This is reflected by the fact that human resource development was identified as the most crucial factor but seriously lacking in SSA. In some countries, support on irrigation rehabilitation (Madagascar and Kenya) and post- harvest processing (Nigeria) were implemented by JICA.

In Section 2, we first review some of the findings on the diffusion of the New Rice for Africa (NERICA) variety in upland ecosystems, mainly in areas where upland rice was not cultivated (Uganda, Kenya, and Zambia). In Section 3, we summarize studies examining the effect of JICA rice training programs on farmers' productivity and income,

[1] National Graduate Institute for Policy Studies (GRIPS)
kijima@grips.ac.jp

separately for short- and long-term direct effects on the training participants and spillover effects to non-participants in the training. Then, we provide the preliminary insights of JICA's technical training on the post-harvest processing industry in Nigeria in Section 4. The final section draws conclusions.

2. Research Findings on the Diffusion of NERICA

NERCIA is a new high-yielding variety of upland rice developed to suit the African environment by mixing the resistance of African rice to pests, diseases, and water stress with the high-yield potential of the Asian species (Africa Rice Center (WARDA)/ FAO/ SAA 2008). We review some of the studies examining the adoption of NERICA and its impact on income in Uganda, Kenya, and Zambia.

In 2003, NERICA was introduced in Uganda by the vice-president initiative development program. At that time, upland rice was not widely grown. Thanks to the relatively high price and the increasing demand, rice was considered as a prominent cash crop for poverty reduction. Including JICA, NGOs and other international organizations as well as the government disseminated NERICA seeds to farmers. There were no clear targeting criteria that the program applied to disseminate NERICA seeds across Uganda. Newspaper articles were released and radio programs were broadcast to announce the great success of the program. The average yield is actually higher than that of the traditional rice variety (2.2 ton[1] vs. 1 ton per hectare) even though a half of the sample households grew rice for the first time (Kijima *et al*. 2006).

Two years later, however, we found that a half of the sampled households who adopted NERICA stopped growing it. Kijima *et al*. (2011) examines what causes this high dis-adoption of the upland NERICA variety in Uganda and finds that households in areas with high rainfall variation and low average rainfall are more likely to disadopt NERICA in 2 years.[2] Unreliable rainfall lowers the yield of NERICA and even results in zero harvest. The result implies that NERICA was disseminated even in areas which are not suitable for upland rice cultivation. In the case of Uganda, NERICA could be used for political purposes in some areas. Although rice was considered as a prominent cash crop by farmers, households in areas new to rice production did not have access to rice millers and traders nearby just after the introduction of NERICA, which led to discouragement among the adopters.

While planting upland rice is not so difficult for those who grow maize and much easier than transplanting in muddy fields (lowland rice cultivation), weeding and harvesting activities for upland rice cultivation are much more laborious than those for maize cultivation in Uganda.[3] Unless the rice harvest is high enough to cover labor costs, households may not continue growing NERICA. In the areas suitable for upland rice cultivation, however, NERICA became a main cash crop and introduction of NERICA with the use of proper cropping patterns to maintain soil fertility has contributed to income generation and poverty reduction (Kijima *et al*. 2008). In such areas, a lot of rice millers have started operating where large and long-distance traders come for buying rice (Kijima *et al*. 2013).

Sakurai *et al*. (2014) conducted a randomized control trial (RCT) in Kenya to understand why NERICA was not cultivated in Kenya, unlike Uganda, and more specifically to test if availability of NERICA seeds is a critical reason for the non-existence of NERICA. Sample areas were selected around the Mwea irrigation scheme so that households knew about rice as a cash crop and where to mill and sell rice. The authors list up households who accepted upland rice cultivation in the area. Then a half of them were randomly selected for free distribution of NERICA seeds (10 kgs). The other half of them were promised to be given the rice seeds in the following year. They found that free distribution of NERICA seeds increased the area under NERICA by 0.36 acre. The authors conclude that NERICA can be adopted once the seeds become available. However, farmers obtained seed with zero cost. Furthermore, it is not clear if farmers could manage to harvest rice so that at least they earn positive income from rice cultivation.

Even though the sample area is near the major rice producing area, upland rice cultivation is different from that in irrigated eco-systems. Dependence on rainfall is expected to increase uncertainty and risk in production. Free distribution of the seeds is a good opportunity for farmers to experiment with rice cultivation on their plots. Unless they are successful with growing rice, availability of NERICA seeds cannot increase the adoption rate of NERICA, as seen

1) The yield for those who grew rice for the first time was 1.7 ton per hectare on average while that for those who had grown rice before NERICA was 2.5 tons.

2) Kijima (2019) finds that loss aversion, not risk aversion, is a critical constraint of growing rice in Uganda.

3) Herbicide for rice was not available in the market.

in Uganda.

Kijima *et al*. (2019) conducted an RCT in Zambia to examine if NERICA seeds become available with cost (farmers have to purchase seeds) in areas where the seeds were not available. This is the same question examined in Sakurai *et al*. (2014). In the sample areas where seasonal wetlands (known as dambo) can be utilized for upland rice cultivation, JICA provided NERICA cultivation training to agricultural extension officers and a few lead farmers in 2013. Each officer was given 50 kg of NERICA seeds by the JICA project. Although these officers were supposed to set up demonstration plots and train other farmers, most of the trained officers were transferred to other areas and trained farmers failed to harvest rice and lost seeds for the following seasons.

In 2018, none of the sample households cultivate rice and seeds are not available locally. Milled rice for consumption can be purchased in small shops located within villages. Many people like the taste and consider it convenient for breakfast though they cannot eat it as often as they like since the price is more than double that of maize. Some households claimed that unavailability of the seeds is a main constraint on their cultivation of rice. However, some of them were beneficiaries of free seed distribution. It is possible that they are not willing to pay for the NERICA seeds due to the anchoring effect.

In the survey conducted in 2018, households were asked how much they would be willing to pay for a 2 kg bag of rice seeds. The hypothetical demand for NERICA seeds is quite high: almost all the sampled individuals responded that they were willing to pay for the seeds (5 individuals out of 1,056 interviewed answered not interested in buying rice seeds). However, 34% of them were not willing to pay as much as the market price.

In the next question, we asked how many kilograms of seeds they would like to buy at the market price. Choices were 2 kg, 5 kg, or 10 kg. About half of them answered that they would buy 2 kgs of seeds. This is not surprising as most of the sample households had never grown rice. Although 33% selected 5 kgs and 18% of them selected 10 kgs in hypothetical demand question, actual seed demand was much lower than the hypothetical demand when we went back to the area for selling NERICA seeds at market price.

The proportion of sample households who actually purchased seeds is 41%. Out of those who purchased seeds, 34% purchased just 1 kg and 43% obtained 2 kgs. Those who purchased 10 kgs of seed accounted for just 4%. The rest (23%) purchased 3 - 8 kgs. When adopting new technologies such as a new crop in this case, farmers need to experiment with it on a small scale. Currently, seed companies pack NERICA seeds in 10 kg bags, which is too large for the first-time growers to purchase. This study may suggest that not only availability but also the minimum quantity of seeds purchased at the market affects the adoption of a new crop.

Glennerster and Suri (2017) look at the health benefit of NERICA in Sierra Leone, where rice is the main crop, but their stock runs out before the next harvesting season. Since NERICA has shorter maturity than varieties commonly cultivated there, it can decrease the period when households suffer from shortage of food. They found that the take-up rate at full and half prices is much lower than that with free distribution (21 and 62% vs. 97%). Harvests started 5 weeks earlier for treated households. The rice yield of NERICA is higher than that of the local variety only when treated households got proper training. The positive effect on child health was found only among those who got both seeds and training. Disseminating NERICA seeds without rice cultivation training did not increase the quantity of rice harvested. They found that the cost of the program (free and discounted seed distribution and training) was much higher than the monetary benefits. For improving child health, however, the program is more cost-effective than other health-related interventions. This study clearly shows the importance of the training for optimizing the high-yielding traits of the NERICA variety.

3. Research Findings on Rice Production Training

1) Short-term Impact of JICA's rice cultivation training programs

JICA has been implementing the training on rice cultivation practices in most of the CARD member countries since it can make significant differences in the productivity. Kijima *et al*. (2012) estimates the short-term impact of JICA's pilot project, which teaches lowland rice cultivation practices in Uganda. In study areas, rice growers did not have proper knowledge of rice cultivation, specifically land preparation for storing water evenly (constructing bunds, leveling, and puddling) and transplanting method (early transplanting and enough spacing between seedlings). JICA firstly trained district agricultural officers and extension workers so that they are better equipped to teach such practices to farmers even after the JICA projects phase out. Then JICA experts and agricultural extension workers trained farmers 3 times in a cropping season (before land preparation, transplanting, and harvesting) in demonstration plots. By using ex-post quasi-experimental data and utilizing the different timing of trainings provided, Kijima *et al*. (2012) found that JICA's training increased the adoption of better cultivation practices and the rice yield by 0.7 ton per hectare, which accounts for a 40% increase. As a result, training participants enhanced their income and profit from rice cultivation.[4, 5]

Similar to that in Uganda, JICA provided rice cultivation training in Tanzania. In one of the irrigation schemes, JICA provided intensive training to 20 key farmers at the training institute over 12 days, then each key farmer invited 5 intermediate farmers to training sessions at a demonstration plot within the irrigation scheme in the following year. Key farmers provided training sessions to intermediate farmers at 3 stages of farming (nursery preparation, transplanting, and harvesting). Then both key and intermediate farmers were encouraged by JICA to teach those practices to other ordinary farmers though JICA does not normally provide any incentives or materials to directly trained farmers to train others.

Since it is often the case that government agricultural extension workers do not have resources to implement demonstration to farmers, this farmer-to-farmer extension is considered to increase the cost-effectiveness of the training projects if trained farmers can teach what they learnt in the training to their fellow farmers. Due to the budget and human resource constraints, JICA wishes for the training benefits to spill over. However, it is not known if the farmer-to-farmer knowledge spillover is actually realized in this JICA training project or not.

Nakano *et al*. (2018a) examines the case in Tanzania described above and finds that rice yields of key farmers were higher than those of the others even before the training. In the year when only key farmers took training, the adoption rate and yield increased only among key farmers. In the second year, when intermediate farmers took training, intermediate farmers increased the yield up to the same level as key farmers, which suggests that there is knowledge spillover from key farmers to intermediate farmers. This result may not be surprising since key farmers should have selected those who are more eager to learn and serious about rice cultivation. Furthermore, JICA enforced training provided by key farmers to intermediate farmers in the demonstration plot for 3 sessions a year. The important question is whether trained farmers would have trained ordinary farmers without its being enforced by JICA. This issue of spillover effect will be discussed below.

2) Long-term effect of JICA rice training

These studies confirm that training on rice cultivation practices is effective for increasing rice productivity both in rain-fed lowland and irrigation schemes at least in the short term among direct training participants. By using the panel data collected in 2009, 2011, and 2015, Kijima (2018) examined if the positive effect of JICA's rice training is sustained for 2 years after the training and if so, if it can be found even after 6 years. In JICA's training project in Eastern Uganda (namely, the SIAD project), the agricultural extension officers and JICA experts provided training in demonstration plots on how to conduct better cultivation practices. It is found that the direct training participants maintained the better cultivation practices both 2 and 6 years after the training. Although more empirical evidence is needed to generalize the long-term effects of JICA's training on direct training participants, at least in the case of the SIAD project, JICA's rice training seems to have had a long-lasting effect on enhancing rice productivity by improving cultivation practices.

3) Spillover effect from training participants to ordinary farmers

Studies so far examined the impact of JICA's training program on training participants. It is often the case that JICA's training programs encourage training participants to share the information with neighbors since the cost of JICA providing training to all the farmers would be prohibitively high. To enhance the cost-effectiveness of the training programs, enhancing farmer-to-farmer information spillover is critical.

4) The impact of JICA's training on technology adoption in rainfel lowland area are also found in northern Ghana (He and Sakurai, 2019).

5) Nakano *et al*. (2018b) examines the effect of a USAID-funded training program implemented in rainfed lowland areas near a large-scale rice farming company. The technology package taught is called the Modified System of Rice Intensification (MSRI) but the contents are quite similar to practices taught in JICA training. The difference is that use of a modern variety (SARO5) and chemical fertilizer was also taught during the training in Tanzania. The study found that training participation increases the adoption of better cultivation practices as well as use of the modern variety and chemical fertilizer and the impact on rice yield is 1.3 tons per hectare (50% increase).

Nakano *et al*. (2018a) found that non-trained farmers who are relatives of trained farmers tend to adopt better cultivation practices, which suggests that there is knowledge spillover from trained to non-trained farmers. According to the results from a spatial autoregressive disturbance model, there also seems to be information sharing among neighboring non-trained farmers whose rice plots are close to each other. The paper interpreted this phenomenon to mean that non-trained farmers with social connection to trained farmers first obtained information about better cultivation practices and then the knowledge was shared with neighboring farmers.

These results show potential for knowledge spillover among ordinary farmers but are unexpected since there is no direct information spillover from the trained farmers to ordinary farmers outside of family ties. It is important to examine further how to select key farmers and intermediate farmers for activating knowledge spillover since the cost-effectiveness of the JICA training can be improved.

Beaman *et al*. (2018) tested if selection of key farmers on the basis of network theory increased the adoption rate of the pit planting of maize in Malawi compared with conventional selection of key farmers by the Ministry of Agriculture. In 41% of villages with the conventional selection method, none of them adopted the new technology, while treated villages where key farmers were selected by network theory improved the adoption rate significantly. Since the conventional selection method is the same as what JICA projects normally use, this paper implies that JICA can improve the performance of the project by just changing the way to select key farmers. The problem of this network-theory-based method is the data requirement before the training is implemented. To identify who the optimal key farmers are, the project has to conduct the network census in all villages in target areas.

Takahashi *et al*. (2019) examined this farmer-to-farmer knowledge spillover by using RCT in Côte d'Ivoire in a very unique setting. They first randomly assigned eligibility of participating in JICA training to mitigate likely selection bias on training participation. Then, they restricted the treatment-group farmers from telling what they learnt to the non-trained farmers and the control-group farmers from obtaining information from the treatment-group farmers to avoid contamination in the first year. In the following year, they encouraged the control-group farmers to exchange information with treated-group farmers.

By this unique design, they identified the causal effect of the direct training participation on productivity in the first year as 0.75 ton per hectare and the positive spillover effect from trained to non-trained farmers in the second year. They found that the control-group farmers caught up with the treatment-group farmers after information exchange between treatment and control groups was allowed. The spillover effect is especially larger for those who have a rice plot closer to that of treatment group farmers.

This finding is encouraging since selection of training participants does not necessary depend on network theory but the extension officers need to provide training to a group of randomly selected farmers. It is important to keep in mind, however, that this is a quite unique case. First, the control group and treatment group share rice fields in the same irrigation scheme. Experimenters asked the control group farmers not to seek training information from the treatment group farmers to identify the pure training effects and then announced that the recommended technologies had a positive effect on the rice yield. This setting created a quite different situation from reality.

When agricultural extension agents come to key farmers for disseminating a new technology, potential information seekers (control groups) do not know about the fact that extension agents are bringing a new technology to the village or how well the technology works in their production environment. Therefore, ordinary farmers do not ask key farmers to provide the information. Even if JICA and agricultural extension agents encourage key farmers to teach what they learnt in the training to other fellow farmers, it is hard to imagine that key farmers provide training and visit fellow farmers to exchange the information if they are not required to do so. However, if fellow farmers come and ask key farmers for the information, it is likely that key farmers tell fellow farmers the information.

Thus, the experiment conducted by Takahashi *et al.* (2019) is likely to enhance the demand for the information among the control group farmers, which makes the information spillover easier than in a real setting. In this sense, existence of the project and profitable technology should be broadly informed to all the villagers ahead of time, which is likely to increase the information-seeking by ordinary farmers and then the information will be shared between key farmers and ordinary farmers.

This insight is consistent with Dar *et al*. (2019). The authors conducted RCT in Bangladesh and tested if establishing a demonstration plot increases information sharing about a new rice variety. In treatment villages, farmer-trainers are requested to establish a demonstration plot with an area for the new rice variety and one for a variety commonly cultivated. In the demonstration plot, experimenters provided only sign boards indicating the names of the new variety and an existing variety in the area. From these signs, other villagers know there is a new variety and how it performs compared with a variety they use. Because of sign boards in the demonstration plot, it is likely that even villagers who are not originally in the existing social network of the farmer trainers talk to the farmer trainers and the information about new rice variety is exchanged. The main finding of this study is that in villages with demonstration plot treatment, characteristics of farmer trainers (if they are ordinary farmers or ones who are better connected to many people) do not matter much to increase awareness of the new variety. In contrast, without a demonstration plot, more connected farmer-trainers induce knowledge to a broader population than ordinary farmer trainers.

4. Rice Post-Harvest Training

As we have seen so far, JICA's support in CARD is focused on increases in rice production and productivity by disseminating NERICA seeds to areas without access to irrigation and wetlands and providing technical training on rice cultivation practices to enhance their adoption. In many Western African countries, domestic rice production has been stagnant because it is less demanded by urban consumers than imported rice. Lower demand for domestic rice is mainly explained by the lower quality characterized by foreign matter (stones and sand), darker color, and breakage of grains. In the case of Nigeria, the government requested JICA and other aid agencies to provide support for improving the quality of domestic rice.[6)] JICA provided training on small-scale parboilers how to improve the quality of the parboiling processing. We conducted the survey on rice processors and traders around the JICA project sites. In this section, preliminary findings from the survy are presented.

Parboiling is a hydrothermal treatment to raw paddy, consisting of soaking, boiling, and drying paddy rice. Parboiling changes the physical properties of grain as starch gelatinizes, thanks to the heat treatment in the presence of water (Islam *et al*., 2001). This practice is also observed in other African countries such as Ghana, Egypt, Niger, and Benin (Dutta and Mahanta, 2014). Among those countries, Nigeria is where parboiled rice is strongly preferred, and almost all locally produced rice is parboiled except for making rice flour. Parboiling, if carried out properly, has several benefits such as improvement of the physical, eating, and nutritional quality of milled rice (Manful *et al*., 2009; Odenigbo *et al*., 2013). In relation to milling, parboiling makes it easier to hull paddy rice and as a result, helps obtain a high conversion rate from paddy to milled rice. This is why most small-scale millers in Nigeria use small and simple milling machines compared to other African countries where parboiling is much less common. The benefits of parboiling, however, are not realized if it fails. A typical characteristic of low quality parboiling rice is a brown color due to over-cooking in the bottom of the pot/can. Such parboiled rice results in a high rate of broken milled rice after milling. Although parboiling to some extent mitigates concerns about the quality of paddy rice and equipment with which paddy rice is milled, it also imposes the risk that the quality of milled rice depends on whether parboiling is successfully conducted.

In September 2011, JICA experts conducted experiments under the Rice Post-Harvest Processing and Marketing Pilot Project (RIPMAPP) in Niger and Nasarawa states to identify the causes of lower quality parboiled rice in the conventional methods that small-scale parboilers use. An easy solution for quality improvement is to use a false bottom and lid when cooking rice (JICA, 2018b). The false bottom, which is made of aluminum or stainless with small holes, separates the water and the wet paddy in the pot so that the water under the false bottom is boiled and is changed into steam by heating the pot. Since the boiling water is not in direct contact with the paddy, it decreases the chance of rice in the bottom of the pot being burned and over-cooked. When the false bottom is used with the lid, the steam can be utilized evenly within the pot. These two items can be manufactured easily by local metal shops. In 2012/3, JICA provided training to parboilers in two rice milling complexes near Lafia town (Lafia milling complex and Asakio rice millers) on how to improve the quality of parboiled rice and rented some false bottoms and lids to parboilers so that they tried them and invested in them after learning the benefits.

6) The Chinese government constructed large scale rice mills with de-stoner and graders in Nigeria.

We conducted the survey in February 2014 (during the project) and March 2017 (after the project) in Nasarawa state. We sampled all 6 milling complexes in Nasarawa state. Unfortunately, we do not have the data before the project; we asked when the false bottoms and lids were obtained and how they learnt about false bottoms and lids retrospectively. Another unique feature of the survey is to sample not only parboilers but also traders and millers that are members of processors' associations registered in each milling complex. The total number of panel observations was 278, among which 107 operated parboiling businesses, 168 were engaged in rice trading businesses, and 99 operated rice milling businesses in 2014. Most of the parboilers were engaged in the rice trading business as well (75 out of 107). In 3 years, the numbers of those who engaged in the parboiling and rice trading business increased to 118 and 180, respectively, while the number of rice millers declined to 59. This increase in the number of parboilers was mainly in Lafia milling complex where JICA conducted quality-improving training for parboilers.[7)]

The number of parboilers who got training on quality improvement increased from 42 to 59. Furthermore, the number of parboilers who used false bottoms was 15 in 2014 and all of them were in the Lafia rice mill. The number increased to 32 in 3 years. It seems that JICA's training on parboiling quality improvement increased the investment in quality-improving false bottom. This leads to the better quality parboiled rice processed, which increases the demand for parboiling services in the Lafia rice mill. As a result, it is likely that some of the non- parboilers started parboiling businesses.[8)] More rigorous analyses are required to determine the effectiveness of JICA's training on parboiling activities.

5. Conclusions

This paper provided an overview of JICA's efforts on increasing rice production in SSA since the mid-2000s. Since most of JICA's technical assistance under CARD is related with technical training on lowland rice cultivation practices in irrigated and lowland eco-systems, we reviewed studies examining the effect of rice production training on adoption of the cultivation practices as well as rice productivity and income. The training on rice cultivation practices provided by JICA has increased the rice production of the training participants, not only in the short term but also in the long term. The benefits seem to spill over to the neighbors though further analyses are needed to understand the mechanism and conditions for when and how knowledge spillover can be enhanced.

In terms of NERICA diffusion, the studies reviewed were not evaluations of JICA's projects. However, since JICA has been using NERICA diffusion for increasing rice cultivation area and rice farmers, the research findings are informative for understanding the potential and constraints of disseminating rice to areas without rice-growing experience. Studies imply that selecting areas suitable for rice cultivation is a key for sustainable adoption of NERICA in an upland eco-system when introducing upland rice to areas where rice was not grown.

In 2019, the second phase of CARD was launched with a goal of achieving the production of 56 million metric tons by 2030. This increase is considered crucial to meet the rapidly increasing rice consumption without increasing rice imports. To compete with imported rice, domestic rice producers and processors need to improve the quality as well. As explained in Section 4, processors play an important role in improving the quality of rice. More studies on the rice post-harvest processing sector are urgently needed for understanding what kind of assistance and training are more cost-effective in SSA for quality improvements.

7) Due to the security reason, JICA could not continue to provide training in Asakio rice millers.
8) Komatsu *et al*. (2019) uses the same dataset and examines the traders' performance when they integrate parboiling and milling business.

References

Africa Rice Center (WARDA)/FAO/SAA (2008) NERICA: the New Rice for Africa – a Compendium, E. A. Somado, R. G. Guei, and S. O. Keya eds., Cotonou, Benin: Africa Rice Center (WARDA); Rome, Italy: FAO; Tokyo, Japan: Sasakawa Africa Association. http://www.africarice.org/publications/nerica-comp/Nerica%20Compedium.pdf (accessed on August 28, 2019).

Beaman, L., A. BenYishay, J. Magruder, and A. M. Mobarak (2018) Can Network Theory-Based Targetign Increase Technology Adoption? NBER Working Paper 24912, National Bureau of Economic Research, USA. http://www.nber.org/papers/w24912.

Dar, M. H., A. de Janvry, K. Emerick, E. M. Kelley, and E. Sadoulet (2019) Endogenous Information Sharing and the Gains from Using Network Information to Maximize Tehcnology

Adoption, Working Paper Series No.85, Center for Effective Global Action, University of California.

Dutta, H. and C. L. Mahanta (2014) Traditional Parboiled Rice-based Products Revisited: Current Status and Future Research Challenges, *Rice Science* 21(4): 187-200.

Glennerster, R. and T. Suri (2017) Agricultural Technology and the Hungry Season: Evidence from NERICA Rice in Sierra Leone. *mimeo.* Retrieved on August 2019 from https://ispc.cgiar.org/sites/default/files/files/events/Nairobi%202017/presentations/Parekh_1.pdf.

He, X and T. Sakurai (2019) Transferability of Green Revolution in Sub-Saharan Africa: Impact Assessment of Rice Production Technology Training in Northern Ghana, *Japanese Journal of Agricultural Economics,* 21: 74-79.

Islam, M. R., N. Shimizu, and T. Kimura (2001) Quality Evaluation of Parboiled Rice with Physical Properties, *Food Science and Technology Research* 7(1): 57-63.

JICA (2018a) Coalition for African Rice Development (CARD) Final Review Assessment, Final Report (March 2018).

JICA (2018b) Alternative to Sand-Casted Aluminium False Bottom for Improved Rice Parboiling, https://www.jica.go.jp/nigeria/english/office/topics/180220.html.

JICA (2019) Coalition for African Rice Development (CARD): Official Launching of the 2nd phase, https://www.jica.go.jp/africahiroba/english/ticad/ticad7/c8h0vm0000f5xm9f-att/ticad7_30.pdf

Kijima, Y., D. Sserunkuuma, and K. Otsuka (2006) How Revolutionary is the "NERICA Revolution"? Evidence from Uganda, *Developing Economies* 44 (2): 232-251.

Kijima, Y., K. Otsuka, and D. Sserunkuuma (2008) Assessing the Impact of NERICA on Income and Poverty Reduction in Central and Western Uganda, *Agricultural Economics* 32: 327-337.

Kijima, Y., K. Otsuka, and D. Sserunkuuma (2011) An Inquiry into Constraints on a Green Revolution in Sub-Saharan Africa: The Case of NERICA Rice in Uganda, *World Development* 39 (1): 77-86.

Kijima, Y., Y. Ito, and K. Otsuka (2012) Assessing the Impact of Training on Lowland Rice Productivity in an African Setting: Evidence from Uganda, *World Development* 40 (8): 1610-1618.

Kijima, Y. and D. Sserunkuuma (2013) The Adoption of NERICA Rice Varieties at the Initial Stage of the Diffusion Process in Uganda, *African Journal of Agricultural and Resource Economics* 8 (1): 45-56.

Kijima, Y. and K. Otsuka (2013) Causes and Consequences of NERICA Adoption in Uganda, in K. Otsuka and D. Larson, eds., *A Green Revolution in Sub-Saharan Africa: Finding Ways to Boost Productivity on Small Farms*, Springer, 123-141.

Kijima, Y. (2015) On the Possibility of Rice Green Revolution in Rainfed Areas in Uganda: Impact Evaluation of a Management Training Program and Guidebook Distribution, in K. Otsuka and D. Larson, eds., *Pursuit of an African Green Revolution: Views from Rice and Maize Farmers' Fields*, Springer, 65-90.

Kijima, Y. (2018) Long-term and Spillover Effects of Rice Production Training in Uganda, JICA-RI Working Paper No.161, JICA Research Institute, Tokyo, Japan.

Kijima, Y. (2019) Farmers' Risk Preferences and Rice Production: Experimental and Panel Data Evidence from Uganda, *PLoS ONE* 14(7): e0219202. https://doi.org/10.1371/journal.pone.0219202.

Kijima, Y., K. Miura, and T. Sakurai (2019) Who Should We Target for Agricultural Technology Diffusion? Experimental Evidence from Zambia, Presented in Japanese Association of Agricultural Economics Annual Meeting.

Manful, J. T., L. D. Abbey, and R. D. Coker (2009) Effect of Artisanal Parboiling Methods on Milling Yield and Cooked Rice Textural Characteristics, *Journal of Food Quality* 32: 725-734.

Komatsu, S., Y. Kijima, and T. Sakurai (2019) Do Firm Boundary Decisions Affect Firm Performances? The Case of the Rice Trading Industry in Nigeria, Presented in Japanese Association for Development Economics Annual Meeting.

Odenigbo, A. M., S. A. Ndindeng, C. A. Nwankpa, N. Woin, and M. Ngadi (2013) In vitro Starch Digestibility and Nutritional Composition of Improved Rice Varieties from Cameroun, *European Journal of Nutrition & Food Safety* 3: 134-145.

Sakurai, T., A. Nasuda, H. Murage, and D. Makihara (2014) Impact of Adopting a New Cash Crop: A Randomized Rice Seed Provision Trial in the Kenyan Highlands, *Japanese Journal of Rural Economics* 16: 25-32.

Takahashi, K., Y. Mano, and K. Otsuka (2019) Learning from Experts and Peer Farmers about Rice Production: Experimental Evidence from Cote d'Ivoire, *World Development* 122: 157-169.