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Toward Quality Upgrading of Rice Production in SSA: Experimental Evidence from Northern Ghana

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Abstract

Quality improvement of domestic milled rice is an urgent issue in sub-Saharan Africa (SSA) because domestic rice cannot compete with imports in the growing urban market. Past studies considered poor milling facilities to be a major factor leading to the inferior quality of domestic rice. However, even with the modern milling facilities recently established in SSA, the quality of milled rice is not yet necessarily competitive with imports. Thus, finding ways to improve the quality of paddy remains an important question in SSA. We hypothesize that the lack of knowledge of paddy quality and its relationship with price causes farmers to continue producing low-quality paddy. We conduct a field experiment in northern Ghana to verify this hypothesis. We randomly selected 108 villages and 10 rice producers from each of the villages. From this sample, we randomly chose 54 treatment villages and provided farmers with information about quality-enhancing technologies and quality parameters appreciated by the market. Utilizing data collected before and after the intervention, we found that the intervention significantly influenced farmers in the adoption of some quality-enhancing practices. Moreover, the intervention induced important behavioral changes among the treated farmers: they sold more aromatic varieties of paddy outside the village than the control farmers and received a higher sales price. Thus, we conclude that the provision of information about paddy quality and quality-based pricing improved farmers' paddy production management and market sales. It is noteworthy that even a low-cost intervention without any technical training was able to generate sufficiently desirable outcomes.

Keywords: Rice, Randomized Controlled Trial, Quality Improvement, Price, Ghana

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1. Introduction

Rice production in sub-Saharan Africa (SSA) has dramatically increased over the last decade (Africa Rice Center 2017; CARD 2018). However, it is insufficient to satisfy the increasing demand from urban consumers who prefer high-quality imported milled rice (Demont 2013; Demont and Neven 2013). The gap in quality between imported and domestic rice suggests that rice producers in SSA are not fully capturing the emerging economic opportunities, as urban consumers are willing to pay a premium price for domestically produced and milled rice if its quality is comparable to imports (Rutsaert, Demont, and Verbeke 2013; Demont and Ndour 2015; Fiamore et al. 2017). Therefore, quality improvement of domestic rice is an urgent issue in SSA that needs to be addressed to promote rice production further.

Consumers are concerned with the quality of the milled rice that they purchase and consume. In recent years, modern rice milling facilities have emerged in SSA to meet consumer demand (Soullier et al. 2020; Mano, Njagi, and Otsuka 2022). Yet since the quality of paddy is not sufficiently high, such facilities alone cannot produce high-quality milled rice comparable to imports, and hence, rice millers are looking for high-quality paddy as inputs. Generally, paddy quality depends on farmers' rice production practices, including varietal choice and post-harvesting activities—such as drying and storing—as the types of seeds and physical characteristics of paddy are major determinants of milled rice quality[4] (Futakuchi, Manful, and Sakurai 2013; Rutsaert, Demont, and Verbeke 2013).

However, rice farmers are still producing low-quality paddy in SSA. Conceptually, both supply (producer) and demand (trader or consumer) sides constrain farmers from producing higher-quality agricultural products (de Janvry and Sadoulet 2020; Abate et al. 2021). If paddy price does not depend on paddy quality due to the absence of demand for quality rice, it would be natural for farmers not to undertake any efforts to produce higher quality products. However, this is not necessarily the case. For example, if we ask farmers, they usually say that paddy quality affects the price in our study site[5] (Ogura, Awuni, and Sakurai 2020). Instead, supply-side factors seem to be more significant. Indeed, farmers do not seem to know how to improve paddy quality to obtain higher prices. Firstly, this is because many rice-production projects and extension activities, either foreign or domestic, have focused on enhancing the quantity of rice production rather than

[4] The types of seeds are based on genetic traits such as grain color, grain shape, aroma, and the extent of their mixture. Physical characteristics of harvested paddy are moisture content, degree of crack, maturity, color and damage to the grain, foreign materials such as stones and husks, and rice mixed in pre-milled paddy rice.

[5] For example, damaged paddy cannot be sold for the same average price as undamaged paddy.

quality,[6] and secondly, farmers do not know which particular paddy quality is appreciated by buyers. The latter situation is typical of local staple food markets in rural SSA, where traders and millers are small-scale, and their transactions are in small lots and infrequent (Dillon and Dambro 2017; Bergquist and Dinerstein 2020; Bold et al. 2022). As it is very costly for farmers to investigate and compare the quality of paddy over space and time, a consistent relationship between price and quality cannot emerge. Thus, we hypothesize that the lack of adequate knowledge is a major constraint on upgrading the rice quality in SSA.

From these discussions, a question arises: if farmers understand that there is an opportunity to sell paddy to buyers that pay a premium for paddy quality, will they be able to improve their paddy quality and sell it to such buyers at a better price? This paper seeks to answer this question through a randomized controlled trial implemented in the northern region of Ghana. It shows that the provision of information about paddy quality and quality-based pricing improved farmers' paddy production management and market sales.

The remainder of this paper is organized as follows. In Section 2, we review the literature. Following this, our data collection methods and intervention design are explained in Section 3. Data descriptions are given in Section 4, while Section 5 provides regression analyses and the results. Section 6 offers some concluding comments on this article.

2. Review of Related Literature

This article considers rice farmers' responses to a short training session, which provides them with information about paddy quality improvement and its pricing. We hypothesize that the impact of such new information will influence farmers' behavior in the following three stepwise aspects: first, farmers will update their knowledge of paddy quality and adopt quality-enhancing practices; second, such practices will improve paddy quality; and third, farmers will sell the improved paddy to buyers at a higher price.

With respect to the first step, this study belongs to the literature on agricultural technology adoption in developing countries. The vast number of studies provide various explanations of why potentially profitable agricultural technologies are not adopted or abandoned within a short period (e.g., see Magruder (2018) and Takahashi, Muraoka, and Otsuka (2020) for reviews). However,

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[6] Some projects in the study area (e.g., AGRA project) of this paper have provided information on paddy quality and quality-enhancing technologies in recent years. They mainly conduct projects in irrigated rice production areas, which comprise only a relatively small part of this region. However, this study focuses on rainfed rice production since it dominates the supply of paddy in this region.

most existing studies have focused on quantity-increasing technologies with less focus on quality-enhancing technologies, although the number of studies on the latter issue has been gradually increasing recently.[7] Among these, the closely related studies to ours are Bernard et al. (2017) and Bold et al. (2022).

Bernard et al. (2017) analyzed the impact of quality certification (labeling) on the adoption of quality-enhancing technologies in the case of onions in Senegal. Their randomized intervention announced the upcoming introduction of a quality-certifying system, and they found that it induced farmers to adopt pre-harvest quality-enhancing farming practices (i.e., optimal compositions of chemical fertilizers). Bold et al. (2022) examined the impact of an extension service that aimed to enhance quality with and without an experimental quality premium in the case of maize in Uganda. They found that the extension service combined with premium quality induced farmers to adopt multiple dimensions of quality-enhancing technologies (especially post-harvest technologies), even though the extension service alone did not change farmers' behavior.[8]

Both studies were conducted in study sites where pricing with a quality premium did not exist, but quality-enhancing practices existed and were well known to farmers. These conditions are similar to our study in northern Ghana. However, our case differs from theirs in two ways. First, paddy quality is determined by several elements: different kinds of pre- and post-harvest technologies affect paddy quality, which is an important determinant of product (i.e., milled rice) quality. Therefore, the goal of improving paddy quality is much more complicated than with onions or maize. Second, the quality-based pricing we introduce to farmers is an authentic system used by a large-scale private rice miller in our study site. On the other hand, quality certification in Senegal is done through public regulation: although it had not been implemented at the time of their study, it was expected to become compulsory for all the onion producers in the study area. The quality premium in Uganda is more of a hypothetical setting introduced for their study in cooperation with a private agrochemical company. Thus, this study, which deals with an existing pricing scheme adopted and implemented by a private firm, differs from the two previous studies.

As for the second step, it is important to examine whether the quality-enhancing technologies actually improve quality. This question has also been investigated by Bernard et al. (2017),

[7] These studies are on onions in Senegal (Bernard et al. 2017), groundnuts in Ghana and Senegal (Magnan et al. 2021; Deutschmann, Bernard, and Yameogo 2021), maize in Uganda (Bold et al. 2022), raw milk in Vietnam (Saenger et al. 2013), and dragon fruit in Vietnam (Park 2021; Park, Yuan, and Zhang 2021).

[8] These findings are similar to Magnan et al. (2021), but the main concern of Magnan et al. (2021) is food safety (aflatoxin contamination in groundnut).

Magnan et al. (2021), and Bold et al. (2022).[9] Bernard et al. (2017) assessed product quality as part of the experiment and found that their intervention increased the share of onions judged as "good." Bold et al. (2022) examined the impact of a quality-enhancing service package on product quality and found that their intervention improved the quality of maize. On the other hand, in Magnan et al. (2021), whose concern is food safety, methods for improving product quality (i.e., to reduce aflatoxin contamination in groundnut) were not well known to farmers at the time of the study. They found that their experimental intervention reduced aflatoxin contamination in groundnut in northern Ghana only when the technology information came with a drying sheet.

Our case should fall between the three studies regarding the prevalence of quality-enhancing technologies before the intervention: most rice farmers knew the technologies that may improve paddy quality to some extent, but they did not know precisely what quality parameters would be used to assess the quality of paddy in the market. As for the nature of quality-enhancing technologies, the technologies affect plant growth in the case of onions in Senegal, while in the case of maize in Uganda and the case of groundnut in Ghana, the technologies relate to the improvement of post-harvest treatment and storage. On the other hand, in the case of paddy in Ghana, the quality-enhancing technologies include a wide range of technologies from pre-planting to post-harvest/storage, and naturally, the quality parameters that each technology improves differ. Because of the complicated relationship between the multiple quality-enhancing technologies and the multiple quality parameters, the impact of quality-enhancing practices on paddy quality may not be so clearly identified.

The third step concerns the relationship between paddy quality and its price. Namely, the question is to what extent paddy quality improvement translates into higher paddy prices. In the case of milled rice, several studies investigated consumer preferences toward rice in SSA using experimental auctions (Demont et al. 2013; Demont and Ndour 2015; Demont, Fiamore, and Kinkpe 2017; Diagne, Demont, and Ndour 2017; Fiamore et al. 2017). They found that urban consumers prefer rice that is white, long-grain, aromatic, and high swelling, as well as less starchy and less broken. It also should have fewer contaminants, a soft texture, and a shorter cooking time. Such consumer preferences for milled rice should be reflected in the price when farmers sell paddy to traders or millers.[10] However, few studies support or reject this conjecture, although

[9] The emerging literature has examined the quality upgrading of food products in developing countries. In addition to the literature mentioned in Footnote 4, other papers examined raw milk quality in Indonesia and India (Treurniet 2021; Rao and Shenoy 2021).

[10] Even in the retail market, it is unclear if milled rice price reflects consumer preferences. Regardless of product quality, uniform pricing is often observed in the agricultural retail market in SSA (Bergquist and Dinerstein 2020; Bold et al. 2022). In this regard, Ibrahim, Sakurai, and Tachibana (2020) showed that an

anecdotal evidence (either for or against) can be obtained from the field.[11] Since most paddy rice transactions between farmers and traders are carried out at the farmgate at the study site, collecting paddy samples and recording the paddy price for each transaction in the field is challenging. In addition, since adopting quality-enhancing practices is each farmer's choice, analyzing the impact of the adoption of such practices on paddy quality and price should lead to an endogeneity problem.[12] Therefore, our approach experimentally introduces information about knowledge of paddy quality and a quality-based pricing scheme to treatment villages. It then assesses its impact on farmers' paddy quality and the sale price of paddy, regardless of their adoption of quality-enhancing practices, i.e., intention-to-treat impact.

Overall, our study differs from the three related studies—Bernard et al. (2017), Magnan et al. (2021), and Bold et al. (2022)—in three ways. First, the relationship between production practices and product quality is more complicated in our case than in the case of the three papers. Second, farmers in our study site can choose the type of buyer when they sell paddy, from those who continue the traditional method of transactions by paying little attention to paddy quality or those who determine the purchase price of paddy depending on its quality. Third, all three papers analyze data from experiments in which they provided direct training or support for adopting quality-enhancing technologies. Our study only provided information on quality-enhancing technologies without providing any direct training or support for production. Thus, our contribution is to investigate the possibility of upgrading the multidimensional quality of staple foods in a natural market environment.

3. Data

3.1 Data Collection

Data sets used in this study were mainly collected as a part of the Coalition for African Rice Development (CARD) project, "An Empirical Analysis on Expanding Rice Production in Sub-Saharan Africa," funded by the JICA Research Institute.[13] The JICA research team, with researchers from the University for Development Studies (UDS) and the University of Tokyo, conducted data collection.

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experimental introduction of a wholesaler who adopted quality-based pricing in retail markets in Kumasi, the central region of Ghana, induced the establishment of quality-based pricing among retailers in the markets where the intervention occurred.

[11] In other staple food markets in SSA, Bergquist and Dinerstein (2020) and Bold et al. (2022) found no exact relationship between price and quality in the local maize market in the case of Kenya or Uganda. Do Nascimento Miguel (2022) found that there was a positive relationship between price and observable quality (but not in unobservable quality) in local wheat markets in the case of Ethiopia.

[12] The endogeneity is caused by the possibility that farmers who potentially produce better quality paddy tend to adopt quality-enhancing practices.

[13] This project is also partially supported by a JSPS Scientific Research Grant (grant number: 16H02733).

In March 2018, the research team conducted a stratified random sampling of rice farmers in the following way. First, we drew a 54 km by 54 km square on a 1/50,000 scale topographic map, at the center of which there is a large-scale rice milling plant,[14] and identified 435 villages within the square. Second, we divided the square into nine blocks of 18km by 18km square and randomly selected 12 villages from each block to obtain 108 sample villages.[15] Finally, we created a list of rice farmers in each sample village and randomly drew ten farmers as sample farmers. This process generated 1,080 randomly selected sample rice farmers. Fig. 1 shows the location of sample villages and the large-scale rice milling plant.

The baseline survey was conducted in August and September 2018 (see the timeline in Fig. 2).

The survey gathered information about sample villages and farmers, including production and sales in the previous year, i.e., the 2017 season. Following the baseline survey, an experimental intervention (to be explained in the next section) was implemented through a group meeting in November and December 2018.

Rice production in the 2019 season was the first production after the intervention. Thus, we collected paddy samples from each participating farmer in November and December 2019 and had their quality analyzed[16] by specialists at SARI (Savanna Agricultural Research Institute) near the large-scale milling plant. Finally, end-line information regarding rice production and sales in the 2019 season was collected in December 2020 and January 2021.

[14] We chose this particular large-scale miller as the center of the study area because we adopted the pricing scheme used by this specific miller. When we designed our experimental study in March 2018, there was only one large-scale miller with modern milling facilities in this region, and its sole status continued until the end of our data collection in January 2021. As shown in Fig. 1, the miller is located close to Tamale, the capital city of the northern region where the central market is situated, and hence, the villages we selected for the study are around Tamale. The private milling facilities were established in this location in 2011, and in 2014, the milling company introduced a new pricing scheme for purchasing paddy from farmers, in which the company determines the purchasing price based on their evaluation of paddy quality. For example, when the authors visited the company in January 2018, they observed a notice indicating that the company's purchase price is 1.25 GHS/kg for aromatic paddy and 1.10 GHS/kg for non-aromatic paddy in the case of grade A paddy, and 1.10 GHS/kg and 1.05 GHS/kg in the case of grade B paddy (the exchange rate was about 1 GHS = 0.22 USD in January 2018). Unlike in local markets, where seasonal price changes are significant, the paddy purchase price of the company is constant throughout the year. Such a pricing scheme attracts more paddy in the harvesting season and allows the rice milling plant to collect better-quality paddy.

[15] The number of sample villages in each block is determined by the data collection capacity of the research team.

[16] The paddy quality analyses adopted the same eight parameters that the large-scale rice miller used, assessing aroma, moisture content, cracked rice, foreign materials, red grain, variety mixture, discolored grain, and immature grains.

3.2 Intervention

In order to implement an experimental intervention, we first randomly assigned treatment status to half of the sample villages. The assignment was stratified by a block unit with nine blocks. Six villages from 12 villages were randomly selected for the treatment in each block. As a result, we had 54 treatment villages and 54 control villages.

In November and December 2018, we conducted a group meeting in each of the treatment villages to provide sample farmers with information on the existence of and details about the pricing system adopted by the large-scale rice milling plant.[17] The meeting was conducted in cooperation with the manager of the large-scale rice milling plant and agricultural extension agents of MoFA (Ministry of Food and Agriculture) assigned to treatment villages. All the sample households were encouraged to participate in the group meeting in the treatment villages.[18]

In the group meeting, the research team provided two kinds of information. The first one comprised business information, and the second one consisted of technical information about paddy quality.[19] The business information includes the concept of the grading and pricing schemes, the plant's location, the procedure to sell paddy to the plant, and the contact phone number of the manager. The technical information includes the definition of eight quality parameters that the system uses to evaluate paddy quality (as explained in footnote 13), the determinants of eight quality parameters, and recommended practices for attaining good paddy quality.[20] The two components are the same package the company uses in regular business

[17] According to an official announcement from the large-scale rice milling company, the company will purchase paddy from any rice farmers or entities who bring paddy to the company. However, very few small-scale rainfed rice producers around the mill knew about the quality-based pricing in 2017 when we started casual interviews with them.

[18] Although most of the sample farmers participated in the group meeting, we provided the same handout used in the meeting to those who were absent from the meeting.

[19] It is important to note that "quality" used in this paper refers to something observable in paddy that potentially influences the sale price after milling. The important point about the quality grading system is that most parameters depend on farmers' production, harvesting, and post-harvest practices, although some parameters are additionally affected by weather conditions during production. Also note that the large-scale milling plant indicates the eight parameters, but local traders do not necessarily use all of the parameters in trading with farmers. Among the eight parameters, the aroma is mainly determined by rice varieties, and aromatic rice varieties have become popular in the Tamale area, as revealed by Ogura and Sakurai (2019) and He and Sakurai (2019). However, in 2012 when their data were collected, it was not yet clear whether local traders had paid a higher price for the paddy of aromatic rice than non-aromatic rice.

[20] These are pre-planting practices (use of aromatic varieties, use of certified seed, seed selection in salt water, and uniform plant growth by leveling), pre-harvesting practices (timely harvesting by the use of

promotions. The information was given to farmers not only orally but also through a handout written in the local Dagbani language.[21]

The exposure to the group meeting creates an exogenous variation in access to information about paddy quality and sales opportunities. Thus, we hypothesize that the intervention will induce farmers to update their knowledge of paddy quality, change their rice farming practices, improve paddy quality, and obtain higher paddy prices.

4. Data Descriptions

4.1 Descriptive Statistics of Baseline Characteristics

Table 1 shows the comparisons of baseline characteristics between the treatment and the control groups. Columns (1) and (2) are full samples interviewed during the baseline survey, and Columns (3) and (4) are subsamples that were available for the endline survey and used panel data analysis for this study.

Farmer (i.e., the household member responsible for rice cultivation) characteristics include gender, age, English literacy, household head status, birthplace, polygamous status, health condition, rice cultivation experience, ethnic group, and household asset holdings. Village characteristics are represented by the distance in km from the village to the central market of Tamale. As for the characteristics of the rice plots, plot ownership, slope, soil, water source, flood frequency, and plot size are compared. As shown in Columns (1) and (2) of Table 1, there is no significant difference between the two groups on average at the time of the baseline survey, except for the share of the Dagomba ethnic group and plots with a steep slope. Thus, apart from these aspects, the random samples are well balanced.[22]

Columns (3) and (4) compare the baseline characteristics of the sample farmers interviewed for the endline survey. Forty-two farmers were unavailable at the time of the endline survey due to being deceased, sick, absent long-term, or rejecting participation. Despite the attrition, it does not seem to have affected the balance between the treated and

machine harvester), and post-harvesting practices (threshing and quick drying on tarpaulin and winnowing). Most practices were already known to rice producers in the study site, but the intervention specifically told them about the relationship between those practices and the eight quality parameters.

[21] Dagbani language is spoken by the Dagomba ethnic group and is the dominant language in terms of the proportion of speakers in the study site.

[22] The total number of farmers selected from the list of rice farmers was 1080 (10 farmers x 108 villages). However, the survey team could not reach some, and hence, the total number of samples at the baseline survey is 1065.

the control groups since the significance level of mean difference is almost the same for the baseline characteristics except for some plot characteristics.[23]

4.2 Descriptive Statistics: Outcome Variables

Table 2 shows the descriptive statistics of the outcome variables of interest that we will use in the regression analysis in the next section.

Knowledge

Panel A of Table 2 is for knowledge about paddy quality that we taught in the group meeting as an indicator of the effectiveness of the intervention. We use two knowledge variables: knowledge of good practices necessary for obtaining a good quality of paddy rice (i.e., quality-enhancing practices) and knowledge about the measurements of paddy quality (i.e., quality parameters). In the interview, we asked farmers to mention quality-enhancing practices and paddy quality parameters that they know. Then, we use the aggregated number of correct items as the measure of the two kinds of knowledge. As shown in Columns (1) and (2) of Panel A, for an unknown reason, farmers in the treatment villages had significantly less knowledge of both quality-enhancing practices and quality parameters before the intervention. However, after the intervention, the knowledge gaps became smaller, and the statistical significance of the gaps disappeared, as shown in Columns (3) and (4). Simple DID estimates confirm that the change in the treatment group is significantly larger than in the control group (Column (5)). Overall, the farmers who received the intervention tended to have increased knowledge, suggesting the intervention was effective.

Quality-enhancing Practices

Quality-enhancing practices include pre-planting, harvesting, and post-harvesting practices, which are measured based on the use of each technology at the household level.

Pre-planting practices comprise “use of aromatic varieties”, “use of certified seed” and “seed selection in salt water”—all of which are binary dummies. The dummy for aromatic varieties takes 1 if the farmer states that they planted AGRA or Jasmine 85, which are aromatic rice varieties that have been disseminated as improved, high-yielding varieties at the study site. As shown in Panel B of Table 1, more than 30% of farmers grew aromatic rice. The share of farmers who grew aromatic rice became significantly higher in

[23] This does not mean that the attrition happened randomly. As shown in Table A1 in the Appendix, the baseline characteristics of the samples attrited are significantly different from the remaining samples in some aspects.

treatment villages than in control villages after the intervention, but no DID impact is observed. On the other hand, the share of certified seed use was significantly higher in control villages than in treatment villages before as well as after the intervention. However, according to DID estimates, the differences were not significant following the intervention. As for seed selection, the adoption rate was very low and did not differ before or after the intervention. Plot leveling had been introduced in the study site as a yield-enhancing technology, but it also contributes to quality-enhancing thanks to its effect on the uniform growth of plants. Although the adoption rate was significantly higher in treatment villages before and after the intervention, the adoption rates were generally low and were not affected by the intervention. Thus, overall, the intervention seems to have had little impact on pre-planting quality-enhancing practices.

Harvesting and post-harvesting practices are represented by "machine harvesting" and "threshing on tarpaulin sheet." Machine harvesting (i.e., harvesting using combine harvesters) is not just for labor-saving but will improve paddy quality by enabling farmers to avoid excessively dry paddy due to harvest delays, while the use of a tarpaulin sheet is designed to avoid contamination from the soil. The adoption rates of these practices were different both before and after the intervention: they are generally low in the case of machine harvesting (i.e., the use of a combine harvester), while they sit at more than 40% in the case of using a tarpaulin sheet for threshing. However, the intervention had a positive and significant impact on both practices. Therefore, the intervention seems to have increased the adoption of harvesting/post-harvesting quality-enhancing practices.

Paddy Quality

We use paddy quality parameters as the outcomes for paddy quality. We obtained a paddy sample only after the intervention; hence, there is no baseline data. The quality parameters are foreign material (% by weight), a mixture of varieties (% by weight), detection of aroma (binary dummy), damaged rice (% by weight), immature rice (% by weight), dehusked rice (% by weight), and cracked rice (% by weight). Moisture (excessively wet) indicates to what extent the sample paddy is wetter than the optimal moisture content (12~14%) measured by the absolute value of the difference in moisture content (if the sample is drier than the optimal, the value is set to be zero). Similarly, moisture (excessively dry) indicates the extent of dryness by the absolute difference in moisture content on the dry side (i.e., the drier, the larger the value becomes). While "excessively wet" can be reduced by drying under the sun, "excessively dry" cannot be adjusted once the paddy becomes too dry, causing broken rice after milling. Therefore, we consider that they are different problems. However, we created a combined indicator of suboptimal moisture content, referring to the absolute value of the percentage point difference from the optimal level.

As shown in Panel C of Table 1, which offers a simple mean comparison after the intervention, only two parameters, i.e., the use of aromatic varieties and moisture content (excessively dry), are better for farmers in treatment villages than those in control villages. On the other hand, a mixture of varieties and moisture content (excessively wet) are better in control villages. Higher aroma detection and lower dryness in the treatment villages seem to be consistent with the quality-enhancing practices shown in Panel B—namely, farmers in treatment villages tend to use aromatic varieties and harvesting machines after the intervention. On the other hand, the higher mixture rate of different varieties in treatment villages also seems to reflect the lower use of certified seeds in treatment villages, as shown in Panel B. Although the use of tarpaulin for threshing is higher in the treatment villages after the intervention, as shown in Panel B, it does not significantly reduce the contamination of foreign material. Thus, although the overall quality of paddy is not as high in treatment villages compared to control villages, we can observe some improvement in important parameters, namely aroma and moisture (dryness side), which is consistent with the change in quality-enhancing practices.

Paddy Sales

For the analysis of the rice sales, the rice sales data are averaged at the household level. Since we use farmers who sold paddy (not in other forms like milled rice and parboiled rice) both in 2017 (recorded in the baseline data) and 2019 (recorded in the endline data), the number of observations in each year is 718. One of the outcomes is whether farmers always sold paddy outside the village, which includes cases where farmers brought paddy to a market or a miller outside the village and cases where farmers sold paddy to buyers coming from outside the village. This behavior is considered to involve seeking a better price compared to selling paddy to a local buyer who lives in the village. Other outcomes comprise whether they always sold aromatic varieties, the average paddy sale price (GHS/kg), the average paddy sale price net of transportation costs (GHS/kg), the total amount of paddy sales (kg), and the total amount of paddy sales revenue (GHS). Panel D of Table 2 shows that farmers in treatment villages increased paddy sales outside of the village and sales of aromatic varieties much more than those in control villages. For an unknown reason, the paddy price went down during the two surveys in the study site, but the price decline was much smaller among farmers in the treatment villages than the control villages.

5. Regression Analysis

5.1 Regression Specifications

The impact of the exposure to the exogenous information provision on the farmers' decisions is statistically assessed using an ANCOVA model (McKenzie 2012) as follows;

$$Y_{ikm1} = \alpha + \beta Y_{ikm0} + \delta T_{km} + \boldsymbol{\gamma} \boldsymbol{X}'_{ikm0} + \omega_m + \varepsilon_{ikm} \quad (1)$$

where subscript i is for household, k is for village, and m is for block. Time indicator takes 1 if the observation is of the end-line or takes 0 if it is of the baseline. Y_{ikm1} and Y_{ikm0} are the outcomes in the 2019 season and in the 2017 season, respectively. T_{km} is the indicator variable that takes the value of 1 if the village is assigned to the treatment. $\boldsymbol{X}_{ikm0}$ is the set of control variables of characteristics of farmers at the baseline, including the distance (km) from the village to the central market in Tamale, which is a village-level variable. In addition, ω_m is block fixed effect, α is constant, and ε_{ikm} is the error term. In the case of paddy sales, each sale made by sample farmers was recorded. However, for the analysis, they are averaged at the household level for each year, with equation (1) also applied. Standard errors are clustered at the village level, which is the unit of the random assignment to the treatment, to account for the correlation in error terms within villages. Given the exogenous assignment of T_{km}, the coefficient δ is interpreted as the average treatment effect. As noted above, some treatment sample farmers did not attend the group meeting, so that the effect is considered as an intention-to-treat effect.

Since we measured the quality of the paddy sample only after the intervention, we do not apply the ANCOVA model specified as equation (1). Instead, we simply conduct a mean comparison between the two groups as shown in Panel C of Table 2. An OLS regression can be applied, but since the results are qualitatively very similar, this study does not show regression results. As paddy samples were obtained from each plot of the sample households, the outcome variables are at the plot level.

5.2 Regression Results

Knowledge

Table 3 shows that the impact of our intervention on knowledge, either quality-enhancing practices or paddy quality parameters, is not statistically significant in spite of the significant estimates of simple DID, as shown in Panel A of Table 2. As shown in Fig. 2, the endline survey was conducted two years after the intervention. Thus, the insignificant impacts may imply that the knowledge tends to be lost after two years. However, it does not necessarily mean that the intervention was ineffective for rice production or sales because rice production started only six months after the information provision, as shown in Fig. 2. In fact, as will be shown in the following sections, farmers in treatment villages adopted some of the quality-enhancing practices and obtained higher sales prices.

Technologies

Table 4 shows the adoption of the quality-enhancing practices. Significant DID estimates are obtained for "machine harvesting" and "threshing on tarpaulin sheet," as shown in Panel B of Table 2 and confirmed by ANCOVA regressions. The results indicate that the intervention had a positive impact on harvesting and post-harvesting technologies to improve paddy quality, but not pre-planting technologies. As discussed above, these significant changes in quality-enhancing practices seem to contribute to the reduction of excessive dryness, but not the reduction of foreign materials. As for the aroma, farmers may have increased the share of aromatic varieties and/or chosen better aromatic varieties. Such a change in practice is not reflected in the binary dummy for the use of aromatic varieties.

Sales results

Finally, Table 5 shows the results of paddy sales. First, there is a statistically significant impact on paddy sales: farmers in treated villages sold paddy more outside their villages than the farmers in control villages (Column (1)). However, we cannot find any significant impact on the sales of aromatic varieties (Column (2)). This is consistent with Table 4, which shows that the intervention did not increase the share of aromatic varieties significantly. As for the paddy sales price (net of transportation cost), the average price is higher in treatment villages than in control villages regardless of the sales outlets or rice varieties (Column (3)). Since sales prices should be affected by the sales outlet as well as rice varieties, we include those variables as explanatory variables. Because they are endogenous binary dummy variables, the intervention is used as an instrumental variable and an endogenous treatment model is applied. The results in Columns (4) and (5) indicate that both sales outside the village and aromatic varieties have a significantly positive effect on paddy sale price. The coefficient for sales outside the village (0.662) seems to be too large compared to the average paddy prices net of transportation cost (from 1.10 to 1.33) for unknown reasons. On the other hand, the coefficient for aromatic varieties (0.100) is reasonable compared with the aroma premium paid by the large-scale miller, as discussed in footnote 11. Thus, our intervention increases the paddy sales price through the change in sales location and the use of aromatic varieties. We also confirm that the intervention increases farmers' paddy sales volume and the revenue from the sales, as demonstrated in Columns (6) and (7).

6. Conclusion

This study examined the impact of information provision regarding paddy quality and quality-based paddy pricing on farmers' rice production and marketing in the Northern region of Ghana through a randomized controlled trial. The effectiveness of the intervention is examined by assessing the change in farmers' knowledge about paddy quality-enhancing practices and paddy quality assessment parameters. Although simple DID estimations show significant impacts of the intervention on farmers' knowledge, regression results do not fully confirm it. Nevertheless, farmers who receive the paddy quality information seem to try to improve the quality, particularly through the adoption of harvesting/post-harvesting technologies. Although we cannot directly demonstrate the consequences of such technology adoption on paddy quality due to data limitations, there are positive associations between the intervention and improved quality parameters, such as more aroma and optimal moisture (less excessive dryness). Our analyses further found several important impacts on paddy marketing: farmers in treatment villages increased sales outside the village and aromatic varieties, and as a result, the average sale price of paddy is higher in treatment villages than in control villages. We consider that these changes in paddy marketing were induced by our information provision, demonstrating that there are opportunities to sell "better quality paddy" at higher prices outside the village. It is confirmed by the finding that either sales outside the village or sales of aromatic varieties increase paddy sales prices.

With respect to quality-enhancing technologies, the impact of our intervention was not substantial, and farmers need to learn more about good practices. Since our intervention was only a short training that provided farmers with information about technologies and did not show how to implement them in practice, this low and modest impact is not unexpected. Rather, we can say that our low-cost intervention can generate sufficiently good outcomes. If more technical training is carried out simultaneously, the impact could be much greater. It is therefore advisable that any technical training should include quality and marketing aspects for the participants to get a larger benefit.

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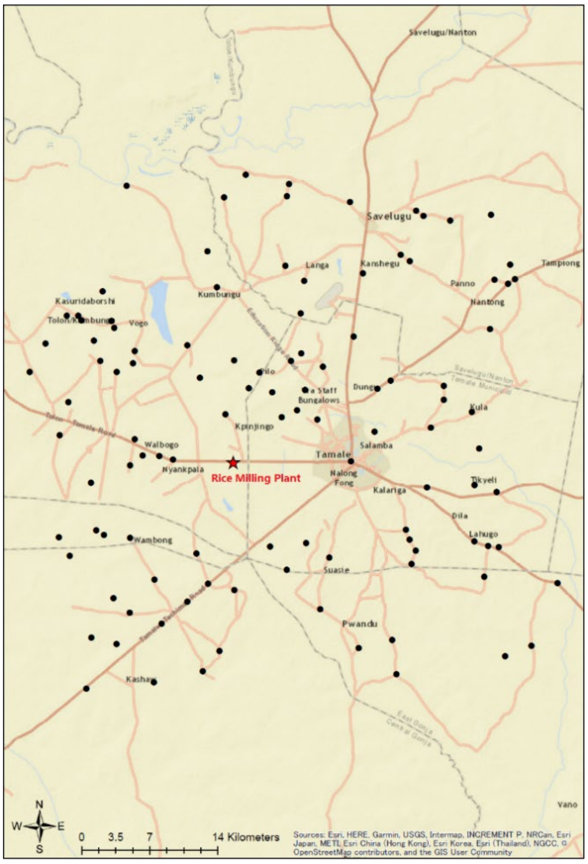

Figure1: Location of Sample Villages

Source: The locations of villages and rice milling plant are authors' own.

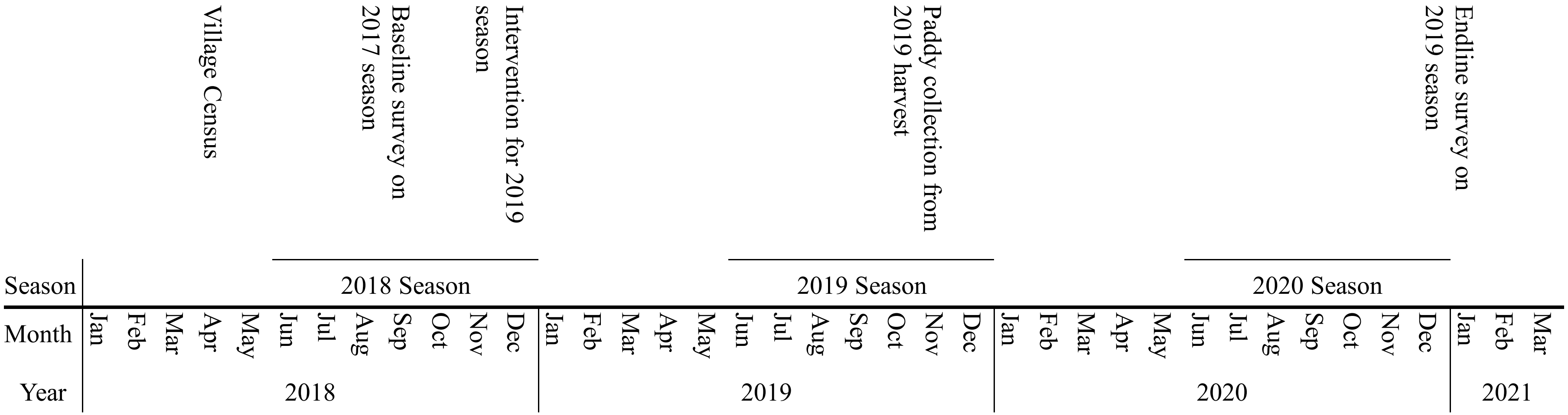

Figure2: Timeline

Source: Authors' own

Table 1: Household/Plot Baseline Characteristics

	Randomly selected samples			Samples in the panel data		
	(1) Treatment	(2) Control	P-value	(3) Treatment	(4) Control	P-value
A: Household (respondent's) characteristics						
Gender (Male =1, Female =0)	0.95	0.96	0.38	0.95	0.96	0.37
Age (Years)	41.0	41.4	0.49	40.9	41.5	0.41
English literacy (speak, read, and write) (1 or 0)	0.08	0.08	0.63	0.08	0.09	0.62
Household head (1 or 0)	0.67	0.67	0.95	0.67	0.67	0.86
Born in the current village (1 or 0)	0.77	0.78	0.70	0.78	0.79	0.71
Polygamously married (1 or 0)	0.44	0.45	0.92	0.44	0.44	0.91
Good health status (1 or 0)	0.98	0.98	0.84	0.98	0.98	0.64
Rice cultivation experience (years)	13.4	12.6	0.16	13.3	12.6	0.21
Value of asset holdings (1000 GHS)	13.3	17.9	0.34	13.6	15.6	0.65
Ethnic group (Dagomba = 1, others = 0)	0.89	0.84	0.01***	0.89	0.84	0.01***
Distance to the central market (km)	20.85	21.04	0.70	20.87	21.17	0.54
Number of observations[1]	534	531		514	509	
B: Plot characteristics (not used in regression analyses)						
Household's own plot (1 or 0)	0.81	0.78	0.19	0.83	0.80	0.35
Steep sloping (1 or 0)	0.05	0.07	0.09*	0.04	0.07	0.10
Fertile soil (1 or 0)	0.35	0.39	0.18	0.33	0.40	0.03**
Rainfed plot (1 or 0)	0.95	0.97	0.14	0.95	0.96	0.32
High frequent flood (1 or 0)	0.025	0.016	0.34	0.023	0.009	0.11
Rice plot size (ha)	1.41	1.26	0.27	1.40	1.24	0.23
Number of observations[2]	480	492		426	423	

Source: Authors' own

* p<0.1, ** p<0.05, *** p<0.01

1) We interviewed 1065 rice farmers during the baseline survey in 2018, but could only meet 1023 of them for the endline survey in 2020/21 because of death, sickness, long-term absence, rejection, etc. Thus, the 1023 farmers constitute a two-year panel for the analyses.

2) Some plot characteristics were intended to be obtained by actually visiting the plot in question with GPS equipment, and as a result we failed to obtain data from some sample plots. Because of the missing data, this paper does not use the plot characteristics for the analyses.

Table 2: Descriptive Statistics of Outcome Variables

	Before Intervention			After Intervention			
	(1) Treatment	(2) Control	P-value	(3) Treatment	(4) Control	P-value	(5) DID
A: Knowledge of Paddy Quality							
Quality-enhancing practices (Score: 0 – 7)	3.06	3.46	0.00***	3.48	3.64	0.12	0.25**
Paddy quality parameters (Score: 0 – 9)	2.70	2.98	0.00***	3.33	3.23	0.35	0.36***
Number of observations	514	509		514	509		
B: Quality-enhancing Practices							
Use of aromatic varieties (0 or 1)	0.35	0.31	0.11	0.38	0.34	0.09*	0.00
Use of certified seed (0 or 1)	0.08	0.12	0.04**	0.09	0.13	0.02**	-0.00
Seed selection by salt water (0 or 1)	0.002	0.002	0.50	0.004	0.004	0.50	-0.00
Plot leveling (0 or 1)	0.025	0.004	0.00***	0.023	0.003	0.00***	-0.00
Machine harvesting (0 or 1)	0.029	0.002	0.00***	0.039	0.002	0.00***	0.01*
Threshing on tarpaulin sheet (0 or 1)	0.48	0.44	0.15	0.51	0.44	0.02**	0.04***
Number of observations	514	509		514	509		
C: Paddy Quality (laboratory examination)							
Foreign material (weight %)	NA	NA	NA	0.70	0.73	0.67	NA
Mixture of varieties (weight %)	NA	NA	NA	2.52	2.01	0.08*	NA
Aromatic (0 or 1)	NA	NA	NA	0.53	0.46	0.07*	NA
Damaged rice (weight %)	NA	NA	NA	68.5	68.7	0.93	NA
Red rice (weight %)	NA	NA	NA	16.2	16.3	0.97	NA
Immature rice (weight %)	NA	NA	NA	1.48	1.30	0.66	NA
Dehusked rice (weight %)	NA	NA	NA	0.68	0.69	0.83	NA
Cracked rice (weight %)	NA	NA	NA	68.2	64.5	0.15	NA
Moisture (too wet) (% point)	NA	NA	NA	0.31	0.07	0.03**	NA
Moisture (too dry) (% point)	NA	NA	NA	3.83	4.30	0.06*	NA
Moisture (too wet/dry combined)	NA	NA	NA	4.14	4.37	0.22	NA
Number of observations				419	405		
D: Paddy Sales							
Sales outside the village (0 or 1)	0.52	0.58	0.15	0.62	0.50	0.00***	0.18***
Sales of aromatic varieties (0 or 1)	0.17	0.28	0.00***	0.44	0.42	0.60	0.12***
Paddy sale price (GHS/kg)	1.25	1.34	0.01**	1.17	1.10	0.07*	0.17***
Paddy price net costs (GHS/kg)	1.24	1.33	0.01**	1.17	1.10	0.06*	0.16***
Total paddy weight sold (kg)	1648	1397	0.14	1522	1221	0.10*	50.0
Paddy sales revenue (GHS)	2178	1928	0.38	1555	1331	0.10*	-24.7
Number of observations[1]	373	345		373	345		

Source: Authors' own

Note: DID is {(3)-(4)}-{(1)-(2)} for Panel A, B, and D; 1 GHS = 25 JPY in January 2018.

* p<0.1, ** p<0.05, *** p<0.01.

1) We collected rice sales data from all the sample farmers who sold rice (either paddy or in any other form, such as milled rice or parboiled rice). However, for this analysis we use only farmers who sold paddy. Total number of farmers who sold rice is 926 at the baseline and 841 at the endline. Among these, 885 and 827 farmers sold paddy in the respective surveys. After eliminating some observations with outlier sale prices, a total of 718 constitute a balanced panel data for the analysis. We had to drop a significant number of observations because many farmers sold paddy in only one of the survey years.

Table 3: Impact on Knowledge about Paddy Quality

	(1) Knowledge: Quality-enhancing practices	(2) Knowledge: Paddy quality parameters
Intervention	-0.015	0.212
	(0.240)	(0.200)
Household level baseline variables	Yes	Yes
Block fixed effect	Yes	Yes
Number of observations	1023	1023

Source: Authors' own

Note: Standard errors clustered at the village level are in parentheses.

Table 4: Impact on Adoption of Quality-enhancing Practices at Plot Level

	(1) Plot leveling	(2) Certified seed	(3) Aromatic varieties	(4) Seed selection	(5) Machine harvesting	(6) Threshing on sheet
Intervention	0.002	-0.004	0.010	-0.000	0.016*	0.037**
	(0.004)	(0.004)	(0.022)	(0.002)	(0.009)	(0.015)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes
Block fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
# of observations	1023	1023	1023	1023	1023	1023

Source: Authors' own

Note: Standard errors clustered at the village level are in parentheses.

* p<0.1, ** p<0.05

***Table 5**:* Impact of Intervention on Paddy Sales

	(1) Sales outside the village (dummy)	(2) Sales of Aromatic varieties (dummy)	(3) Paddy Sales Price (GHS/kg)	(4) Paddy Sales Price (GHS/kg)	(5) Paddy Sales Price (GHS/kg)	(6) Total paddy sales in weight (kg)	(7) Total paddy sales in value (GHS)
Intervention	0.145**	0.028	0.061*	NA	NA	322*	255*
	(0.056)	(0.045)	(0.036)			(178)	(142)
Sales outside the village	NA	NA	NA	0.662*	NA	NA	NA
				(0.346)			
Sales of aromatic varieties	NA	NA	NA	NA	0.100***	NA	NA
					(0.054)		
Household control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Block Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# of observation	718	718	718	718	718	718	718

Source: Authors' own

Note: Standard errors clustered at the village level are in parentheses.

* p<0.1, ** p<0.05, *** p<0.01.

Table A1: Comparison of Baseline Characteristics between Remained and Attrited

	(1) Remained	(2) Attrited	P-value
A: Household (respondent's) and village characteristics			
Gender (Male =1, Female =0)	0.96	0.95	0.89
Age (Years)	41.2	40.6	0.72
English literacy (speak, read, and write) (1 or 0)	0.08	0.05	0.42
Household head (1 or 0)	0.67	0.64	0.73
Born in the current village (1 or 0)	0.78	0.57	0.00***
Polygamously married (1 or 0)	0.44	0.50	0.44
Good health status (1 or 0)	0.98	0.93	0.02**
Rice experience (years)	12.9	15.5	0.08*
Household value of asset holdings (1000 GHS)	14.6	39.5	0.04**
Ethnic group (Dagomba = 1, others = 0)	0.87	0.88	0.77
Distance to the central market from the village (km)	20.02	19.03	0.11
Number of observations	1023	42	
B: Plot characteristics			
Household's own plot (1 or 0)	0.82	0.67	0.00***
Steep Sloping (1 or 0)	0.058	0.065	0.75
Fertile soil (1 or 0)	0.37	0.40	0.49
Rainfed plot (1 or 0)	0.96	0.94	0.47
High frequent flood (1 or 0)	0.016	0.049	0.02**
Rice plot size (ha)	1.32	1.45	0.50
Number of observations	849	123	

Source: Authors' own

* $p<0.1$, ** $p<0.05$, *** $p<0.01$

Abstract (in Japanese)

要　約

サハラ以南アフリカ（SSA）では、成長する都市の市場において国産米が輸入米に対抗できないため、国産精米の品質向上は喫緊の課題となっている。過去の研究では、精米施設の不備が国産米の品質が低いことの主要因であると考えられていた。SSAには最近になり近代的な精米施設が建設されているが、そこで精米された米の品質は必ずしも輸入米と競争できるものではない。したがって、精米の原料となる籾米の品質を向上させることが、SSAにおける重要な課題として残されている。この問題に関する我々の仮説は、籾の品質とその価格との関係についてコメ農家が十分に理解していないことが、低品質の籾の生産が続いている原因であるというものである。この仮説を検証するために、ガーナ北部でフィールド実験を行った。108の村を無作為に選択し、各村から10人のコメ生産者を無作為に選んだ。108の村から半数の54か村を無作為に選び処理村とした。処理村では、籾米の品質を向上させる技術や市場における品質評価に使われる品質パラメータについて農家に情報を提供した。介入前後に収集したデータを用いた分析の結果、介入は農家がいくつかの品質向上技術の採用に有意な影響を与えたことがわかった。さらに、介入は農民の行動に重要な変化をもたらした。すなわち、介入を受けた農民は対照農民と比べて香り米を村外で販売する傾向が強く、その販売価格も高かった。このように、籾の品質および品質に基づく価格設定に関する情報を提供することで、農家の籾の生産と販売を改善したと結論づけられる。技術的な訓練を伴わない低コストの介入であったにもかかわらず、十分に望ましい成果が得られたという点は特筆に値する。

キーワード：コメ、無作為化比較試験、品質向上、価格、ガーナ