Varietal Adoption and Economics of Rice Production in Ejura-Sekyedumase and Atebubu-Amantin Municipalities of Ghana

Edward Tsinigo[1*] Kwasi Ohene-Yankyerah[2] Simon Cudjoe Fialor[2] Isaac Tweneboah Asante[3]
1. Innovations for Poverty Action, Accra, Ghana
2. Department of Agricultural Economics, Agribusiness, and Extension, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana
3. Ministry of Food and Agriculture, Nkawkaw, Ghana

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Abstract
In this paper, we analyse the factors that drive the adoption and non-adoption of the New Rice for Africa as well as compare the costs and returns associated with such decisions in the Ejura-Sekyedumase and Atebubu-Amantin Municipalities of Ghana. A structured questionnaire was administered to 216 smallholder rice farmers who were sampled through a three-stage stratified sampling approach. Data analyses were conducted using descriptive statistics, the Chi-square test, Kendall's coefficient of concordance, the independent sample t-test, and the gross margin analysis. The results show that the adoption of the improved rice variety was driven by its higher yield advantage and early maturity as well as good taste and aroma. However, the non-availability of the improved seed, lack and/or inadequate information, and delays in input supply restrained the farmers from adopting the improved rice variety. The production of the improved rice variety was labour and capital intensive given its higher cost of production compared with the unimproved rice varieties. The adopters reported a significantly higher cost of production and gross margin than did the non-adopters. The results demonstrate the need to integrate technology promotional activities with an effective input supply system to facilitate the adoption of improved rice varieties.
Keywords: Adopters, non-adopters, NERICA, cost, returns, gross margin.

1. Introduction

The World Bank (2010) recognises the agricultural sector as predominantly in most Sub-Saharan Africa economies; contributing more than one-third of the regional gross national product and employing more than two-thirds of the labour force. However, the sector remains largely underdeveloped, in respect of production both in the domestic market and for export (Food and Agriculture Organisation [FAO] 2000). The resulting effects are low production of major staple foods and rising import substitution. For instance, the agricultural sector in Sub-Sahara Africa has continued to lag behind other developing nations due to its low cereal yield and high reliance on grain imports (Wikipedia 2016). More clearly, Ghana's total rice consumption is about 500,000 tonnes, of which more than 70% are imported (Government of Ghana 2009). The challenge for successive governments since independence has been to increase domestic rice production to reduce the unsustainable overreliance on imports.

Rice plays a decisive role in the socio-economic development goals of countries. Accordingly, the FAO (2006) considers rice as the most important staple food for a large share of the world's human population and the grain with the second-highest worldwide after maize. To remain competitive, deliberate multi-sectoral policies need to be implemented to boost the productivity of rice. Productivity changes in food production systems, such as rice production, are driven by technical change, socio-economic, climatic, and economic policies (Ahearn, Yee, Ball & Nehring 1998; Hussain & Perera 2004; Kaur & Sekhon 2005). Technical/agronomic factors result from the use of technologies such as mechanisation, high-yielding varieties, fertilisers, irrigation, herbicides, and pesticides (Ahearn et al. 1998; Hussain & Perera 2004). Socioeconomic factors that drive productivity include education, experience, farm size, tenancy terms, prices, and availability of credit (Hussain & Perera 2004). Climatic factors such as rainfall, temperature, and the sunshine play a vital role in influencing agricultural productivity (Hussain & Perera 2004). The efficacy of these factors depends largely on the prevailing economic policies on agricultural productivity growth. Accordingly, Ahearn et al. (1998) and Kaur and Sekhon (2005) identify economic policies as a vital precondition for productivity increases. While these factors may affect productivity separately, their combined effects are visible. This implies that rice production requires substantial investment in productivity enhancing technologies and policy reforms to increase productivity.

Among the factors driving productivity gains in food production, agricultural technologies have been identified as the cardinal determinants of productivity, profitability, and sustainability (Dixon, Gulliver, & Gibbon 2001; Shideed & Salem 2005). The realisation of these objectives provides a major pathway for sustainable poverty reduction and food security. Smallholder farmers benefit from technological breakthroughs through prospects to lower the cost of production; either by increasing output from the same inputs or by holding the same output from reduced inputs (Adewuyi 2006; Oni, Pender, Phillips & Kato 2009). However, changes in market prices of inputs and outputs may significantly influence farmers' resource use and productivity goals (Rehman & Parkinson 2006) as higher levels of variable inputs (Shideed & Salem 2005) are required to derive the full benefits from improved technologies. Smallholder farmers' profitability gains may, thus, be investment biased and driven by the demands for inputs and the extent of productivity gains. For resource-constraint farmers, this is a major limiting factor for technology adoption and productivity gains; requiring appropriate policies to remove impediments for farmers to adopt improved technologies.

In developing countries such as Ghana, low productivity of rice possesses a major concern not only for smallholder farmers but also for researchers, crop scientists, development agents, and policy makers. Low productivity of rice is further aggravated by the persistent differences in the productivity estimates across the various regions of the country; with some regions reporting far below the national average of 2.6Mt/ha (Ministry of Food and Agriculture [MoFA] 2011). These yields gap present sufficient scope to increase the productivity of rice through productivity enhancing technologies. One such technologies that have been promoted in sub-Saharan African countries is the New Rice for Africa (NERICA). The introduction of NERICA has been seen as a major policy directive for boosting the economic incentives - productivity and profitability - of rice farmers. Following its introduction in 1996, NERICA has spread quickly in Nigeria, Cote D'Ivoire, Ethiopia, Mali, The Gambia, and Ghana. Available evidence from Ethiopia, Mali, and The Gambia, for example, suggests that NERICA achieves high yields between 3000 and 6000 kg ha^{-1} in rain-fed dependent production system (Zenna, Gebre-Tsadik & Berhe 2008) with prospects for additional yield gains between 140 kg ha^{-1} and 1000 kg ha^{-1} (Adégbola, Arouna, Diagne & Souléïmane 2006; Dibba 2010). NERICA's yield gains are reportedly higher than the very low yields of between 700 and 1500 kg ha^{-1} of traditional rice varieties under the same production system (African Development Fund 2001).

The improved rice variety has also been known to be profitable. For instance, even though the improved rice variety has been associated with higher production cost compared to the unimproved rice varieties (Abdullahi 2012; Kuma & Singh 2013), it's adoption tends to increase the profitability of farmers (Abdullahi 2012; Kuma & Singh 2013; Shideed & Saleem 2005; Abdullahi 2012). Yet, the adoption rates among smallholder farmers in developing countries are reportedly low (Jansen, Pender, Damon & Schipper 2006; Wollni, Lee & Janice 2010). The questions that arise are why the low adoption rates of the improved rice varieties and how does the adoption of the improved rice variety compares with the unimproved rice varieties in terms of cost and returns? An empirical evidence on these issues within the Ghanaian context would help policy makers and researchers integrate different agronomic and socio-economic perspectives into the promotion of future agricultural technologies. The objectives of this paper are in three-folds: (1) to analyse reasons/factors influencing the adoption and non-adoption of the improved rice variety; (2) compare the costs and returns of rice production among the adopters and non-adopters; and (3) establish whether there is a statistically significant differences in the costs, returns, and gross margins of adopters and non-adopters. The rest of the paper is organised as follows. The next section presents the methodology of the study. Thereafter, the results and discussion are presented. Finally, conclusions are drawn based on the findings of the study.

2. Methodology

2.1 Study area, sampling technique and data collection procedure

The study was conducted in the Ejura-Sekyedumase Municipality of the Ashanti Region and the Atebubu-Amantin Municipality in the Brong-Ahafo Region of Ghana. These Municipalities were selected based on the high concentration of adopters and non-adopters of the improved rice variety. The Ejura-Sekyedumase Municipality emanated from the former Sekyere and Offinso Districts. It is situated in longitudes 1˚5W and 1˚39'W and latitudes 7˚9'N and 7˚36'N. It's land size is closely 1,782.2sq. km; constituting 7.3% of the Region's total land area and being the fifth largest district in the Region. The Atebubu-Amantin Municipality, on the other hand, is surrounded by the East Gonja District in the Northern Region, Pru district and Ejura-Sekyeredumasi Municipality in the Ashanti Region, as well as Sene District, Kintampo and Nkoranza Districts, all in the Brong-Ahafo Region. The Municipality has predominantly small-scale and subsistence farmers (about 63%) who largely produce food crops such as rice, yam, cassava, millet, and beans (www.ghanadistricts.com). This study focused on rice farmers who produced the improved rice variety (NERICA4 and NERICA9) and the unimproved rice varieties (red rice and Mr Moorl) in the two Municipalities.

The descriptive research design was used based on a cross-sectional survey strategy. Smallholder rice farmers in the two Municipalities formed the target population of the study. A three-stage stratified random sampling method was used to select operational areas, communities, and 216 rice farmers from the two Municipalities. This method was used to achieve a high degree of representativeness by providing the farmers with equal chances of being selected. Primary data were collected using mainly a structured questionnaire. Data collection involved three stages. In the first stage, a focus group discussion was conducted with eight rice farmers from each Municipality to gain insights into the production of the improved rice variety. Insights from the focus group discussion formed the basis for the development of the structured questionnaire. For instance, the reasons identified for the adoption and/or non-adoption of the improved rice variety were integrated into the structured questionnaire. Farmers were then asked to rank the reasons with rank one being the least important reason and seven as the most important reason. The structured questionnaire was used to collect additional information on the inputs and outputs in rice production as well as the rice farmers' socioeconomic characteristics. The second stage involved piloting the structured questionnaire on 20 randomly sampled adopters and non-adopters of the improved rice variety from the Ejisu-Juaben Municipality in the Ashanti Region of Ghana. This ensured that unnecessary questions were eliminated while rephrase ambiguous questions that may pose a challenge to the rice farmers. The final stage involved the actual data collection. The primary data covered the 2011/2012 major rice production season. The researchers with support from Agricultural Extension Officers collected the data. Data collection activities were monitored by the researchers to guarantee high-quality data for the analysis. Of the 216 rice farmers who participated in the study, eight of them were dropped due to the incomplete information on inputs use and output.

2.2 Method of data analytical procedures

Data were analysed using frequencies, percentages, gross margin analysis, Kendall's coefficient of concordance, the Chi-square test, and the independent samples t-test. These statistics were computed using the IBM SPSS Statistics (version 22) software. The empirical data were analysed and presented by comparing the reasons for the adoption/non-adoption of the improved rice variety, the cost of production, the gross return, and the gross margin between the adopters and non-adopters of the improved rice variety.

Mean ranks were obtained based on Kendall's coefficient of concordance ω, to measure the degree of agreement among the rice farmers regarding the ranking of the reasons that motivated (demotivated) them to adopt (not to adopt) the improved rice variety. The ω is mathematically represented as:

$$\omega = \frac{12\left[\sum T^2 - \left(\sum T\right)^2 / n\right]}{nm^2\left(n^2-1\right)} \tag{1}$$

Where T is the sum of ranks for each reason/factor ranked by a farmer; m is the number of farmers who ranked the particular reason, and n is the number of reasons ranked by the farmers. It was hypothesised that an agreement exists between the rankings of the reasons that influenced the adoption decision of the adopters and non-adopters.

Frequencies and percentages were run to describe the socio-economic characteristics of the sampled rice farmers. Additionally, a 2 × 2 contingency table with the Chi-square (χ^2) test was used to test whether a statistically significant relationship exist between the socio-economic characteristics and the adoption of the improved rice variety. The Chi-square statistic is illustrated as:

$$\chi_c^2 = \sum \frac{\left(O_i - E_i\right)^2}{E_i} \tag{2}$$

Where O is the observed value, E is the expected value, and "i" is the "i th" position in the contingency table.

Gross margin analysis was employed to determine the cost and the returns associated with the production of the improved rice variety and the unimproved rice varieties. In calculating the gross margin, we assumed a fixed cost structure and valued labour at the price of its best alternative use (i.e., opportunity cost). The cost of production, gross return, and gross margin were measured per hectare. The variable inputs of seed, labour, herbicide, fertiliser, and miscellaneous costs such as transportation were used to determine the cost of production or the total variable cost. Labour cost comprised the cost of land preparation, sowing, weeding, fertiliser application, harvesting, and threshing. Following Murphey and Sprey (1983), the working capacity of one adult man was expressed as one labour unit, the working capacity of one adult woman as 0.8 of a labour unit, and that of a child as 0.5 of a labour unit. The person-days were computed based on 8 hours of a day's work. The gross return (i.e., total revenue) was computed by multiplying the price of paddy/bag by the number of bags sold. The gross margin (GM) then is the difference between the gross return (TR) and the total variable cost (TVC), given by:

$$GM = TR - TVC \tag{3}$$

Mean and mean differences were calculated using the independent sample t-test to establish whether statistically significant differences exist between the adopters and non-adopters in terms of the cost of production, gross return, and gross margin. The study hypothesised that the adopters will report higher cost of production, gross return, and gross margin compared to the non-adopters. The gross margin per person-day was estimated by dividing the gross margin by the total person-days per hectare. Two efficiency analyses were obtained from the gross margin as measures of net returns to the most limiting resources (i.e., labour and capital). These were the gross margin per person-days and the gross margin per unit cost. The gross margin per person-days was worked out by dividing the gross margin per hectare by the labour person-days. In the case of the gross margin per unit cost, the gross margin per hectare was divided by the total variable cost (Murphey & Sprey, 1983). As gross margins do not account for changes in prices and yields, sensitivity analyses were conducted to measure the impact of changes in total variable costs, yield, and output price on the gross margin.

3. Results and Discussions

3.1 Socioeconomic characteristics of the rice farmers

Table 1 presents the socioeconomic characteristics of the adopters and non-adopters. The result showed that 58% of the rice farmers were males. Specifically, 55% and 45% of the adopters and non-adopters, respectively, were males. It is evident that there was a statistically significant association between gender and the adoption of the improved rice variety [$\chi^2(1) = 3.964$, $p < .046$]; that is, females were more likely to adopt the improved rice variety than their male counterpart. A greater proportion of the adopters were 50 years and above. This is consistent with the mean age of 50 years in Ghana as reported by MoFA (2011). The finding indicates that rice farming is a preserve for middle-aged people and illustrates the need to step up efforts to increase the interest of the younger generation in farming. Promoting farming among the younger generation is vital because they are more productive in non-agricultural activities, particularly given the relatively higher education in comparison with older generations.

Most of the adopters were educated (60%) compared to the non-adopters (40%). A statistically significant relationship exist between the educational status of the rice farmers and the adoption of the improved rice variety [$\chi(1) = 4.609$, $p < .05$]. Rice farmers who are educated are more likely to adopt the improved rice variety than their counterparts. This illustrates the need to provide an informal form of education to the farmers to increase their skills and knowledge on improved technologies. With the educational status of the adopters, they are better positioned to process information relating to improved technologies. Their educational attainment may also enable them to process information accurately leading to the development of favourable attitude toward the acceptance of improved technologies. Moreover, 54% of the adopters had a household size between 5 and 10 while the non-adopters (55%) had less than 5 people in their households. The availability of these labour provides enormous opportunities for the farmers to utilise enough costless labour for farm activities; thereby promoting the adoption of labour-intensive technologies.

Table 1. Socioeconomic characteristics of the non-adopters and adopters

Variables	Non-Adopters	Adopters	χ2	*p*
Gender				
Male	67 (55.4)	54 (44.6)	3.964	0.046*
Female	36 (41.4)	51 (58.6)		
Age (years)				
Less than 30 years	13 (56.5)	10 (43.5)	4.420	0.220
30 – 39 years	20 (57.1)	15 (42.9)		
40 – 49 years	30 (55.6)	24 (44.4)		
50 years and over	40 (41.7)	56 (58.3)		
Educational status				
Illiterate	69 (55.6)	55 (44.4)	4.609	0.032*
Literate	34 (40.5)	50 (59.5)		
Household size (number)				
Less than 5	35 (54.7)	29 (45.3)	1.292	0.524
5 – 10	52 (46.0)	61 (54.0)		
10 and more	16 (51.6)	15 (48.4)		
Farm size				
Less than 2 ha	98 (48.8)	103 (51.2)	2.305	0.316
2 – 3 ha	2 (100.0)	0 (0.00)		
More than 3 ha	3 (60.0)	2 (40.0)		
Access to extension services				
Yes	42 (29.2)	102 (70.8)	77.550	0.000**
No	61 (95.3)	3 (4.7)		
Access to credit				
Yes	17 (19.3)	71 (80.7)	55.656	0.000**
No	86 (71.7)	34 (28.3)		
Sample size	103	105		

Note: * = $p < .05$, ** = $p < .001$. Percentages are indicated in parentheses after frequencies.

Fifty-one percent of the adopters, compared to 48% of the non-adopters, had farm size less than 2 ha. This implies that the rice farmers are predominantly smallholders. The 2 ha farm size in this study is consistent with the reported average farm holdings in Ghana as reported by MoFA (2011). The small cultivated farm size could be due to the increased demands for cash and labour in rice production. This is indicative that perhaps efforts to promote improved technologies with credit supports to smallholder farmers need to be stepped up. Access to extension services was more visible among the adopters compared to the non-adopters. An overwhelming proportion of the adopters (71%) reported having contact with the extension agents. This is further strengthened by the significant relationship between access to extension services and the adoption of improved rice variety [$\chi(1) = 77.550$, $p < .000$], suggesting that rice farmers who have access to extension services were more likely to adopt the improve rice variety. This is partly because extension service contact and delivery was an integral part of the NERICA Rice Dissemination Project [NRDP], which promoted the improved rice variety. Not only did the extension agents create awareness and build the capacity of the adopters, but also they provide technical guidance in line with the adoption of the improved rice variety. The high proportion of the non-adopters (95%) who reported not having access to extension services is surprising considering the many opportunities offered to the farmers to access extension services. This finding may also be deemed worrying given that government efforts to increase the presence of extension agents are central to technology adoption and productivity increases. In terms of access to credit, only 17% of the non-adopters reported having access to credit facilities. This shows how the non-adopters are constrained in accessing credit and thus illustrates that perhaps efforts to provide specialised credit facilities for non-adopters need to be stepped up. The non-adoption of the improved rice variety might be due to the lack of credit facilities for the non-adopters. In contrast, the high proportion of the adopters who accessed credit facilities benefited from the specialised credit scheme from the NRDP. The relationship between access to credit and adoption of the improved rice variety was statistically significant [$\chi(1) = 55.656$, $p < .000$]; suggesting that rice farmers who have access to credit facilities were more likely to adopt improved rice varieties. The result is consistent with the observations of CIMMYT (1993) that an efficient credit programme facilitates the adoption of technologies that require significant cash investment for the rice farmers.

3.2 Reasons for adopting or not adopting the improved rice variety

The rice farmers were asked to rank a number of reasons (identified through the focus group discussions) for the adoption or non-adoption of the improved rice variety. Statistical tests were applied to the ranking of the farmers and discussed as follow.

3.2.1 Reasons for adopting the improved rice variety

The adopters were asked to rank six reasons for adopting the improved rice variety. The most important reason was ranked one whiles the least important six. Table 2 presents the ranking of the reasons for adopting the improved rice variety and the tests for Kendall's coefficient of concordance. Kendall's chi-square has a value of 0.738 with 5 degrees of freedom and a p-value of 0.000. The result is statistically significant at the 5% significance level. The researchers reject the null hypothesis in favour of the alternate hypothesis. The value of Kendall's coefficient of concordance (0.738) implies that 73.8% of the adopters agreed to the ranking of the reasons that influenced them to adopt the improved rice variety. Hence, there is a reasonably high degree of agreement among the adopters regarding the ranking of the reasons for adopting the improved rice variety.

Table 2. Reasons for adopting the improved rice variety

	Mean Rank	Overall Rank
Higher yield advantage	1.77	1st
Early maturing	2.20	2nd
Good taste and aroma	2.41	3rd
Resistance to drought	4.07	4th
Resistance to pest and diseases	4.84	5th
Acid tolerant	5.71	6th
Total N	105	
Kendall's W	0.738	
Test Statistic	387.420	
Degree of Freedom	5	
Asymptotic Sig. (2-sided test)	0.000**	

Note: $^{**}p < .001$.

The result suggests that the main reasons why the rice farmers adopted the improved rice variety were because of its: (1) higher yield advantage; (2) early maturity; (3) good taste and aroma; (4) and resistance to pest and diseases. This is consistent with Bzugu, Mustapha, and Zubairu's (2010) finding that early maturity, resistance to pests, and high yields were the major reasons for the adoption of the improved rice variety. The findings indicate that rice farmers want more yields so that they could consume some and sell the rest to meet their household financial needs. Similarly, the early maturity of the improved rice variety gave farmers the added advantage to harvest quickly on time and sell the produce at the time that paddy is relatively unavailable. In fact, the improved rice variety takes within 80 – 100 days to mature, compared with the unimproved rice varieties, which takes longer days (about 120 days).

3.2.2 Reasons for not adopting the improved rice variety

The non-adopters were asked to rank seven reasons considered for not adopting the improved rice variety. The most important reason was ranked one, while the least, seven. Table 3 presents the results of the ranking of the reasons for the non-adoption of the improved rice variety and the tests for Kendall's coefficient of concordance. The results showed that Kendall's chi-square has a value of 0.246 with 6 degrees of freedom and a p-value of 0.000. The result is statistically significant at the 5% significant level. Hence, the null hypothesis was rejected in favour of the alternate hypothesis. It can also be observed that the value of Kendall's coefficient of concordance (0.246) suggests that 24.6% of the non-adopters agreed to the ranking of the reasons for not adopting the improved rice variety.

Table 3. Reasons for not adopting the improved rice variety

	Mean Rank	Overall Rank
Non-availability of the improved seed	2.34	1st
Lack/inadequate information on the improved rice variety	3.59	2nd
Delays in input supply	3.66	3rd
High price of NERICA seeds	3.66	3rd
High demands for inputs by the improved rice variety	4.24	4th
Loss of quality of the improved rice when delayed on field	4.73	5th
Difficulty in threshing	5.77	6th
Total N	58	
Kendall's W	0.246	
Test Statistic	85.581	
Degree of Freedom	6	
Asymptotic sig. (2-sided test)	0.000**	

Note: $^{**}p < .001$.

The finding thus suggests that 49% of the rice farmers did not cultivate the improved rice variety because of (1) the non-availability of the improved seed, (2) lack, and/or inadequate information on the improved rice variety, and (3) delays in input supply as well as high price of the improved seeds. The result revealed that the non-availability of the improved seed coupled with lack or inadequate information on the improved variety were solely responsible for the non-adoption of the improved variety. These results are consistent with Kijima, Otsuka and Sserunkuuma's (2008) observations that these factors are responsible for the non-adoption of the improved rice variety. The finding thus illustrates that efforts to promote improved technologies need to be integrated with an efficient input supply system to facilitate the adoption process. The focus group discussion revealed that some of the adopters were included in the project because of their association with the extension agents, experience in rice farming, and their scale/consistency in production. Such purposive nature of selecting the adopters may have disadvantaged some of the non-adopters. Similarly, some of the rice farmers complained that the improved rice variety was difficult to thresh, hence, demotivating them from adoption the improved rice variety. In effect, apart from the non-availability of the improved rice variety, technical and other constraints might have prevented some of the rice farmers from adopting the improved rice variety. Therefore, efforts to promote improved technologies must remove impediments that prevent its adoption.

3.3 Economics of rice production of the improved and unimproved rice varieties

3.3.1 Differences in the cost of production

Table 4 presents the cost of rice production in the two Municipalities. The result indicated that input-specific costs differed between the non-adopters and adopters. The share of land preparation through ploughing was GH¢ 144.67 ha^{-1} for the adopters and GH¢ 95.80 ha^{-1} for the non-adopters. The cost of ploughing has thus increased by 51% due to the adoption of the improved rice variety. The increased cost of ploughing was because the adopters plough their land twice. The first ploughing is the usual tractor ploughing while the second is meant for harrowing. The share of seed cost was GH¢ 59.89 ha^{-1} for the adopters and GH¢ 71.38 ha^{-1} for the non-adopters. The reduction in the cost of seed (16%) for the improved rice variety could be due to the subsidised nature of the certified seed and the considerable reduction in seed rate. It could also be due to the quality of seeds used as quality seeds have high germination and thus less quantity for planting. Policies to promote and create awareness on the economic gains from quality seed is therefore highly needed.

Expenditure on fertiliser (64%) was higher for the adopters (GH¢ 240.37 ha^{-1}) compared with the non-adopters (GH¢ 146.46 ha^{-1}). The high expenditure on fertiliser by the adopters could be due to the high demand for fertiliser by the improved rice variety. The result further revealed that the cost of herbicide was higher for the non-adopters (GH¢ 37.95 ha^{-1}) compared to the adopters (GH¢ 34.01 ha^{-1}); a reduction by 10%. This suggests that the non-adopters incur higher expenditure on herbicide since it is non-weed competitive. Moreover, the expenditure on labour was higher for the adopters (GH¢ 935.38 ha^{-1}) than the non-adopters (GH¢ 736.03 ha^{-1}). This implies that the cost of labour has increased by 27% because of the adoption of the improved rice variety. The high expenditure on labour could be due to the increased demand for labour for harvesting and threshing. Hence, the expenditure on labour could be reduced substantially using labour saving technologies in rice production. Miscellaneous cost (including the cost of transportation) for the adopters was higher (GH¢ 64.19 ha^{-1}) than the non-adopters (GH ¢44.37 ha^{-1}).

Table 4. Mean differences in the costs of production between non-adopters and adopters

Variable Inputs	Non-Adopters Amount (GH¢ ha^{-1})	Non-Adopters %	Adopters Amount (GH¢ ha^{-1})	Adopters %
Land preparation[a]	95.80	8.46	144.67	9.78
Seed	71.38	6.31	59.89	4.05
Fertiliser	146.46	12.94	240.37	16.26
Herbicide	37.95	3.35	34.01	2.30
Labour	736.03	65.02	935.38	63.27
Miscellaneous	44.37	3.92	64.19	4.34
Total variable cost	1131.99 (495.81)	100.00	1478.51 (456.45)	100.00
Mean differences in total variable cost			346.52	
t-value			5.246**	
df			206	

Note: Standard deviations appear in parentheses; $^{**}p < .001$; [a] Land preparing by tractor ploughing and/or harrowing.

Overall, the average cost of producing the improved rice variety was GH¢ 1478.51 ha^{-1}, which is higher compared to GH¢ 1131.99 ha^{-1} for the unimproved rice variety. This implies that the improved rice variety has increased the cost of producing rice by about 31%. Therefore, the improved rice variety is capital intensive. In cash-constrained, subsistence setting, this limitation is severe; acting as a disincentive for the adoption of the improved rice variety. The adoption of the improved rice variety will, therefore, be dependent on whether farmers have access to credit for the additional expenses they incur. In contrast, the cultivation of the unimproved rice variety requires a minimal amount of cash. The major constituent of the expenditure for the improved rice variety is labour. The cost incurred on fertiliser ranked the second highest in the total variable cost for the improved rice producers. For the non-adopters, the dominant cost components were labour and fertiliser. In general, expenditure on labour and fertiliser occupies a very high proportion of the total capital expended in the production of the improved and unimproved rice varieties. The results are, therefore, consistent with Abdullahi (2012) and Kumar and Singh (2013) who found the expenditure on these inputs to constitute more than half of the cost of producing rice varieties. The independent sample t-test revealed a statistically significant difference between the adopters and non-adopters ($t = 5.246$, $df = 206$, $p < 0.001$). The adopters ($M = 1478.51$, $SD = 456.45$) reported significantly higher total variable cost per hectare than did the non-adopters ($M = 1131.99$, $SD= 495.81$). Thus, production cost differs substantially by the type of variety grown. The higher covariance for the non-adopters (44%) suggests that there is greater flexibility in the cash requirements for the production of the unimproved variety compared to the improved variety, which has a covariance of 31%. The glaring difference in the cost of rice production is due to the high labour expenditure for the improved rice variety. The high cost of rice production might have contributed to the non-adoption of the improved rice variety. This is particularly a challenge to the rice farmers, as the majority of them (58%) had no access to credit facilities. Clearly, the cost of production of the improved rice variety has to be reduced substantially through labour saving technologies if it is to be competitive.

3.3.2 Yields and gross returns of paddy

Table 5 presents the yield and gross returns for the non-adopters and adopters. The mean yield for the adopters was 3027.26 kg ha^{-1}, about 56% higher than that of the non-adopters (1936.89 kg ha^{-1}). The improved rice variety increases net farm income. It generates net returns with GH¢ 2362.44 ha^{-1}, which is about two times more than its cost of production and the gross return from the unimproved rice variety (GH¢ 1449.64 ha^{-1}). The gross return of the improved rice variety has actually increased by about 63% over that of the unimproved rice variety. There was no observed difference in the paddy price for the non-adopters and adopters. The result demonstrates a higher gross return of the improved rice variety. The higher gross return in this study is more than likely linked to the high productivity of the improved rice variety. Thus, rice farmers who adopt the improved variety would report higher gross returns.

Table 5. Mean differences in gross return between non-adopters and adopters

	Non-Adopters	**Adopters**
Yield (kg)	1936.89	3027.26
Number of bags (maxi ha^{-1})	16.52	27.05
Price (GH¢ bag^{-1})	87.77	87.33
Gross return (GH¢)	1449.64 (652.45)	2362.44 (978.82)
Mean differences in gross return	912.80	
t-value	7.928**	
df	182	

Note: Standard deviations appear in parentheses; $**p < .001$.

The independent sample t-test indicated a statistically significant difference between the adopters and non-adopters ($t = 7.928$, $df = 182$, $p < 0.001$). The adopters ($M = 2362.44$, $SD = 978.82$) had significantly higher gross returns from paddy than the non-adopters ($M = 1449.64$, $SD = 652.45$). The significant difference in the gross return could be due to the higher productivity of the improved rice variety. It can be inferred that rice farmers adopt the improve variety because of economic motivation. The covariance for the non-adopters was 43% while for the adopters was 41%. Hence, even though there were greater variations in the cost of production for non-adopters, implying greater flexibility in input requirements, the covariance for gross returns are almost the same. The implication is that yields of unimproved variety are more stable and less sensitive to variable input use than the improved variety.

3.3.3 Gross margin analysis

The gross margin analysis of rice cultivation is presented in Table 6. The result showed that adopters had a higher gross return (GH¢ 2362.44 ha^{-1}) and gross margin (GH¢ 883.93 ha^{-1}) than the non-adopters (gross return = GH¢ 1449.64 ha^{-1}; gross margin = GH¢ 317.65 ha^{-1}). This implies that the improved rice variety is more economically viable and therefore has a larger positive return to capital, than the unimproved rice variety. According to Zandstra, Price, Litsinger, and Morris (1981), new technologies, which have at least 30% higher return than that of traditional technology, are more likely to be adopted by farmers. As evident from this study, the gross margin for the improved rice variety was about 178% more than the unimproved rice variety, that is, the gross margin was more than doubled for the adopters. Hence, the smallholder rice farmers will always prefer the improved rice variety to the unimproved rice variety due to its economic incentives of higher returns. Overall, it is evident that the adopters have realised increased productivity (in the midst of the high cost of production) and returns than the non-adopters. This conforms to the findings of Abdullahi (2012), which reported higher gross margin for the improved rice variety. As indicated in Table 6, there was no difference in the mean paddy price received by the non-adopters and adopters. Thus, given the output price, productivity and cost of production are the main determinants of profitability in rice production in the two Municipalities. Thus, an increase in the cultivation of the improved rice variety will lead to increased productivity and thus more returns to the adopters. Encouraging and supporting farmers to adopt the improved rice variety will greatly increase their income, thereby, reducing rural poverty.

Table 6: Mean differences in gross margin between non-adopters and adopters

	Non-Adopters	Adopters
Labour (person-days ha^{-1})	116.89	135.66
Total variable cost (GH¢ ha^{-1})	1131.99	1478.51
Gross return (GH¢ ha^{-1})	1449.64	2362.44
Gross margin [GM] (GH¢ ha^{-1})	317.65 (792.62)	883.93 (1046.38)
Gross margin per person-days	2.72	6.52
Gross margin per unit of cost	0.28	0.60
Mean differences in gross margin	566.29	
t-value	4.405**	
df	193.68	

Note: Standard deviations appear in parentheses. ***p* < .001.

Table 6 further presents the gross margin per person-days and gross margin per unit of cost. The gross margin per person-days was higher for the adopters (GH¢ 6.52 person-days^{-1}) than the non-adopters (GH¢ 2.72 person-days^{-1}). Thus, in spite of the high labour demand for the improved rice variety, it is still more economically worthwhile and profitable than the unimproved rice variety. This could partly be due to its high productivity. Moreover, the gross margin per unit of cost (i.e., total variable cost) revealed that the improved rice variety gave a higher return per unit of money spent on inputs (0.60) compared to the unimproved rice variety (0.28). Therefore, even though the improved variety has high capital expenditure, its benefit/cost ratio was higher than the unimproved rice variety. Notwithstanding, the high benefit/cost ratio may be due to the high expenditure on labour and partly, on fertiliser. The results illustrate that the improved variety gives higher returns on labour and total variable cost, compared to the unimproved variety; making it more competitive. The results of the independent sample t-test showed a statistically significant difference between adopters and non-adopters ($t = 4.405$, $df = 193.68$, $p < 0.001$). Adopters (M = 883.93, SD = 1046.38) reported significantly higher gross returns from rice production than the non-adopters (M = 317.65, SD = 792.62). Therefore, rice farmers who adopt the improved variety will have higher gross margins compared to those who did not adopt. The significant difference in the gross margin could be due to the higher productivity of the improved rice variety.

3.3.4 Sensitivity of gross margin to changes in prices and yield

While the gross margin analysis indicated the proportion of costs in relation to income, it fails to account for risks. In order to correct this defect, a sensitivity analysis was conducted to illustrate the impact of gross margin due to changes in yield, output prices, and total variable costs. Two cases of the sensitivity analysis are presented in Table 7 and Table 8. The first case of the sensitivity analysis related to the changes in the gross margin of both varieties from a 10% change above and below the yield and output price of rice (Table 7). Two scenarios were presented. In the first scenario, a 10% increase or decrease in the yield of the unimproved rice variety (assuming the output price remains constant) results in 45.55% increase or decrease in the gross margin for the non-adopters. For the adopters, a 10% change in the yield will result in 26.56% increase or decrease in the gross margin. Hence, the unimproved rice variety is highly sensitive to 10% change in the yield of rice at constant output price than the improved rice variety. In the second scenario, a 10% change in the output price (assuming the yield remains constant) results in 45.62% increase or decrease in the gross margin of the unimproved variety and 26.52% change in the gross margin of the improved variety. This implies that the unimproved variety is more sensitive to changes in the output price and yield than the improved variety. Overall, the results showed that the profitability of the unimproved rice variety is highly sensitive to changes in the yield and output price than the improved variety.

Table 7. The sensitivity of gross margin to changes in the yield and price of paddy

Yield		Price (GH¢ bag^{-1})				
Kg ha^{-1}	***Bag ha^{-1}***	***70.21***	***78.99***	***87.77***	***96.55***	***105.33***
			Non-adopters			
1743.20	14.87	-87.97	42.59	173.15	303.71	434.27
1936.89	16.52	27.88	172.92	317.97	463.02	608.06
2130.58	18.17	143.73	303.26	462.79	622.32	781.86
			Adopters			
2724.53	24.34	230.40	444.11	657.81	871.52	1085.22
3027.26	27.05	420.67	658.17	895.67	1133.17	1370.67
3329.99	29.76	610.94	872.23	1133.53	1394.82	1656.11

Note: Reference gross margins are GH¢ 317.97 and GH¢ 895.67 ha^{-1} for the non-adopters and adopters, respectively.

The second case of the sensitivity analysis emphasised the resulting effect on the gross margin from a 10% change in the cost of production (assuming the levels of gross returns remain constant) [Table 8]. A 10% decrease or increase in the cost of production of the unimproved rice variety leads to a 35.64% increase or decrease in the gross margin for the non-adopters. In contrast, a 10% decrease or increase in the cost of production of the improved rice variety leads to a 16.71% increase or decrease in the gross margin for the adopters. This illustrates that the gross margin of the non-adopters is more sensitive to a 10% decrease in the cost of production compared with the adopters. This could be due to the low productivity of the unimproved variety. Overall, the sensitivity analyses demonstrate that the unimproved rice variety showed very high sensitivity to changes in the prices of input and output compared with the improved rice variety. A 10% decrease in the yield (at constant output price) and a 10% increase in the cost of production (at constant gross returns) tend to be more sensitive to the profitability of the unimproved rice variety than the improved variety.

Table 8. The sensitivity of gross margin to changes in the cost of production

Gross returns (GH¢ ha^{-1})	**10% change in cost of production (GH¢ ha^{-1})**	**Gross margin**	
		GH¢ ha^{-1}	**% Change**
	Non-adopters		
1449.64	1018.79	430.85	35.64
1449.64	1131.99	317.65	Reference
1449.64	1245.19	204.45	-35.64
	Adopters		
2362.44	1330.66	1032.78	16.71
2362.44	1478.51	884.93	Reference
2362.44	1626.36	737.08	-16.71

Note: Reference gross margins are GH¢ 317.97 and GH¢ 895.67 ha^{-1} for the non-adopters and adopters, respectively.

4. Conclusions

The study sought to investigate the varietal adoption and economics of rice production in the Ejura-Sekyedumase and Atebubu-Amantin Municipalities of Ghana. Three goals have been accomplished in this paper. First, reasons for adopting and not adopting the improved rice variety were analysed. Second, the differences in the costs, returns, and gross margins between the adopters and the non-adopters were computed and compared. Finally, inferential statistical tests were conducted to establish whether these costs, returns, and gross margins statistically differ between the adopters and the non-adopters. The results showed that the main reasons for the non-adoption of the improved rice variety were the non-availability of the improved seed, lack, and/or inadequate information on the improved rice variety, and delays in input supply. Conversely, the rice farmers were largely motivated to adopt the improved rice variety given its higher yield advantage; early maturity; and good taste and aroma. The results confirmed the hypothesis that there exists an agreement among the rice farmers regarding the reasons that influenced their adoption of the improved rice variety. We also observed that rice farmers who have access to extension contacts and credits were more likely to adopt the improved rice variety compared to those who do not have access. The improved rice variety, in spite of its cost intensiveness, is more profitable than the unimproved rice variety. It has significantly higher costs of production, yields, and returns and thus has superiority over the unimproved variety in terms of yield and profitability. Evidence from the statistical analysis confirmed the hypothesis that rice farmers who adopt the improved rice variety were more likely to have higher cost of production, gross margin, and gross return compared to their counterparts. These findings suggest the need to take into account farmer-identified reasons that drive the adoption of improved rice varieties into future policies regarding the development, dissemination, and adoption of improved rice varieties.

Also, efforts to promote the adoption of the improved rice variety must be integrated with effective input supply system and enhanced extension service delivery.

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CONFLICT OF INTERESTS
The authors have no financial/relevant interest in relation to the development of this manuscript.

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