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Rice Production under the System of Rice Intensification and Conventional Methods: Which is more Profitable in Ghana?

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Authors' contributions

This work was carried out in collaboration between both authors. Author VA designed the study, conducted the literature searches, performed the statistical analysis and wrote the first draft of the manuscript. Author LAT managed the data collection, contributed in the statistical analysis and edited the manuscript. Both authors read and approved the final manuscript for publication.

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ABSTRACT

Some studies consider the System of Rice Intensification (SRI) method of rice production as more profitable than the Conventional method. Others, however, claim that there is no significant difference in yields between the two methods. The mixed representation of the economic value of the two methods of rice production by various authorities demands an empirical examination of the profitability of the two methods in Ghana. The study was, therefore, designed to identify which of the two methods of rice production is more profitable in Ghana. Two-stage sampling technique was used to select 220 farmers, comprising 110 farmers under each of the two methods of rice production which are predominant in Ejura-Sekyedumase Municipality and Sekyere East District of the Ashanti Region of Ghana. The data collected from farmers were summarized using descriptive statistics including arithmetic mean, standard deviation, minimum, maximum, frequencies and percentages. Gross margin and gross profit ratio were used to estimate profitability per acre of rice production under each method. The study revealed that, while farmers under the SRI method

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obtain GH¢60.68 for every GH¢100.00 sale of rice, farmers under the conventional method obtained GH¢44.04 per every GH¢100.00. The study, therefore, concludes that SRI method of rice production, though a little more costly, is more profitable resulting from a higher yield brought on by the adoption of best agronomic practices associated with the method. Based on the empirical results, the study recommends for the promotion of the System of Rice Intensification method of production in Ghana through awareness creation, extension services and training.

Keywords: Conventional method; system of rice intensification; rice production; yield; gross margin; gross profit ratio; profitability.

1. INTRODUCTION

Rice is the second most important cereal after corn and has become a major staple food in Ghana. Rice consumption in Ghana has increased along with population growth, and rice is increasingly becoming a main part of the diet in many Ghanaian homes [1]. The per capita rice consumption in Ghana as at 2016/17 was estimated at about 35 kg/year, which increased to 35.4kg/year in 2017/18 and is expected to reach 40 kg/year by 2020 [2].

Increasing urbanization, a growing entrepreneurial middle class, a rapidly growing tourism sector, and an increase in women working outside the home are boosting demand for rice. Whilst rice consumption is on the increase in Ghana, the country currently is only about 30% self-sufficient in rice production. The country is producing only about 150,000MT compared to a current consumption requirement of about 700,000MT [1].

In an attempt to bridge the gap between rice production and rice consumption, the Ministry of Food and Agriculture (MoFA) has made commitments to increase rice production through the introduction of improved high yielding and disease resistant rice varieties, and the promotion of low cost water management practices-the System of Rice Intensification [3].

Prior to the introduction of the System of Rice Intensification (SRI), rice production in Ghana was basically, by the conventional method which employs broadcasting of seeds or randomly transplanting seedlings with limited or no spacing required, flooding the field constantly with water, limited amount of weeding and greater use of inorganic fertilizer [4]. The Conventional method of rice production contributed to low yields because of its traditional, rudimentary and ineffective methods [5,6].

The System of Rice Intensification employs the use of transplanting single, much younger seedlings with wider spacing, discontinuous application of water to the field, use of a mechanical weeder (which also aerates the soil) and soil rich in organic matter to improve productivity. It seeks to improve the productivity of rice grown in paddies through healthier, more productive plants in more fertile soil systems by supporting greater root growth of plants and by nurturing the abundance and diversity of soil organisms [7,8]. The System of Rice Intensification (SRI) is a climate-smart and agro ecological methodology to increase the productivity of irrigated rice as a practice for other crops, by changing the management of plants, soil, water and nutrients. The SRI method helps increase yields by over 30%, while using 40% less water than conventional method [9,10]. The method was initially developed in the 1980s in Madagascar and has been validated in 43 countries. The SRI practices and concepts have also been successfully adapted to upland rice and to other crops such as wheat, finger millet, and sugarcane. SRI methodology is characterized by changing a range of rice management practices, consisting of: (1) early transplanting of seedlings, 8-12 days old, (2) shallow planting (1–2 cm) of one or two seedlings, (3) thin planting in checkrows (more than 20 × 20 cm), and (4) intermittent irrigation [11]. Neither new seed variety nor additional external inputs are required [12]. The SRI management usually shortens the crop cycle by 1-2 weeks, frees up land for other uses and reduces crops' exposure to climatic stresses, pest and disease risks [13]. Other studies, however, claim that there is no significant difference in yields between the conventional method and the SRI method and that the cost involved in SRI is higher than that of conventional method, thereby affecting farmer's profit [14,15,16]. Sarangi *et al*. [11] establish that

SRI is not an opportunistic fixed combination of best practices for higher yield. It represents a strategy for improving crop growth, yield and factor productivities under well-known agronomic practices. Moser and Barrett [17] estimate SRI as too labor-intensive but Sato and Uphoff [18] explain that labor is intensive for first users and less intensive when farmers gain experience. Antralina et al., [19] identify a little higher production cost with the SRI than the conventional method. However, Na [20] states that the SRI has higher production cost but the net benefit is greater than that of the conventional method. Uphoff, [9,10] dismisses the fact that rice production is significantly improved under the SRI. The mixed representation of the economic value of the two methods of rice production by various authorities demands an empirical examination to ascertain which of the methods is more profitable in Ghana. The objective of the study was, therefore, to identify a more profitable rice production method in Ghana.

2. METHODOLOGY OF THE STUDY

2.1 Study Area

The study was restricted to the Ejura-Sekyedumase Municipality and Sekyere East District of the Ashanti Region of Ghana where both SRI and conventional methods of rice production are practiced by many farmers. The study area falls within the forest-savanna transitional zone of Ghana. The area has bimodal rainfall pattern with two cropping seasons. Rainfall in the area is copious and well distributed over the cropping seasons. The climatic and edaphic conditions are vital for on-farm activities. Endowed with wetlands suitable for rice cultivation, the area forms part of the Ashanti Region noted for producing rice. Farming in the area is mainly subsistence and small-scale employing 63% of the active labour force [21].

2.2 Sample Size, Sampling Technique and Data Collection

Subject to budget constrain, the sample size for this study was restricted to 220 rice farmers in the study area [22]. Two-stage sampling technique was used for collecting the data for the study [23,24]. At the first stage, purposive sampling was used to sample Ejura-Sekyedumase Municipality and Sekyere East District of the Ashanti Region of Ghana where both SRI and conventional methods of rice production are practiced. Secondly, a systematic random sampling technique was used to sample 55 farmers from a list of farmers practicing the conventional method in each of the two parts of the study area. Similarly, 55 farmers from a list of farmers practicing SRI method in each of the two parts were also sampled. A total of 110 farmers were selected in each of the two municipalities/districts to obtain a total sample size of 220, comprising 110 farmers under each of the two methods of rice production. Structured questionnaires were used to collect data from farmers in April 2019.

2.3 Data Analysis

Descriptive statistics used to summarize the data were minimum, maximum, arithmetic means and standard deviation. Gross margin and gross profit ratio were used to estimate profitability of rice production under each of the two methods.

2.3.1 Gross margin and gross profit ratio

The Gross Margin (GM) per acre of rice production, which is the difference between the Total Revenue (TR) and the Total Variable Cost (TVC), was used to estimate the profitability of rice production. Gross Margin is a useful planning tool in situations where fixed capital is a negligible part of production [25].The gross margin model is express in Equation *1*.

$$\mathrm{GM} = \mathrm{TR} - \mathrm{TVC} \quad (1)$$

To compare the profitability of the two methods of rice production, the Gross Margin of each farmer was converted to Gross Profit Ratio to provide a basis for comparison. The Gross Profit ratio, presented in *Equation 2,* was used to assess a farmer's ability to generate earnings to offset the relevant costs of production [26].

$$\text{Gross Profit Ratio} = \frac{\mathrm{GM}}{\mathrm{TR}} \mathrm{X}100 = \frac{\mathrm{TR}-\mathrm{TVC}}{\mathrm{TR}} \mathrm{X}100 \quad (2)$$

3. RESULTS AND DISCUSSION

The cost structure, revenue and profitability of rice production under the conventional and the SRI methods of rice production are presented and discussed under this section.

3.1 Cost Structure of Rice Production under the Two Methods

The components of the cost structure per acre of rice production are shown in Table 3. Aside from the total cost of other variable inputs (including wellington boots, nose mask, cost of size-5 bags,

tarpaulin and nets) and the total cost of services (including transportation cost, milling cost, irrigation cost, hired equipment cost, storage cost) which are significantly different between the two methods of rice production, the cost components were almost same for the two methods as indicated by the *t-statistic.*

3.1.1 Cost of seed rice

Farmers had to purchased seed rice at current market price. The mean cost of seed rice per acre procured by farmers under the conventional method of rice production was found to be GH¢97.10 which was slightly less than the mean cost of GH¢108.87 incurred by farmers under the SRI method of rice production. Though, this price differential is statistically insignificant, it increases the cost of production under the SRI method and might be compensated for with higher productivity. Farmers under SRI method of rice production were more knowledgeable of the source of viable and high-yielding seeds and for that matter purchased them at slightly higher cost with an anticipation of a better outcome. While 53.6% of farmers under SRI, as shown in Table 1, purchased seed rice from the Ministry of Food and Agriculture (MoFA), the proponent of the SRI method, majority made up of 73.6% of farmers under the conventional method procured seed rice from other sources including neighboring farmers at lower cost and quality. This observation accounts for the price differential.

Table 1. Qualitative statistics of farm characteristics

Farm characteristics		Conventional method		SRI method		Pooled sample	
		Freq.	Percentage	Freq.	Percentage	Freq.	Percentage
Type of ownership of farm land	Own/family	24	21.8	17	15.5	41	18.6
	Sharecropping	3	2.7	3	2.7	6	2.7
	Hired land	83	75.5	90	81.8	173	78.6
	Total	110	100	110	100	220	100
Type of labour mainly used	Hired labour	89	80.9	95	86.4	184	83.6
	Family labour	21	19.1	15	13.6	36	16.4
	Total	110	100	110	100	220	100
Source of paddies for planting	Farmers field	40	36.4	12	10.9	52	23.6
	Agrochemical shop	41	37.3	39	35.5	80	36.4
	MoFA	29	26.4	59	53.6	88	40.0
	Total	110	100	110	100	220	100
Type of planting practice	Direct planting	110	100	1	0.9	111	50.5
	Transplanting	0	0.0	109	99.1	109	49.5
	Total	110	100	110	100	220	100
Pre-planting application of manure	Yes	12	10.9	38	34.5	50	22.7
	No	98	89.1	72	65.5	170	77.3
	Total	110	100	110	100	220	100
Method of planting practiced	Row planting	38	34.5	110	100	148	67.3
	Haphazard planting	72	65.5	0	0.0	72	32.7
	Total	110	100	110	100	220	100
Field condition for planting rice	Flooded	54	49.1	1	0.9	55	25.0
	Muddy	46	41.8	50	45.5	96	43.6
	Moist	10	9.1	59	53.6	69	31.4
	Total	110	100	110	100	220	100
Main method of weed control	Mechanical	9	8.2	4	3.6	13	5.9
	Chemical	101	91.8	106	96.4	207	94.1
	Total	110	100	110	100	220	100
Additional application of inorganic fertilizer	Yes	87	79.1	108	98.2	195	88.6
	No	23	20.9	2	1.8	25	11.4
	Total	110	100	110	100	220	100
Birds control method	Netting	22	20.0	61	55.5	83	37.7
	Bird scaring	88	80.0	49	44.5	137	62.3
	Total	110	100	110	100	220	100

Source: Survey Data, 2019

Table 2. Quantitative statistics of farm characteristics

Farm characteristics	Conventional method N=110				SRI method N= 110			
	Min.	Max.	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.
Size of rice farm(acre)	1.0	30.0	4.08	4.319.000	0.5	12.0	3.14	2.607
Plant population (stands per acre)	404750.0	1619002.0	946837.65	440815.790	101188.0	179889.0	128684.80	27313.860

Source: Survey Data, 2019

Table 3. Gross Profit Ratio for rice production under conventional and SRI methods compared

Components of gross profit ratio	Conventional method N=110				SRI method N= 110				t-statistic	p-value
	Min.	Max.	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.		
Cost of production (GHc)										
Total cost of seed rice	10.5	470.0	97.10	79.738	10.0	640.0	108.87	91.8 71	-957	.331
Total labour cost for cultural practices	69.8	2530.0	583.62	446.068	61.3	1375.0	572.52	380.451	.199	.843
Total cost of herbicides	56.0	1835.0	327.17	226.172	58.8	970.0	329.43	178.031	-.082	.934
Total cost of other variable inputs (wellington boots, nose mask, cost of size-5 bags, tarpaulin and nets)	26.7	842.50	218.85	233.112	54.8	731.0	272.15	169.671	-1.939	.054
Total cost of services (irrigation cost, cost of hired equipment, transportation cost, storage cost and milling cost)	58.5	1142.5	351.29	227.803	88.8	1610.0	548.89	361.789	-4.847	.000
Total cost of rice production	383.9	5246.5	1578.04	781.525	388.8	4035.0	1831.41	696.264	-2.539	.012
Yield										
No. of size 5 bags of threshed rice (yield)	3.0	27.5	10.92	5.362	3.3	45.0	18.37	9.156	-7.371	.000
Milled rice obtained (in 50kg bag)	4.5	41.3	16.45	7.921	5.0	75.5	29.32	17.857	-6.911	.000
Price and Revenue(GHc)										
Price per 50kg bag of milled rice	142.5	220.0	188.32	26.544	142.5	250.0	188.68	28.838	-.097	.923
Total revenue of rice production	641.3	8250.0	3093.78	1546.732	900.0	20306.3	5528.92	3187.651	-7.208	.000
Profitability										
Gross margin	10.0	6169.0	1515.75	1194.246	115.1	18447.5	3697.51	2791.345	-7.537	.000
Gross profit ratio (%)	0.7	79.6	44.04	20.405	8.2	92.3	60.86	16.904	-6.658	.000

Source: Survey Data, 2019

3.1.2 Labour cost

Farmers used varied combinations of family and hired labour to execute all the cultural practices on rice production. Hired labour constituted the major form of labour used. As is evident in Table 1, 81% and 86% of farmers under the conventional and the SRI methods respectively used hired labour. These forms of labour were factored in computing labour cost for rice production. The cultural practices performed were land preparation, sowing, transplanting, fertilizer application, weeding, spraying of pesticides, bird control, harvesting, threshing and bagging of threshed rice. The mean total labour cost of GH¢583.62 identified for farmers under the conventional method, though not significantly different, was economically higher than the mean cost of GH¢572.52 for farmers under the SRI method. This observation corroborates well with Sato and Uphoff [18] who explain that labor is intensive for first users of the SRI method and less intensive when farmers gain experience.

3.1.3 Cost of services

Cost of services incurred by farmers under rice production constituted irrigation, hired equipment, transportation, storage and milling. The mean total cost of services per acre were GH¢351.29 and GH¢ 548.89 respectively for the conventional and SRI methods of rice production. Clearly depicted by the *t-statistic* in Table 3, the cost of services incurred under the SRI method was significantly higher than that of the conventional method. As the yield of rice production improves under the SRI method, demand for services like irrigation, hiring of equipment, transportation, storage and milling, increases making the cost of services higher. The mean yield of rice under the SRI method, as indicated in Table 3, is almost twice that of the conventional method.

3.1.4 Cost of herbicides and other variable inputs

As is evident in Table 3, the mean total costs of herbicides under conventional and SRI methods of rice production were GH¢327.17 and GH¢329.43 respectively. The *t-statistic* in Table 3 shows no significant difference in the costs incurred in procuring herbicides under the two methods of rice production. This observation resulted from the fact that both group of famers, as shown in Table 1, used herbicides as the main method of weed control.

Cost of other variable inputs including Wellington boots, nose mask, 'size-5' bags, tarpaulin and nets was found to be significantly different between the two methods. The mean cost of GH¢218.85 for other variable inputs per acre under the conventional method was less than the mean cost of GH¢272.15 identified under the SRI method of rice production. As is indicated in Table 3, the yield of rice production was significantly higher under the SRI method demanding increasing quantities of 'size-5' bags, tarpaulin and net. The yield differential accounted for the difference in cost of such variable inputs under the two methods of rice production.

3.1.5 Total cost of production

The mean total cost of rice production under the SRI method was found to be GH¢1,831.41, compared to GH¢1,578.04 for the conventional method. The significant total cost differential between the two methods is explained by the use of Wellington boots, nose mask, 'size-5' bags, tarpaulin, nets and services which are demanded in increasing quantities with increasing yield under the SRI method. The costs of these inputs are significantly higher under the SRI method of rice production. A higher yield of rice production under the SRI method requires increasing quantities of these variable inputs. The cost differential is explained by the increasing costs of inputs associated with combinations of management practices employed under the SRI method [11,14,15,16].

3.2 Revenue from Rice Production

Revenue from rice production was obtained as the product of quantity of milled rice and the current market price.

Yield of rice production under the two methods is outlined in Table 3. The mean yield under the conventional method of rice production was 16.45bags ('50 kg bag') of milled rice per acre. The yield, as indicated by the *t-statistic* in Table 3, was significantly less than a mean yield of 29.32bags (50 kg bag') per acre recorded under the SRI method. The yield under the SRI method was almost twice that of the conventional method. It is established that, SRI method is more productive than the conventional method. This trend resulted from the use of management practices that makes rice production more productive under the SRI method [11]. Agronomic practices that characterized the SIR method of rice production and made it high-

yielding are outlined in Table 1. While more than half of farmers under the SRI method procured paddies for planting from the recommended source, the Ministry of Food and Agriculture, less than a third of farmers under the conventional method procured seed rice from that source. Planting by seedlings, a recommended practice for high yield was adopted by almost all the farmers under the SRI method with none of the farmers under the conventional method practicing it. Row planting and application of inorganic fertilizer, recommended as improved rice production technologies, were fully adopted by almost all farmers under the SRI method. While more than half of the farmers under the SRI method practiced netting as a more productive method of bird control only a fifth of farmers under the conventional method adopted the practice. Maintaining moist or muddy condition on rice filed as a recommended practice was adopted by almost all the farmers under the SRI method. A half of farmers under the conventional method adopted this practice. The mean planting population of farms under the SRI method shown in Table 2 was 128,684 stands per acre cultivated using row planting. Farms under the conventional method were overpopulated with an average plant stand of 946,837 per acre. Planting through broadcasting method, farmers under the conventional method adopted a planting rate which was more than 7 times the recommended rate.

The combination of best practices under the SRI method is labour demanding [17,18]. As is shown in Table 2, farmers under this method intensively cultivated small farm sizes. averaging 3.14 acres due to its labour requirement. Conversely, farmers under the conventional method ineffectively cultivated extensively large farm sizes with an average of 4.08 acres due to its traditional and rudimentary nature [5,6].

As is evidenced in Table 3, the mean price for milled rice was almost same for farmers under both methods of rice production. Though there was no significant difference in the market price, a mean price of GH¢188.68 per 50kg bag for famers under the SRI method was GH¢0.36 higher than that obtained by farmers under the conventional method. Farmers under the SRI method had the tendency to bid for prices that are a little higher than prices accepted by farmers under the conventional method. This was done to compensate for the additional input required under the SRI method.

The mean total revenue obtained from the sale of rice under SRI method was GH¢5,528.92 per acre. This value is almost twice the mean revenue of GH¢3,093.78 per acre obtained by farmers under the conventional method. The significant and huge revenue differential in favour of the SRI method is attributed to the increase in yield of rice due to the adoption of best combination of agronomic practices by farmers under the SRI method.

3.3 Profitability of Rice Production

The mean gross margin, which is the difference between total revenue and total variable cost of rice production, was GH¢3,697.51 per acre of rice production under SRI method. This value is more than twice the mean gross margin of GH¢1,515.75 per acre obtained under the conventional method. The statistically significant revenue differential, as exhibited in Table 3, is attributed to the improvement in productivity, yield and revenue under the SRI method.

Gross margin ratio, which is a measure of profitability, was established as the percentage of gross margin on the total revenue obtained from rice production. The mean gross margin ratio obtained for the production of rice under the SRI was 60.68% compared to 44.04% obtained under the conventional method. While farmers under the SRI method obtain GH¢60.68 for every GH¢100.00 sale of rice, farmers under the conventional method obtained GH¢44.04 per every GH¢100.00. It is, therefore, established that SRI method of rice production in Ghana, though a little more costly, is more profitable than the conventional method. This observation is consistent with, Berkelaar [27], and Nissanka and Bandara [28] who established that SRI yields higher economic returns than the Conventional method.

4. CONCLUSION AND RECOMMENDATION

The study concludes that SRI method of rice production, though a little more costly, is more profitable than the conventional method resulting from a higher yield brought on by the adoption of a combination of best agronomic practices.

The study provides the following recommendations for improving the rice industry and farmers' livelihoods:

i. Rice farmers need to be encouraged by the Ministry of Food and Agriculture

(MoFA) to adopt the System of Rice Intensification for better outcomes through awareness creation, extension services and training

ii. The system of Rice Intensification needs to be promoted in Ghana by MoFA to increase the country's current level of self-sufficiency in rice production

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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