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Potential of rice farmer groups in the production of improved seed in Upper Denkyira East Municipality

Clifford Yeboah-Manson[1], Enoch Kwame Tham-Agyekum[2*], Eli Gaveh[3], John-Eudes Andivi Bakang[4]

[1]Department of Horticulture, KNUST-Kumasi, Ghana.
[2]Department of Agricultural Economics, Agribusiness and Extension, KNUST- Kumasi, Ghana.
[3]Department of Horticulture, KNUST-Kumasi.
[4]Department of Agricultural Economics, Agribusiness and Extension, KNUST- Kumasi, Ghana.

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Increasing local production and savings in foreign exchange is important that local rice producers are supplied with quality seed in a timely manner. The overall goal of the research was to assess the seed-rice production potential amongst rice farmer groups in Ghana. A two-stage sampling technique was deployed in the sampling process. Analysis of data was mainly by mean, frequencies and percentages, while the Kendall's coefficient of concordance was used to rank opportunities and challenges. The stochastic frontier approach using the Cobb-Douglas model was used in determining production technical efficiency. Empirical results disclosed that high group cohesiveness among rice member groups helps to attain individual goals and ensure member commitment. The most important production opportunities for rice production were identified as timely extension contacts, suitability of production agroecology and access to production inputs. Lack of production and processing equipment, however, was a key constraint. Overall, rice farmers within all the study groups were technically efficient. The study recommends that government, stakeholders, and rice farmer groups should invest into timely agricultural extension services, and equipment such as planting equipment; machinery, milling equipment, and bird exclusion nets and devices.

Key words: Cohesiveness, improved seed production, potential, resource use, rice farmer groups, stochastic frontier approach, technical efficiency.

INTRODUCTION

Rice (*Oryza sativa* L.) is Ghana's second most significant food crop after maize (Yahaya et al., 2019). Despite the country's strong production capacity, the majority of rice consumed in the country is imported. In 2020, imports were expected to range between 6.5 and 10.1 million tons (Seck et al., 2010). In 2020, total rice imports to Ghana hit nine-hundred and fifty thousand tons, with average annual growth rate of 12.52% from 1971 to 2020. This volume of import suggests that in order to increase savings in foreign exchange, there is the need to increase local production of rice. This also implies that key inputs such as quality seeds are supplied to farmers

*Corresponding author. E-mail: ektagyekum@knust.edu.gh.

in a timely manner (Knoema, 2020).

Quality seed, characterised by high germination, appropriate moisture level, diseased free and high purity is of great significance in any seed system (FAO, 2014). According to Sah et al. (2015), using good quality seed alone could enhance agricultural yields by up to 30%. To Paudel et al. (2013), a gap in seed supply and demand can result in low uptake of enhanced seed. It is imperative in any successful seed programme that all seeds are available in desired quantities (FAO, 2014).

It is critical, according to Kumar et al. (2019) to increase the supply of high-quality seed by encouraging farmers to participate in seed production. Farmer groups and co-operatives have the potential to contribute massively to the formal seed production through increased access if they are engaged as contract farmers (Mezgebo, 2019). Importance of farmer group in seed production is evident in Nepal where farmer groups are the largest contributor of quality seed to the formal seed production system. When farmers are engaged in contract farming, their profits are enhanced. Farmers' participation is determined by the size of their farms and their primary occupation. There is evidence to suggest that promotion and upscaling of contract farming will help to augment seed production (Kumar et al., 2019). Farmers' engagement in seed production, according to Kalamkar (2012), has the ability to improve the livelihoods of rural poverty farmers by boosting revenue. According to the FAO (2014), it is critical to decentralize seed production. Local seed production enhances the production of seeds that are highly adaptable to local conditions. However, decentralised seed production cannot be possible if resources for seed growing, harvesting, processing, treating and storage are unavailable.

The use of high-quality seed, according to Sah et al. (2015) has the potential to increase yield by up to 30%. The year is 2015. The official seed industry, which comprises the National Seed Council and the National Variety Release Committee, is overseen by Ghana's Ministry of Food and Agriculture (MoFA). The official seed sector exists to provide farmers with better seed types for maximum yields (Aidoo et al., 2013).

Nevertheless, the formal seed sector has failed to provide this crucial production input to farmers in a timely and sufficient manner. The formal seed sector contributed just around 3% of the total area of farmed rice in Ghana in 2015. For farmers, the informal seed supply system accounted for up to 97% of seed supplies. The burden of certified seed production is placed in the hands of a few producers, posing a threat to quality and timely supply at critical times (Aidoo et al., 2013). The informal seed supply sector in Ghana feeds the majority (80%) of farmers across major food crops. As a result of the limited formal seed suppliers, certified seeds have consistently been unavailable to farmers at the time of need forcing them to resort to farmer-saved seeds, thus, selecting seeds from their grain harvest to sow. Further, late supply of improved seeds has paved way for certain unscrupulous persons to sell packaged grains to farmers as seed. This unethical activity is unacceptable, and Ghana has to encourage seed-rice production to address it (Mabaya, 2016; Aidoo et al., 2013).

There are existing studies that have established the importance of rural producer organisations in solving collective farmers' problems such as reducing transaction costs through collective action, with specific emphasis on its relevance in developing countries (Ito et al., 2012; Latynskiy and Berger, 2016). More importantly, there is empirical evidence that showed that an increase in farm revenue, as well as an improvement in the economic welfare of farmers, can be enhanced by their participation in farmer groups especially agricultural cooperatives through increased technical efficiency and yield (Deng et al., 2016). Farmers' participation in both formal and informal associations can facilitate access to inputs and high yieldenhancing improved technological innovations such as pesticides, improved seed varieties, irrigation facilities, and fertilisers. The use of improved technologies ensures that an increase in technical efficiencies of farmers and yield are achieved through an increase in the optimal combination and use of inputs (Mojo et al., 2017).

There has been growing interest from policymakers and stakeholders on the relevance of farmer groups especially agricultural cooperatives in the improvement of technical efficiency and yield of smallholder farmers in developing countries. Results from research studies conducted on this important subject shows mixed results. For instance, studies such as Abate et al. (2014), Gedara et al. (2012), Petcho et al. (2019) and Wollni and Bru¨mmer (2012) reported insignificant and significant impact for farmers respectively. Possible reasons for this mixed evidence include differences in the structure of the formation and operation of farmer groups (cooperatives) and the estimation techniques employed.

Although a couple of studies have been conducted in the area of rice farmer groups (Abdul-Rahaman and Abdulai, 2018; Acheampong et al., 2017), the potential of some rice farmer groups (measured in terms of group cohesion, opportunities and challenges, resource use and technical efficiency of inputs among rice farmer groups) in the Upper Denkyira East and West districts has not been studied. Therefore, the study sought to find out, (1) the state of cohesiveness of rice farmer groups, (2) the factors affecting group cohesion, (3) the opportunities and constraints facing rice farmer groups, (4) the extent of resource use among rice farmer groups and (5) the technical efficiencies of rice farmer groups (inputs and rice production).

MATERIALS AND METHODS

Upper Denkyira East is a District in the Central Region with Dunkwa-

Table 1. Study groups.

Rice farmer group	No. of members
Akyerekrom rice farmers association	26
Jamasi-Kona rice farmers association	17
Zion camp rice farmers association	58
Total	101

on-Offin as the capital. This study employed the quantitative research design. The study used descriptive design, which also falls under quantitative research. A multi-stage sampling technique was used in the sampling process. First, the study area, which is the Upper Denkyira East District, was selected purposively. The dominance of rice production within the District and existing rice farmer associations is what influenced its selection for the study. The second stage was the selection of farmer associations within the District for the study. All rice farmer associations registered with the Ministry of Agriculture within the District were selected. The third stage involved the selection of individual farmers as respondents to the study. Due to the relatively low number of members within every farmer group, a census-based sampling was used; thus, all farmers who were members for each group were selected for data collection (Table 1).

Data was obtained using a field survey questionnaire. Respondents answered questionnaires to give information on socio-demographic characteristics, production resources availability, production technical efficiency and group cohesiveness. Farmer Groups were engaged in a focus group discussion to discuss the opportunities available to them and constraints faced. Respondents were asked to rank the opportunities and constraints.

Kendall's coefficient of concordance: This study employed the Kendall's coefficient of concordance for the ranking of opportunities and constraints the various farmer groups are exposed to. According to Al-Hassan et al. (2008), the coefficient of concordance is given by the formula:

$$W = \frac{12[\Sigma T^2 - \frac{(\Sigma T)^2}{n}]}{nm^2\,(n^2-1)} \tag{1}$$

where, W = Kendall's Coefficient of Concordance, T = sum of ranks for factors being ranked, m = number of respondents, n = number of factors being ranked.

The Kendall's coefficient of concordance procedure is a nonparametric statistical test used to rank a given set of challenges or issues, from the most important to the least important. It also measures the degree of agreement or concordance among the respondents. Opportunities and constraints would be ranked from the most important to the least important using numerals 1, 2, 3 ... n in that order (where n is a positive integer).

The total rank score for each opportunity/challenge was computed and the opportunity/ challenge with the lowest score will be ranked as the most important, while the one with the highest score will be ranked as the least important. The total rank score computed will then be used to compute the Kendall's coefficient of concordance (W), which measures the degree of agreement among respondents in the ranking.

Group cohesiveness: Group cohesiveness was ranked among respondents based on a 3-Point Likert scale [(1= high cohesiveness); (2 = moderate cohesiveness), and (3 = low cohesiveness)]. The information obtained from the questionnaires were subjected to descriptive statistics using percentages and frequencies for each category of cohesion. A single-point mean score was then used as the determining factor for the overall group cohesiveness.

Production technical efficiency: The production technical efficiency (TE) of farmer groups was determined using the stochastic frontier approach (SFA) to determine the farmers' ability to convert farm inputs such as seed, labour and fertilizer into output. The SFA was independently proposed by Aigner et al. (1977) and Meeusen and van Den Broeck (1977). It is based on an econometric specification of a production frontier. SFA specification allows for a non-negative random component in the error term to generate a measure of technical inefficiency. The stochastic frontier production function, according to Aigner et al. (1977), is defined by;

$$Yi = f(Xi;\beta) + ei \tag{2}$$

Where i = 1,2,3,4 …... N

But

$$ei=vi-ui \tag{3}$$

where Y_i is the yield/output level of the ith farm household, $f\ (X_{i;}\ \beta)$ is the production function of the vector, xi is the inputs for the ith farm household and a vector β is the parameter to be estimated. e_i denotes an error term composed of two components v_i and u_i. The error term v_i accounts for random effects that arise out of measurement errors and other production factors that are not under the control of the farmer. u_i is a non-negative error term that relates to farmer-specific factors, that hinders the farmer from obtaining optimum production efficiency. u_i therefore the technical inefficiency effects that occur within the control on the farmer/decision-making unit.

Authors such as Mabe et al. (2018), Abdulai et al. (2018), and Danso-Abbeam et al. (2015) specified technical efficiency of an individual farm household as the ratio of the observed output to the corresponding output of the frontier, based on the level of inputs used by the farm household. Since technical efficiency measures producing the maximum amount of output using the minimum possible inputs, it means that technical inefficiency looks at how much/the margin by which a farmers' level of output falls below the frontier output (Konja et al., 2019). Therefore, technical efficiency of the ith farm household could be specified as:

$$TE_i = \frac{Observed\ output\ of\ ith\ farm\ household}{Frontier\ output\ of\ all\ farm\ households} = \frac{Yi}{Y_i^*} = \frac{(f(X_i;\beta).e^{v_i - U_i})}{f(X_i;\beta).e^{v_i}} = e(-u) \tag{4}$$

$$Technical\ inefficiency = 1 - TE_i \tag{5}$$

Table 2. Description of variables in the stochastic frontier translog production model.

Variable	Description	Measurement	Expected sign
Yield	Quantity of output	Kilogram	+
Seed	Seed quantity used	Kilogram	+
Weedicide	Quantity of weedicide used	Liters	+
Fertilizer	Fertilizer quantity used	Kilogram	+
Labour	Quantity of labour used	Man-day	+
Farm size	Size of farm cultivated	Acreage	+

Table 3. Akyerekrom - Group cohesion.

Akyerekrom Rice Farmers Association				
Variable	**High Freq. (%)**	**Moderate freq. (%)**	**Low freq. (%)**	**Mean rank**
Level of group cohesion	22 (84.62)	4 (15.38)	0 (0)	1.15
Jamasi-Kona Rice Farmers Association				
Variable	**High Freq. (%)**	**Moderate Freq. (%)**	**Low Freq. (%)**	**Mean Rank**
Level of group cohesion	2 (11.76)	8 (47.06)	7 (41.18)	2.29
Zion Camp Rice Farmers Association				
Variable	**High Freq. (%)**	**Moderate Freq. (%)**	**Low Freq. (%)**	**Mean Rank**
Level of group cohesion	18 (31.03)	36 (62.07)	4 (6.90)	1.76

Source: Field Survey (2020).

The variables expressed in the empirical stochastic frontier translog production model for determining the factors that influence yield/output of the *i*th rice farmer household and their a-priori expectations have been presented in Table 2.

RESULTS AND DISCUSSION

Group cohesion

Group cohesion refers to a sense of attraction or a bond that pulls people towards membership in a certain group and a feeling of morale associated with their membership in that group. It further measures the strength of members' desire to remain in a group (group pride), their sense of belonging and their commitment to it (Forsyth, 2006) (Table 3). In Akyerekrom, a high group cohesion was reported among members. Twenty-two farmers representing 84.62% of respondents rated the groups' cohesion as high. Nevertheless, 4 farmers (15.38% of respondents) rated group cohesion as moderate. Considering the information available, it could be said that unity among members was high. A mean rank of 1.15 further supports the idea that there is a high level of group cohesion among members of the Akyerekrom Farmers group. The high group cohesion could be as a result of good leadership, fairness and clear definition of group objectives. It also means that members have a sense of belonging to the group and would desire to continue associating with their colleagues (Paulus, 2012). In confirmation to the results of this study, Taruvinga et al. (2021) suggested that members in their study also had a significant sense of belonging and a feeling of morale associated with their membership in the group. Amongst rice farmers in Jamasi-Kona, out of the 17 members in the group, only 2 (11.76%) of the farmers indicated that there is high level of cohesiveness in the group. Eight of them representing 47.06% indicated that there is moderate cohesiveness within the farming group. A significant number of rice farmers (41%) also ranked cohesiveness within their group as low. Based on the reported findings and the 2.29 mean rank, overall group cohesion within the Jamasi-Kona rice farmer group is rated as moderate. Majority (62%) of the respondents within the Zion Camp Rice Farmers Association indicated that there is a moderate cohesion among members of the group. About 31% said that the cohesion in the group at Zion Camp was high while the remaining 7% revealed that there is a low cohesion in the group. With a mean rank of 1.76, overall group cohesion in Zion Camp is rated as moderate. This means that the rice farmers' association in Jamasi-Kona and Zion camp do not have a strong bond of belongingness and their members will not be motivated to achieve the goals and objectives of their association (Paulus, 2012; Dakurah et al., 2005).

Table 4. Factors affecting group cohesion.

Factors	Yes		No		Obs.
	Frequency	Percentage	Frequency	Percentage	
Akyerekrom rice farmers association					
Continuity	26	100	0	0	26
Commitment	26	100	0	0	26
Group attraction	26	100	0	0	26
Participation	26	100	0	0	26
Individual goals	23	88.46	3	11.54	26
Withdrawal	0	0	26	100	26
Jamasi-Kona rice farmers association					
Factors	**Yes**		**No**		**Obs.**
	Frequency	**Percentage**	**Frequency**	**Percentage**	
Continuity	17	100	0	0	17
Commitment	17	100	0	0	17
Group attraction	17	100	0	0	17
Participation	17	100	0	0	17
Individual goals	2	11.76	15	88.24	17
Withdrawal	0	0	17	100	17
Zion camp rice farmers association					
Factors	**Yes**		**No**		**Obs.**
	Frequency	**Percentage**	**Frequency**	**Percentage**	
Continuity	58	100	0	0	58
Commitment	57	98.28	1	1.72	58
Group attraction	58	100	0	0	58
Participation	58	100	0	0	58
Individual goals	46	79.31	12	20.69	58
Withdrawal	2	3.45	56	96.55	58

Source: Field Survey (2020).

However, the farmers in these groups have the opportunity to develop their cohesiveness. They need to have similar values, aspirations and beliefs and they feel that they can trust each other (Gikunda and Lawver, 2019) (Table 4).

Findings from Akyerekrom and Jamasi-Kona Rice Farmers Association revealed that all farmers within the group would want to continue as members into the future. Expectedly, all farmers indicated that the group is attractive and they show commitment and active participation in group activities. In Akyerekrom, twenty-three of the farmers constituting 88.46% mentioned that the group has helped to achieve their individual goals, whilst 3 farmers (11.54%) stated that their individual goals are yet to be met. In Jamasi-Kona, fifteen of the farmers constituting 88.24% mentioned that the group has helped to achieve their individual goals, whilst 2 farmers (11.76%) stated that their individual goals are yet to be met. No farmers in both Akyerekrom and Jamasi-Kona Rice Farmers Association had decided to withdraw from the group. On the factors that affect group cohesion, Jussila et al. (2012) and Paulus (2012) agreed that it is highly dependent on the commitment of group members and their ability to patronize the group. If members are not committed to their cooperative, they often lack the motivation to perform optimally towards the activities of that group.

All the rice farmers in the Zion Camp rice farmer group reported that they were willing to continue as members of the group. It was also revealed that all the members were attracted to the group, hence their participation in the group's activities. About 12 members representing 20.69% indicated that their personal goals had not been met by the group while 2 (3.45%) were ready to withdraw from the group. The study by Abdul-Rahaman and Abdulai (2018) revealed that farmers who engage in farmer groups tend to benefit positively from the groups. Taruvinga et al. (2021) also found that the key factors that enhance group cohesion were financial performance, communication within the coopoerative, involvement

Table 5. Opportunities available to rice farmer groups.

Akyerekrom			Jamasi-Kona			Zion Camp		
Opportunities	**Mean Score**	**Rank**	**Opportunities**	**Mean rank**	**Rank**	**Opportunities**	**Mean rank**	**Rank**
Timely extension contacts	2.71	1st	Suitable agro-ecology	1.59	1st	Working capital	1.92	1st
Suitable agro-ecology for production	2.76	2nd	Access to input	1.65	2nd	Extension contact	2.07	2nd
Access to inputs	3.00	3rd	Access to road	3.24	3rd	Suitable agro-ecology	2.66	3rd
Active member participation	3.62	4th	Access to electricity	3.53	4th	Access to roads	3.34	4th
Feel of ownership by members	3.95	5th	-	-	5th	-	-	-
Access to electricity	4.95	6th	-	-	-	-	-	-
			Test statistics					
Number of observations	21		Number of observations		17	Number of observation	58	
Kendall's W	0.21		Kendall's W		0.63	Kendall's W	0.25	
Chi-Square	22.442		Chi-Square		32.224	Chi-square	43.922	
Degree of freedom	5		Degree of freedom		3	Degree of freedom	3	
Asymptotic significance	0.00		Asymptotic significance		0.00	Asymptotic Significance	0.00	

Source: Field survey (2020).

in decision making, trust and role in the community. All the significant factors had a positive relationship with group cohesion, indicating that an improvement in these factors result in an increase in group cohesiveness. Among the significant factors, 'trust' had the highest β-value of 0.642 and was significant at 1% level, highlighting its great influence on group cohesion.

Opportunities and challenges

Based on the Kendall's ranking technique, the rice farmers in Akyerekrom stated that availability of timely extension service was the topmost opportunity they can take advantage of. This had a mean score of 2.71. The second ranked opportunity was the presence of suitable agro-ecology for production. The agro-ecology favours the cultivation of rice and respondents see this as a great opportunity. Access to production inputs was also ranked as the third most important opportunity. It has a mean score of 3.00. Though access to electricity was considered an opportunity, it was of little importance to the group. It was ranked sixth with a mean score of 4.95. These ranking were observed among 21 respondents and there was a relatively low (21.4%) level of agreement (Kendall's W) amongst the ranked opportunities (Table 5).

Among the rice farmers in Jamasi-Kona, the Kendall ranking revealed that suitable agro-ecology was ranked the topmost important by the rice with a mean rank of 1.59. Also, access to input was ranked the next important opportunity with a mean rank of 1.65, while access to electricity was ranked the least important opportunity after access to road with mean ranks of 3.53 and 3.24 respectively. The Kendall's W shows that there was a relatively high (63.2%) as the level of agreement among the 17 rice farmers.

Among the rice farmers in Zion camp, the analysis showed a Kendall's W of 0.25, which indicates that there is a relatively low (25%) level of agreement among farmers concerning the ranking of the opportunities. The study found that working capital was the most common opportunity available to farmers at Zion Camp. Additionally, access to extension was ranked second by the respondents. The farmers indicated further that at Zion Camp, there is a suitable agro-ecology for rice farming. Hence, this was ranked as the third opportunity in the area. Finally, the respondents indicated that access to roads is another opportunity identified at Zion Camp, which was ranked fourth among the opportunities. Access to capital ranking as the first opportunity affirms findings from Yiadom-Boakye et al. (2013) that less than 50% of farmers face capital or credit challenges (Table 6).

The top three challenges among rice farmers in Akyerekrom were: inadequate working capital

Table 6. Challenges facing rice farmer groups.

Akyerekrom			Jamasi-Kona			Zion camp		
Challenge	Mean score	Rank	Challenge	Mean score	Rank	Challenges	Mean score	Rank
Inadequate working capital	1.53	1st	Bird infestation	1.41	1st	Bird infestation	1.76	1st
Lack of equipment	1.80	2nd	Lack of planting, threshing, and milling equipment	1.71	2nd	Unattractive market price	2.81	2nd
Bird infestation	3.05	3rd	Unattractive market price	3.06	3rd	Lack of harvesting and threshing equipment	2.97	3rd
Unattractive market price for commodity	4.18	4th	Poor member participation	4.06	4th	High cost of fertilizer	3.67	4th
High cost of weedicide and insecticide	4.45	5th	Non-availability of storage facility	5.24	5th	Lack of effective selective weedicide	3.78	5th
Access to electricity	4.95	6th	Poor extension contact	5.53	6th	-	-	-
			Test Statistics					
Number of observations	20		Number of observations		17	Number of observation		58
Kendall's W	0.71		Kendall's W		0.87	Kendall's W		0.27
Chi-Square	56.95		Chi-Square		73.91	Chi-square		61.42
Degree of freedom	4		Degree of freedom		5	Degree of freedom		4
Asymptotic significance	0.00		Asymptotic significance		0.00	Asymptotic Significance		0.00

Source: Field survey (2020).

(1.53), lack of equipment (1.80) and bird infestation (3.05).

Unattractive market price for produce, and high cost of weedicide and insecticides were also seen as challenges, though, of little importance. They were ranked fourth and fifth respectively. There was a relatively high level of agreement (71.2%) among the farmers. The top three challenges among the rice farmers in Jamasi-Kona were bird infestation (1.41), lack of planting equipment (1.71) and unattractive market price (3.06). Poor member participation, non-availability of storage facility and poor extension contact followed with mean ranks of 4.06, 5.24 and 5.53 respectively. There was a relatively high level of agreement (87%) among the farmers. The top three challenges among the rice farmers in Zion camp were bird infestation (1.41), unattractive market price (2.81) and lack of harvesting and threshing equipment (2.97). In contrast, a study by Denkyirah et al. (2016) revealed that market price is not a major challenge faced by rice farmers. Furthermore, the farmers indicated that another challenging issue they face in their rice production was high cost of fertilizer. This was ranked as the fourth most severe challenge by rice farmers at Zion Camp. This finding is in congruence with Denkyirah et al. (2016) who found that inputs costs represent a major challenge in rice farming. Lastly, the lack of selective weedicide for rice cultivation was ranked as the fifth most severe constraint in rice farming by the respondents at Zion Camp. There was a relatively low level of agreement (27%) among the farmers.

Resource use among rice farmer groups

Overall, resource (seed, labour, weedicide) quantities used were very low compared to studies such as Konja et al. (2019) and Lema et al. (2017). Except for fertilizer usage which was relatively high compared with Lema et al. (2017). The study also showed that all the 3 farmer groups achieved yield higher than what was reported by Konja et al. (2019) but the area of cultivated farm size were similar (Table 7).

The study revealed that farm size, quantity of fertilizer, weedicide, seed used and number of man days expended in production had effect on the output level of rice in the study area. From Table 8, farm size had a coefficient of 0.66 and was statistically significant at 1%. This means that when a farmer increases farm size by 100%, holding other variable inputs constant, output would increase by approximately 66%. This finding is in line with Konja et al. (2019) and Abdulai et al. (2018). Further, it was shown that the quantity of fertilizer used is statistically significant at 1% with a coefficient of 0.46. This

Table 7. Extent of resource use among rice farmer groups.

Variable	Unit	Average	Std. Dev.	Min.	Max.
Akyerekrom rice farmers association					
Farm size	Acre	2.43	1.37	1	7
Yield	Kilograms (Kg)	1232.38	727.11	480	3900
Labour used in production	Man-days/acre	6.62	3.89	2.14	20
Seed	Kg/acre	12.14	7.43	0	26.67
Weedicide	Liters/acre	1.30	0.50	0.57	2.33
Fertilizer	Kg/acre	114.63	210.18	0	666.67
Jamasi-Kona rice farmers association					
Variable	**Unit**	**Average**	**Std. Dev.**	**Min.**	**Max.**
Farm size	Acre	2	1.13	0.5	5
Yield	Kilograms (Kg)	1734.12	1055.62	360	3900
Labour used in production	Man-days/acre	6.28	2.91	2.4	13
Seed	Kg/acre	12.87	9.33	2.6	40
Weedicide	Liters/acre	1.53	0.94	0.5	4
Fertilizer	Kg/acre	106.33	159.06	25	550
Zion camp rice farmers association					
Variable	**Unit**	**Average**	**Std. Dev.**	**Min.**	**Max.**
Farm size	Acre	2.53	1.06	1	6
Yield	Kilograms (Kg)	1398.07	572.35	600	3600
Labour used in production	Man-days/acre	4.69	3.55	0.75	15
Seed	Kg/acre	9.79	5.96	3.33	40
Weedicide	Liters/acre	1.35	0.75	0.33	4
Fertilizer	Kg/acre	53.73	36.46	16.67	200

Source: Field survey (2020).

Table 8. Maximum likelihood estimates of the stochastic translog production frontier model.

Variables	Coefficient	Standard error	P-values
ln Q (Main model)			
ln Farm size	0.66***	0.05	0.00
ln Fertilizer	0.46***	0.04	0.00
ln Weedicides	0.59***	0.00	0.00
ln Seeds	0.080***	0.02	0.00
ln Labour	-0.15***	0.03	0.00
Constant	4.96	0.26	0.00
Insig2v	-34.25	1137.59	0.98
Insig2u	-4.26	0.54	0.00
sigma_v	3.66	0.00	
Sigma_u	0.12	0.03	
sigma2	0.01	0.01	
lambda	3255225	0.03	
Number of observations = 7			
Log likelihood = 9.82			
Wald chi^2 (5) = 7.89			
Prob > chi^2 = 0.00			

***Significant at 1%. ln = natural log, Q = quantity of rice output (kg).
Source: Field survey (2020).

Table 9. Technical efficiency of inputs.

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Efficiency	7	0.95	0.09	0.74	0.99

Source: Field survey (2020).

Table 10. Log likelihood estimation of the stochastic frontier production.

Variables	Coefficient	Std. error	Z	P>|z|
ln Q (Main model)				
ln Farm size	1.93*	1.08	1.79	0.07
ln Fertilizer	0.53***	0.12	4.60	0.00
ln Weedicides	0.42**	0.20	2.08	0.04
ln Seeds	2.18*	1.23	1.77	0.08
ln Labour	-1.38*	0.73	-1.89	0.06
Constant	1.80	2.68	0.67	0.50
Lnsig2v	-4.27	0.50	-8.54	0.00
Lnsig2u	-13.55	662.51	-0.02	0.98
Sigma_v	0.12	0.03		
Sigma_u	0.00	0.58		
Sigma2	0.01	0.01		
Lambda	0.01	0.59		
Number of observations = 8				
log likelihood = 5.75				
Wald chi^2 (5) = 73.45				
Prob > chi^2 = 0.00				

***, **, * Significant at 1; 5 and 10% respectively. ln = natural log, Q = quantity of rice output (kg).
Source: Field survey (2020).

implies that when fertilizer use increases by 100%, ceteris paribus, output would increase by about 46%. This result is consistent with Mabe et al. (2018) and Amaechina and Eboh (2016).

Similarly, weedicide was statistically significant at 1% with coefficient of 0.591. This means that output would likely increase by 59% when the quantity of weedicide used increases by 100%. This is contrary to the findings of Konja et al. (2019) and Amaechina and Eboh (2016) where a negative relationship was revealed in both studies. Seed quantity usage was statistically significant at 1% with a coefficient of 0.08, denoting that for every 100% quantity increase in seed usage, output is likely to increase by 8%, holding other variable inputs constant. Lastly, man days expended in production was statistically significant at 1% with a coefficient of -0.15. This also implies that when the number of labour man days used in production increases by 100%, ceteris paribus, output would decrease by about 15%. This is surprising since the a-priori expectation was that more labour hours should contribute positively to yield.

Technical efficiency of inputs

From Table 9, technical efficiency based on the stochastic frontier estimation was within the range of 73.6 and 99.9%. On average, farmers were 95.2% efficient with use of resources. Thus, the level of inefficiency among farmers in turning inputs into output is 4.8%. This finding implies that rice farmers within the study area achieve about 95% of output whilst close to 5% of output is lost as a result of production inefficiencies. Konja et al. (2019) reported a TE range of 11 to 98%, and the findings conformed with those of Abdulai et al. (2018) and Mabe et al. (2018). The distribution of TE in this study is not in line with the findings of these authors.

The estimation of the model parameters was calculated using the frontier models in STATA with the Cobb-Douglas modelling form. Table 10 presents the results obtained from running the stochastic frontier production function. All the variables measured were statistically significant. The result shows that the coefficients of farm size, fertilizer, weedicides and seeds were positively

Table 11. Overall technical efficiency of rice production.

Variable	Mean	Std. Dev.	Min.	Max.	Obs.
Technical efficiency	0.98	0.00	0.98	0.98	38

Source: Field survey (2020).

significant but the coefficient of labour was negatively significant. Farm size in acres showed was significant at 10% with a coefficient value of 1.93. This result means that a percentage change in size of the farm would affect yield by 193%. The coefficient of fertilizer was statistically significant at 1% that of weedicides was significant at 5% but the coefficient of seeds and labour are significant 10%. The implication of the result is that by holding all factors at their constant, a one percent increase in expenditure on fertilizer will lead to 53% increase in yield per acre. Again, a percent increase in weedicides is likely to increase yield per acre by 42%. This is not surprising because the use of weedicides checks and reduces weed growth thereby allowing crop to utilize the available nutrients in the soil. Furthermore, a percent increase in expenditure on seeds and labour will lead to 218% increase and 138% decrease in yield per acre respectively. The result is consistent with the study of Yiadom-Boakye et al. (2013) who found that labour, fertilizer and seed (valued in Cedis) and land had significant effect on yield of rice farmers. It is also consistent with the result of Ma et al. (2018). The study reported that expenditure on labour, fertilizer, and seed yams, which are major inputs in yam production, were shown to be significant in the frontier production function (Table 10).

From Table 11, technical efficiency for the pooled sample based on the stochastic frontier estimation was within the range of 97.97 to 98.25%. On average, farmers were 98.11% efficient with their use of resources (fertilizer). This implies that the level of inefficiency among farmers in turning inputs (fertilizer) into output is 1.89%. The results suggest that participation in rice farmer groups results in greater technical efficiency than non-participation. Within the farmer group, wholesales are negotiated on behalf of the farmers to gain a stronger price negotiating power. Farmers do not need to look for marketing channels. Also using the pooled function, the average technical efficiency of non-members as found by Qu et al. (2020) was slightly higher than members, although the difference was not significant. In that study, eventhough the marketing-cooperative membership was positively related to output, such cooperatives could not increase efficiency for their members.

Conclusions

Based on empirical evidence, it is concluded timely extension contacts; suitability of agroecology for production, and access to production inputs are important considerations as opportunities for a successful rice farming business. Amongst the rice production bottlenecks, important ones that call for immediate attention are: lack of equipment (planting; machinery, milling, and bird exclusion equipment), and high bird pest on rice fields. High group cohesiveness among members helps to attain individual goals, and ensure active participation and member commitment. When farmers increase the quantity of fertilizer per acre used (to optimal levels) output level would increase significantly, ceteris paribus. Overall, rice farmers within all the study groups are technically efficient, and it could be due to the timely extension contacts and high group cohesion. Seed-rice production could prove a feasible investment among rice farmer groups, considering the high extension contact, adept production experience, the suitable agroecology and the high technical efficiency with input resource use. The main considerations would be to avert the overriding challenges, in order to leverage on this opportunity. The following recommendations have been made, as policy measures to ensure successful rice production and the general success of rice farmer associations.

(i) Rice farmer association leaders should promote maintaining high cohesion among members through implementation of relevant programmes, ensuring fairness and equity, and clear description of group goals. High group cohesiveness helps to achieve individual goals, and subsequently, group goals.
(ii) Timely agricultural extension services should be promoted by government in the rice production sector, since farmers consider it an important production factor.
(iii) Factors that could promote suitable production agro-ecology including the provision of irrigation should be provided through joint effort by government, and rice farmer associations.
(iv) Government, stakeholders, and rice farmer groups should invest into important pre-harvest and post-harvest equipment such as planting equipment; machinery, milling equipment, and bird exclusion nets and devices. This would significantly reduce post-harvest loses, and improve productivity and grain quality.
(v) The study suggests that future research should conduct a comparative assessment of production technical efficiency of farmer groups and non-farmer group individual producers. This would help determine whether there is any statistically significant difference among the two groups and whether group membership has any implication on technical efficiency.

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CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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