PERCEPTION AND KNOWLEDGE OF RICE VALUE CHAIN ACTORS ON THE EFFECT OF IMPROVED PRACTICES ON YIELD AND MILLING CHARACTERISTICS OF RICE IN THE SAGNARIGU AND KUMBUNGU DISTRICTS OF GHANA

ABSTRACT

This study presents findings from a comprehensive survey conducted between January and March 2021, aimed at elucidating the agricultural practices and perceptions of rice farmers, processors, and marketers in the Sagnarigu and Kumbungu districts of the Northern Region in Ghana. The research sought to gather essential data on improved techniques employed in rice cultivation, milling, and marketing, as well as understand the perceptions surrounding these practices within the local farming communities. Employing a multi-stage sampling methodology, primary data were collected through face-to-face interviews with 134 rice farmers, 82 processors, and 22 marketers.Key findings revealed that a significant proportion (54.7%) of farmers preferred cultivating local rice varieties such as Moses, Bumbass, Mandii, Bazolgu, Salimasaa, and Assemblyman. Moreover, the survey indicated that 54.5% of farmers adopted the broadcasting method for planting seeds, while only 18% practiced line transplanting with well-defined spacing. Additionally, a majority of transplanting activities occurred when seedlings were at least 4 weeks old, highlighting potential inefficiencies in timing.The study identified several constraints hindering rice production in both lowland and irrigated rice ecosystems across the surveyed districts. These constraints include the prevalence of poor-quality seed varieties, inadequate spacing, suboptimal

timing of transplanting, and low soil fertility. Addressing these challenges is imperative for enhancing rice productivity and promoting sustainable agricultural practices in the region.

Keywords: Rice cultivation, Agricultural practices, Northern Ghana, Farming communities, Sustainable agriculture.

1 Introduction

In Africa, rice has emerged as a linchpin in the quest for food security, assuming a pivotal role in dietary sustenance(IRRI, 2013). With rapid urbanization, burgeoning population rates, and evolving culinary preferences, rice consumption has outpaced that of other staples across the continent. As Seck et al. (2013) highlight, this surge in rice consumption signifies its burgeoning importance in African diets, ranking third in significance overall and serving as the primary source of dietary energy in West Africa.

Despite this rising demand, local rice production in Africa struggles to keep pace (Seck *et al.*, 2013). The aftermath of the 2007–2008 food crisis witnessed a rapid expansion in local rice output, yet supply still falls short of demand. Muthayya*et al.* (2014) indicate that only 54% of rice consumed is domestically produced, leaving Africa reliant on imports to bridge the deficit. Even with increased domestic production, the continent continues to import substantial quantities of rice to meet its needs, with imports accounting for a significant portion of the global rice trade.

Africa's rice industry grapples with multifaceted challenges, necessitating comprehensive support to bolster productivity and sustainability. Key areas requiring attention include establishing robust seed systems, promoting climate-resilient varieties, advocating for good agricultural practices (GAP), enhancing quality control along the value chain, and investing in critical infrastructure (Macauley, 2015). These initiatives are paramount in optimizing rice production and addressing the persistent gap between supply and demand.

Ghana, endowed with favorable agronomic conditions, stands as a promising locus for year-round rice cultivation (Addai *et al.,* 2022). With vast agricultural land and considerable irrigation potential, Ghana holds the capacity to significantly boost rice yields (McCarthy, 2020). However, regional disparities persist, with certain districts outperforming others in terms of yield performance. While some regions exhibit commendable yields, others struggle to meet even the national average.

The Northern region of Ghana, a key rice-producing area, faces myriad challenges impeding optimal productivity. Factors such as limited adoption of modern agricultural technologies, inadequate access to fertilizers, reliance on low-yielding varieties, and paucity of credit facilities hinder the region's agricultural potential (Tanko *et al*., 2016). These challenges underscore the imperative of implementing targeted interventions to uplift the region's agricultural landscape and enhance rice production.

Amidst these challenges, the adoption of improved practices holds promise in bolstering rice productivity. However, empirical validation of this expectation is essential. Thus, this study seeks to investigate the perception and knowledge of rice

value chain actors regarding the efficacy of improved practices on rice yield and milling characteristics in Ghana's Sagnarigu and Kumbungu Districts. By delving into stakeholders' perspectives, this research aims to unravel the nuances of rice production dynamics and inform strategic interventions aimed at unlocking the full potential of the rice sector

2. Materials and methods

2.1 Study area

The survey was conducted from January to March 2021 in the Sagnarigu and Kumbungu districts in the Northern region of Ghana.

2.2 Sampling techniques and data collection

Sampling techniques play a crucial role in ensuring the accuracy and reliability of research findings, particularly in studies focusing on agricultural dynamics. In this study, a meticulous multi-stage sampling methodology was employed to capture the intricate nuances of rice production in the Sagnarigu and Kumbungu Districts of Ghana.The first stage of sampling involved the purposive selection of SagnariguKukuo and Bontanga, identified as prominent rice-producing localities within the northern region of Ghana. These locales were chosen strategically due to their significance in the regional rice landscape, setting the stage for subsequent data collection efforts.Subsequently, the second stage saw the implementation of a stratified sampling approach, which enabled the categorization of the target population into distinct groups based on key variables. These primary categories encompassed producers, including both irrigated and rain-fed farmers, processors, and marketers. By stratifying the population, the study aimed to ensure adequate representation of

diverse stakeholder groups, thereby enriching the depth and breadth of collected data.Within each stratum, sample sizes were determined using simple random sampling techniques, ensuring the equitable and unbiased selection of participants. Specifically, 134 farmers—comprising 69 rain-fed and 65 irrigated—were randomly chosen to provide insights into the distinct challenges and opportunities encountered within each farming condition. Similarly, 22 marketers and 82 processors were selected through simple random sampling, reflecting the varied roles and perspectives along the rice value chain.Data collection was facilitated through the administration of a well-structured questionnaire, meticulously designed to elicit comprehensive information from participants. Conducted via face-to-face interviews, this approach fostered direct engagement with respondents, enabling nuanced exploration of their experiences, perceptions, and practices within the rice production domain.

2.3 Data analysis

The SPSS statistical analysis program was used to compile all the responses into a datasheet, and the means were then separated using LSD at 5%.

3. Results

3.1 Gender

Table 1: Genderof farmers, processors, and marketers

	Farmers		Processors		Marketers	
Gender	Frequency	Percent	Frequency	Percent	Frequency	Percent
Male	126	94.0	6	7.3	3	13.6

Female	8	6.0	76	92.7	19	86.4
Total	134	100.0	82	100.0	22	100.0
Mean	1.06		1.93		1.86	
SEM	.021		.029		.075	
Std. Deviation	.238		.262		.351	
Variance	.057		.069		.123	

134 farmers, 82 processors, and 22 marketers who consist of 94 %, 7.3%, and 13.6 malesand 6%, 92.7%and 86.4 %females respectively were interviewed from the two districts (Table 1).

3.2 Age

Table 2: Age of farmers, processors and marketers

	Farmers		Processors		Marketers	
Age	Frequency	Percent	Frequency	Percent	Frequency	Percent
18 – 24	16	11.9	1	1.2	1	4.5
25 – 35	33	24.6	10	12.2	0	0
36 – 45	49	36.6	43	52.4	10	45.5
46– 70	36	26.9	28	34.1	11	50.0
Total	134	100.0	82	100.0	22	100.0
Mean	3.78		4.20		4.45	
SEM	0.084		0.077		0.127	
SD	0.976		0.693		0.355	
Var.	0 .953		0.480		1	4.5

36.6% of the farmers fell within the age range of 36 to 45 years (Table 2). whereas 11.9% of the respondents were within the 18 to 24 age brackets. 52.4% of the rice processors in the study area fell within the age brackets36 – 45 (Table 2). The least age bracket was 18 – 24 which was made up of 1.2% of the sample population. 50.0%

of the rice marketers in the study were within the age brackets 46- 70 years old (Table2). The age range with the least population (4.5 %) was from years. 18- 24 years

3.3 Education

Table 3:Education of farmers, processors and marketers

	Farmers		Processors		Marketers	
Educational level	**Frequency**	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percent**
No formal educ.	84	62.7	76	92.7	22	100.0
Primary	11	8.2	1	1.2		
JHS/Middle Sch.	13	9.7	4	4.9		
SSS/SHS	12	9.0				
Tertiary	14	10.4	1	1.2		
Total	134	100.0	82	100.0		
Mean	1.96		1.16		1.00	
Std. Error of Mean	.123		.068		.000	
Std. Deviation	1.427		.618		.000	
Variance	2.036		.382		.000	

62.7 % of the farmers had no formal education while 10.4 % of them had received tertiary education (Table 3).

92.7% of the processors had no formal education (Table 3). whereas 1.2% of the population had either primary school education or tertiary education.

All the marketers had no formal education (Table 3).

3.4 Seed source

Table 4: Seed source

Seed source	**Fre**	**%**	**Reasons for choice**	**Frequency**	**%**
Cheaper than certified seeds	8	6.0	Cheaper than certified seeds	8	6.0
Readily available	11	8.2	Readily available	11	8.2
Higher yield obtained from the	21	15.7	Higher yield obtained from	21	15.7

previous season			previous season		
Certified seeds are costly	65	48.5	Certified seeds are costly	65	48.5
To supply certified seeds to farmers	4	3.0	To supply certified seeds to farmers	4	3.0
Higher yield	10	7.5	Higher yield	10	7.5
Own seeds performed well	11	8.2	Own seeds performed well	11	8.2
High yield obtained from the farmer	4	3.0	High yield obtained from the farmer	4	3.0
Total	134	100.0	Total	134	100.0
Mean	4.04		Mean	4.04	
Std. Error of Mean	.139		Std. Error of Mean	.139	
Std. Deviation	1.608		Std. Deviation	1.608	
Variance	2.584		Variance	2.584	

Only 8.2 % of the farmers in the study area used certified seed in cultivating rice (Table4). 75.4 % of the farmers used their seed in cultivating rice in the 2020 cropping season.

The majority of the farmers (54.5 %) from the study area did not use the certified seed because the certified seeds were costly (Table 4). 15.7 % of the farmers were contended with the yields they had the previous season and continued with their seed.

3.5 Variety cultivated in the 2020 cropping season

Table 5: Variety cultivated, processed or marketed in 2020 in Sagnarigu and Kumbungu districts in the noethern region of Ghana

	Farmers			**processors**			**Marketers**	
Variety	**Fre**	**%**	**Variety**	**Fre**	**%**	**Variety**	**Frequency**	**%**
Bumbas	7	5.2	Gbewaa rice	10	12.2	Gbewaa rice	6	27.3
Moses	32	23.9	Agra rice	53	64.6	Agra rice	2	9.1
Digang	6	4.5	Moses	4	4.9	Moses	2	9.1

Mandii	9	6.7	Digang	2	2.4	Digang	1	4.5
Bazolgu	3	2.2	Gomma	2	2.4	Gomma	2	9.1
Salimasaa	4	3.0	Mandee	1	1.2	Mandee	1	4.5
Assemblyman	3	2.2	Tops	1	1.2	Tops	1	4.5
Kuradoo	2	1.5	Anofula	1	1.2	Anofula	1	4.5
Tox	1	.7	Bazolgu	8	9.8	Amaru	1	4.5
Digang	2	1.5				Bazolgu	3	13.6
Agra	50	37.3				Faaro	1	4.5
Gbewaa rice	15	11.2				GR18	1	4.5
Total	134	100.0	Total	82	100.0	Total	22	100.0
Mean	8.19		Mean	3.37		Mean	6.18	
SEM	.453		SEM	.384		SEM	1.086	
Std. D	5.248		Std. D	3.477		Std. D	5.096	
Variance	27.541		Variance	12.087		Variance	25.965	

The variety that was used the most in the 2021 cropping season in the study area was Agra, 37.3 % of the farmers used this variety in the 2021 cropping season (Table 5). This was followed by the Moses variety as 23.9% of the farmers planted this variety. These were followed by Gbewaa rice, mandi, Bumbass, Digang, and salimasaawith the respective percentage of farmers' usage of 11.2 %, 6.7 %, 5.2 %, 4.5 %, and 3.0 %. 64.6% of the rice processors in the study area prefer Agra rice to Paddy for processing (Table 5). 12.2% of the respondents prefer Gbwewa rice as their paddy for processing while 9.8% of the respondents prefer Balzogu rice variety as their raw material for processing4.9% of them prefer Moses, 2.4% of them prefer Digam or Gomma and 1.2% of them prefer Mandii, Tops, Anofula as paddy processing.

27.3% of the rice marketers in the study area preferred Gbewaa rice as paddy for marketing (Table 5). 13.6 % of the marketers preferred Bazolgu in doing their business. 9.1% of the respondents preferred either Agra rice, Moses rice, or Gomma

rice as their paddy for marketing while 4.5% of the respondents preferred either Digang rice, Mandiirice, Tops rice, Anofula rice, Amaru rice, Faaro rice or GR18 paddy or milled rice for marketing.

3.6 Reason for choice of the variety

Table 6: Reason for choice of the variety in cultivating in the 2020 cropping season

Reason for choice of variety	Frequency	Percent
Seeds are available	1	.7
Change of variety	4	3.0
High yielding	122	91.0
Good price for the paddy	4	3.0
Milled grains are of good quality	2	1.5
Recommended by MoFA or other institutions	1	.7
Total	134	100.0
Mean	4.03	
Std. Error of Mean	.044	
Std. Deviation	.505	
Variance	.255	

The majority (91 %) of the farmers selected varieties based on the yield (Table 6). However, most of the farmers at Bontanga selected the Moses variety due to not only its high-yielding ability but also its good milling qualities when harvested at 12 % moisture content.

3.7 Method of planting the rice

Table 7: Method of planting the rice

Method of planting	Fre	%		**Frequency**	%
Broadcasting haphazardly	73	54.5	Carrying out cultural practices is easy	5	3.7
Transplanting seedlings without a definite distance or space between plants	38	28.4	Transplanting is costly	6	4.5
Hand drilling in rows without approximate spacing	1	.7	Inadequate tractor services	1	.7
Dibbling without approximate spacing	4	3.0	Transplanting is faster	29	21.6
Line transplanting	18	13.4	Broadcasting is faster	3	2.2
			Less costly	45	33.6
			Higher yield	18	13.4
			Less labour	17	12.7
			No labor available for transplanting	2	1.5
			Right plant population	8	6.0
Total	134	100.0	Total	134	100.0
Mean	2.06			5.83	
Std. Error of Mean	.146			.180	
Std. Deviation	1.685			2.083	
Variance	2.839			4.339	

54.5 % of the farmers planted their seeds using the broadcasting method (Table 7). The majority of these farmers were from lowland rain-fed ecology. While the majority of the farmers under irrigated ecology nursed and transplanted their rice seedlings. 28.4 % of the respondents transplanted seedlings without a definite distance or space between plants. However, 13.4 % of the sample population practiced line transplanting with well-defined spacing. Most of the farmers selected broadcasting because they could not afford the cost involved in transplanting and those who selected transplanting indicated that transplanting gave them better yield (Table 7).

3.8 Age of seedling at transplanting

Table 8: Age of seedling at transplanting

Age of seedling	Frequency	Percent
2 weeks after nursing seeds	2	1.5
3 weeks after nursing seeds	15	11.2
4 weeks after nursing seeds	8	6.0
5 weeks after nursing seeds	10	7.5
6 weeks after nursing seeds	14	10.4
More than 6 weeks after nursing seeds	7	5.2
N/A	78	58.2
Total	134	100.0
Mean	5.63	
Std. Error of Mean	.163	
Std. Deviation	1.891	
Variance	3.574	

The 41.8% of the farmers in the study area, who practiced transplanting, transplanted at different ages of the seedlings (Table 8). Only 12.7% of the sample population transplanted when the seedlings were 2 and 3 weeks old. 6 % and 7.5 % of the sample population were transplanted when the seedlings were at least 4 weeks and 5 weeks old respectively. 10.4 % and 5.2 % of the farmers transplanted when the seedlings were 6 or more weeks old respectively. It is worth noting that 58.2 % of the farmers did not use transplanting in planting their rice.

3.9 Rate and type of fertilizer application

Table 9: Rate and types of fertilizer application and reason for the choice

Rate/type of fertilizer	Fre	%	Reason	Frequency	%
Only basal application of chemical fertilizer	59	44.0	Recommended by MoFA	27	20.1
Only the second application of chemical fertilizer	12	9.0	Cannot afford the recommended rate	5	3.7

Application of self-prepared organic manure (compost) or farm yard manure	1	.7	Can only afford the basal application	9	6.7
No fertilizer application	1	.7	Can only afford a second application	2	1.5
Chemical fertilizer (solid) application at the recommended rate	59	44.0	Higher yield	76	56.7
Both chemical and compost fertilizer applications at recommended rates	2	1.5	Chemical fertilizer application is costly	14	10.4
			Less costly	1	.7
Total	134	100	Total	134	100.0
Mean	2.98		Mean	4.73	
Std. Error of Mean	.170		Std. Error of Mean	.190	
Std. Deviation	1.971		Std. Deviation	2.204	
Variance	3.887		Variance	4.860	

Coincidentally, 44 % of the farmers applied only the basal application of chemical fertilizer, and chemical fertilizer at the recommended rate(Table 9). Only 1.5% of the farmers applied both compost and chemical fertilizer. 9.0 %,0.7 %, and 0.7 % of the farmers in the study area applied onlya second application of chemical fertilizer,self-prepared organic manure (compost), or farm yard manure, and no fertilizer respectively.

56.7 % of the farmers in the study area choice of the type and rate of fertilizer application was tied to higher yield (Table 9).Most of the farmers who could not apply the recommended rate linked it to their inability to afford it.

3.10 Qualities that influence the choice of paddy

Table 10: Qualities that influence the choice of paddy for processing and marketing

	Processors	**Marketers**

Qualities	Fre	%		Frequency	%
Unbroken grains	20	24.4	Unbroken grains	2	9.1
Aromatic grains	4	4.9	Long grains	4	18.2
Uniformity of grains	28	34.1	Broken grains	3	13.6
Cooking characteristics	22	26.8	Aromatic grains	3	13.6
The moisture content of grains	8	9.8	Uniformity of grains	4	18.2
			Cooking characteristics	5	22.7
			The moisture content of grains	1	4.5
Total	82	100.0	Total	22	100.0
Mean	4.90		Mean	4.32	
Std. Error of Mean	.285		Std. Error of Mean	.485	
Std. Deviation	2.580		Std. Deviation	2.276	
Variance	6.657		Variance	5.180	

34.1% of the rice processors in the study area made their choice of a variety of paddy based on the uniformity of the grains(Table 10). 26.8 % and 24.4 % of these processors made their choice based on the cooking characteristics and the percentage of unbroken grains respectively. Those who made their choice based on the moisture content of grains and aromatic characteristics of the grains were 9.8 % and 4.9% of the processors respectively.

22.7 % of the rice marketers in the study area made their choice of a variety of paddy based on the cooking characteristics (Table 10). 18.2 % of the rice marketers made their choice of paddy based on long grains or uniformity of grains. 13.6 % of these marketers made their choice based on broken grains or aromatic grains. 9.1 % of the marketers preferred unbroken grains. Finally, 4.5 % of the marketers in the study area made their choice based on the moisture content of grains.

4. Discussion

4.1 Gender of farmers, processors and marketers

Gender dynamics play a significant role in shaping the landscape of rice production, processing, and marketing in Ghana's Northern region. Our study delved into these dynamics to elucidate the extent of gender disparity and its implications for the rice sector in the study area.

According to our findings, 94% of the farmers interviewed were males, underscoring the prevailing dominance of men in rice cultivation within the two districts under study (see Table 1). This observation corroborates previous research by Addison et al. (2023), which highlighted the historical predominance of male farmers in rice production across Northern Ghana. However, the low representation of females in rice farming raises concerns about gender equity and its potential impact on overall rice productivity. Women traditionally play crucial roles in various aspects of rice production, including land preparation, planting, and weeding, making their limited participation a matter of concern for the sector's sustainability.

In contrast, our study revealed that 92.7% of the processors operating in the study area were females (see Table 1). This disparity underscores the significant involvement of women in rice processing activities, aligning with the findings of Lelea (2020), who identified women as key players in tasks such as parboiling, a popular processing method in Northern Ghana. The dominance of women in rice processing reflects their integral role in adding value to rice post-harvest, contributing to the local economy and food security.

Similarly, our study found that 86.4% of the marketers engaged in rice trading within the two districts were females (see Table 1). This trend highlights the predominance of women in rice marketing activities, with men playing a comparatively smaller role. However, this imbalance raises concerns about gender inclusivity and the equitable distribution of economic opportunities within the rice value chain. Addison et al. (2014) further support this observation, noting that women are predominantly involved in post-harvest tasks such as threshing, winnowing, and drying, as well as selling rice in local markets.

The gender dynamics observed in our study underscore the need for targeted interventions aimed at promoting gender equity and inclusivity within Ghana's rice sector. Efforts to increase female participation in rice farming through access to resources, training, and support programs are essential for enhancing productivity and ensuring sustainable development. Moreover, initiatives to empower women in rice processing and marketing can unlock their full potential as key contributors to the sector's growth and resilience.

4.2 Age of farmers, processors, and marketers

Among the farmers surveyed, 36.6% fell within the age range of 36 to 45 years, indicating a significant presence of individuals in their prime working years (see Table 2). Notably, 11.9% of respondents were aged between 18 to 24 years. This finding suggests that while a considerable portion of the active youth are engaged in rice cultivation, there is a lack of participation among individuals aged 24 and below. The average age of farmers in Ghana, as reported by the Ministry of Food and Agriculture

(MoFA, 2013), is 55 years, underscoring the importance of attracting younger individuals to ensure the sector's vitality and sustainability.

Turning to rice processors, our study found that 52.4% fell within the age brackets of 36 to 45 years, with the average age of processors being 46 years (see Table 2). Coincidentally, this aligns with findings by Frimpong *et al.* (2023), who also reported an average age of 46 years for rice processors in the Northern region of Ghana. This age range falls within the productive years for agricultural activities in Ghana, suggesting a positive outlook for rice processing in the country. However, the low representation of individuals aged 18 to 24 years (1.2%) highlights the need to attract younger talent to sustain and invigorate the processing sector.

In the realm of rice marketing, our study revealed that 50.0% of marketers in the study area were aged above 45 years (see Table 2), with the average age of marketers being 51 years. This skew towards older individuals indicates a potential challenge in attracting younger generations to engage in rice marketing activities. To ensure the vibrancy and competitiveness of the rice market, efforts must be made to entice younger individuals to enter the sector and bring fresh perspectives and innovations.

4.3 Education of farmers, processors, and marketers

Among the farmers surveyed, a staggering 62.7% reported having no formal education, while only 10.4% had received tertiary education (see Table 3). This stark disparity underscores the challenges faced by a significant portion of the farming population in accessing technical information and training necessary for the adoption of modern agricultural practices. Comparatively, File and Nhamo (2023) reported a

lower percentage of farmers without formal education in the Northern region, highlighting the need for targeted interventions to address educational disparities and facilitate technology transfer within the farming community. Tanko and Ismaila (2021) corroborate this concern, suggesting that farmers with lower levels of education may face barriers in adopting current agricultural production technologies.

Similarly, our study revealed that a staggering 92.7% of rice processors lacked formal education, with only a minimal percentage having received primary or tertiary education (see Table 3). This finding underscores the significant educational gap among processors, posing challenges for the adoption of modern processing technologies and techniques. Adams *et al.* (2019) further support this observation, reporting a similarly high percentage of rice processors in Ghana's Northern region lacking formal education. Addressing this educational deficit among processors is critical for enhancing efficiency and value addition within the rice processing segment.

In the domain of rice marketing, all respondents reported having no formal education (see Table 3). This unanimity underscores a concerning trend whereby the majority of marketers in the study area lack the educational foundation necessary for informed decision-making and market analysis. This educational deficit not only hampers the efficiency of rice marketing activities but also poses challenges for broader economic development within the region.

4.4 Seed source

Our findings revealed that a mere 8.2% of farmers surveyed utilized certified seed in their rice cultivation endeavors (see Table 4). This low adoption rate aligns with the observations of Ragasa *et al.* (2013), who reported that 54.5% of Ghanaian farmers relied on their own seeds for planting, while 31.1% sourced seeds from fellow farmers. The predominance of non-certified seed usage among Ghanaian rice farmers underscores the prevalence of traditional farming practices and the limited uptake of modern agricultural technologies.

The low adoption of certified seed poses significant challenges for rice production, particularly in terms of varietal purity and the preservation of desirable traits associated with certified varieties. Certified seeds offer assurances of quality, uniformity, and genetic purity, thereby contributing to higher yields and improved crop resilience. However, the reliance on farmers' seeds, often characterized by varietal degeneration and genetic impurities, compromises the potential for optimal production outcomes.

4.5 Reasons for Seed Source

Our study revealed that a significant proportion of farmers (48.5%) in the study area opted not to use certified seeds due to the perceived high cost associated with them (see Table 4). This finding resonates with the observations of Ragasa and Chapoto (2017), who identified the high cost of hybrid rice seeds as one of the major barriers to rice production in Ghana. The prohibitive cost of certified seeds poses a formidable

obstacle for smallholder farmers, limiting their access to high-quality seed varieties and impeding their ability to adopt modern agricultural practices.

The financial burden of purchasing certified seeds is particularly pronounced for resource-constrained farmers, many of whom operate within subsistence farming systems characterized by limited access to credit and financial resources. In the face of competing demands and uncertainties inherent in agricultural production, farmers are often compelled to prioritize immediate needs over long-term investments, opting for cost-effective but potentially inferior seed sources.

In addition to cost, other factors such as availability, awareness, and perceived benefits also influence farmers' decisions regarding seed sources. Access to certified seeds may be limited in remote rural areas, where distribution networks and extension services are inadequate. Furthermore, farmers' knowledge and understanding of the advantages associated with certified seeds may vary, impacting their willingness to invest in these higher-cost options.

4.6 Choice of variety

Among farmers surveyed, the Agra variety emerged as the most favored choice for the 2021 cropping season, with 37.3% of farmers opting for this variety (see Table 5). Following closely behind was the Moses variety, chosen by 23.9% of farmers. Notably, a significant proportion (54.7%) of farmers continued to rely on local seed varieties such as Moses, Bumbass, Mandii, Bazolgu, Salimasaa, and Assemblyman. The preference for local varieties underscores farmers' familiarity with and confidence in these traditional cultivars, with factors such as market demand and yield potential

influencing their choices. For instance, the Moses variety is popular among farmers in Bontanga due to its marketability and high-yielding characteristics, particularly when harvested with optimal moisture content.

In the processing segment, our study found that 64.6% of rice processors preferred the Agra variety for processing (see Table 5). This preference aligns with findings by Azumah*et al*. (2022), who noted a widespread adoption of improved rice varieties like Agra, Sakai, Jasmine 85, and Afife among farmers in the region. Similarly, Adams *et al*. (2019) highlighted the popularity of Jasmine and Agra rice among women engaged in parboiling activities in the Northern region. These varieties are valued for their aroma, grain size, and cooking characteristics, which appeal to consumers' preferences and contribute to market acceptance and demand.

In the marketing sphere, our study revealed that 27.3% of rice marketers preferred Gbewaa rice as paddy for marketing (see Table 5). This preference is consistent with previous research by Asante *et al*. (2013) and Adams *et al.* (2019), who identified Jasmine and Agra rice as the predominant varieties processed and marketed in the Northern region. The qualities of these varieties, including aroma, grain size, and cooking quality, align with consumer preferences and contribute to their popularity in local markets.

The variety preferences observed among farmers, processors, and marketers underscore the dynamic interplay between agricultural production, processing, and market demand in Ghana's rice sector. By aligning variety choices with consumer preferences and market trends, stakeholders can enhance the competitiveness and sustainability of the rice value chain, driving economic growth and rural development.

4.7 Reason for choice of the variety

Our study revealed that an overwhelming majority of farmers (91%) selected rice varieties based on their yield potential (see Table 6). This finding underscores the paramount importance of yield in farmers' decision-making processes, highlighting their emphasis on maximizing productivity and ensuring a bountiful harvest. However, it is noteworthy that farmers in Bontanga exhibited a preference for the Moses variety, primarily due to its superior milling qualities when harvested at 12% moisture content, in addition to its high-yielding ability. This nuanced consideration reflects farmers' awareness of the importance of post-harvest characteristics and marketability in addition to yield potential.

Similarly, findings by Bissah*et al.* (2022) support our observations, indicating that Ghanaian farmers prioritize certain rice varieties based on taste, aroma, and high-yielding potential. These attributes are valued not only for their impact on crop productivity but also for their influence on consumer preferences and market acceptance. By selecting varieties with desirable taste and aroma profiles, farmers can enhance the marketability of their produce and capture value-added opportunities within the rice value chain.

The reasons behind farmers' choice of rice varieties are multifaceted, encompassing considerations related to agronomic performance, market demand, and personal preferences. While yield remains a primary consideration for many farmers, factors such as taste, aroma, milling qualities, and post-harvest characteristics also play

significant roles in shaping variety preferences. Moreover, regional variations in soil conditions, climate, and market dynamics further contribute to the diversity of variety choices observed among farmers across different locations.

Understanding the drivers behind farmers' choice of rice varieties is essential for informing targeted interventions and support mechanisms aimed at enhancing agricultural productivity and sustainability. By aligning research and extension efforts with farmers' preferences and priorities, policymakers, researchers, and agricultural extension agents can foster a more conducive environment for variety adoption and innovation within Ghana's rice sector.

4.8 Method of planting

Our study revealed that 54.5% of farmers employed the broadcasting method to plant their rice seeds (see Table 7). This method, characterized by scattering seeds evenly across the field surface, was particularly popular among farmers in lowland rain-fed ecologies. In contrast, farmers operating under irrigated conditions predominantly utilized the nursery and transplanting approach for rice cultivation. However, it is worth noting that a significant portion of these transplanted rice seedlings were done without definite spacing, indicating suboptimal practices that may impact crop yield and overall farm efficiency. Only 18% of farmers practiced line transplanting with well-defined spacing, suggesting a low adoption rate of this more precision-oriented planting technique.

These findings align with observations by Ragasa *et al*. (2013), who noted that broadcasting remains the predominant planting method among rice farmers in the Northern region of Ghana. The prevalence of broadcasting can be attributed to several factors, including the traditional farming practices, labor availability, and access to agricultural inputs and mechanization. Additionally, the predominance of lowland rain-fed ecologies in the study area may further contribute to the widespread adoption of broadcasting, as this method is often favored in such environments due to its simplicity and cost-effectiveness.

The low adoption of line transplanting with well-defined spacing highlights the need for targeted interventions and extension efforts to promote more precision-oriented planting practices among farmers. Line transplanting offers several advantages over broadcasting, including improved weed control, better utilization of resources, and enhanced crop uniformity, ultimately leading to higher yields and better farm productivity. By encouraging the adoption of line transplanting and providing farmers with the necessary training and support, stakeholders can contribute to the sustainable intensification of rice production in Ghana.

4.9 Reason for choice of method of planting

Our study revealed a divergence in planting methods, with a majority of farmers opting for broadcasting due to cost considerations, while others chose transplanting for its perceived yield benefits (see Table 7). The affordability of broadcasting emerged as a key driver for its widespread adoption among farmers, with many citing the lower cost involved compared to transplanting. This finding resonates with the observations

of Hindersah*et al*. (2022), who highlighted the simplicity, cost-effectiveness, and labor-saving advantages of the broadcasting method as factors contributing to its popularity among rice farmers in the Northern region of Ghana.

Conversely, farmers who selected transplanting cited its potential for higher yields as the primary motivation behind their choice. Transplanting offers several advantages over broadcasting, including better control over plant spacing, reduced competition from weeds, and enhanced nutrient uptake, ultimately leading to improved crop uniformity and productivity. Despite the higher labor and input costs associated with transplanting, some farmers prioritize yield optimization and quality considerations, demonstrating a nuanced understanding of the trade-offs involved in planting method selection.

The reasons behind farmers' choice of planting methods underscore the complex interplay of economic, agronomic, and practical factors shaping agricultural decision-making in Ghana. While cost considerations and labor availability often influence farmers' choices, perceptions of yield potential, crop quality, and resource utilization also play significant roles in shaping planting method preferences. Moreover, regional variations in agroecological conditions, market dynamics, and access to agricultural inputs may further influence farmers' decision-making processes, leading to diverse planting practices observed across different locations.

4.10 Age of seedling at transplanting

Our study revealed that 41.8% of farmers who practiced transplanting transplanted seedlings at various ages, with the majority opting to transplant when the seedlings were at least 4 weeks old (see Table 8). Conversely, only 12.7% of farmers transplanted seedlings aged 2 to 3 weeks. Studies have demonstrated that early transplanting can reduce transplanting shock, leading to better establishment and ultimately higher productivity. This finding is supported by recommendations from Koudjega*et al*. (2019), who advocate for transplanting rice seedlings between 8 and 15 days of age, as well as insights from Reuben *et al*. (2016), indicating superior crop growth performance with earlier transplanting.

The age at which seedlings are transplanted reflects farmers' practices and knowledge regarding optimal transplanting techniques. By transplanting seedlings at the appropriate age, farmers can enhance crop establishment, minimize transplanting shock, and promote robust early growth, laying the foundation for high-yielding rice crops. Therefore, promoting awareness and adoption of best practices related to transplanting timing can contribute to improved rice productivity and farm profitability in Ghana.

4.11 Rate and type of fertilizer application

Our study found that farmers who applied only the basal application of fertilizer were comparable to those who applied chemical fertilizer at the recommended rate, with both groups accounting for 44% of the sample population (see Table 9). Only 1.5% of farmers applied both compost and chemical fertilizer. However, the adoption of the

recommended rate of chemical fertilizer was suboptimal, and the application of compost was minimal. On average, farmers applied 2.34 bags per acre or 5.84 bags per hectare of fertilizer on their rice farms.

The low adoption of recommended fertilizer rates and limited use of compost highlight the challenges and constraints faced by rice farmers in accessing and utilizing appropriate soil nutrients. This finding is consistent with previous research by Ragasa *et al.* (2013), which identified low fertilizer usage among farmers in northern Ghana. Additionally, Tetteh *et al*. (2002) noted that recommended fertilizer dosages are often outdated and may not align with farmers' practical needs and resource constraints.

\

4.12 Reason for choice of type and rate of application

Our study revealed that 76% of farmers in the study area cited higher yield as the primary reason for their choice of fertilizer application rate (see Table 9). These finding underscores farmers' focus on maximizing productivity and enhancing farm profitability through optimized fertilizer management practices. Indeed, research by Addison *et al*. (2023) supports this observation, highlighting the potential for government subsidies to incentivize rice farmers to adopt modern cultivation practices and improve agricultural productivity. By offering subsidies for fertilizers and other inputs, policymakers can empower farmers to invest in soil fertility management and increase their yields, contributing to food security, income generation, and poverty reduction in rural Ghana.

The preference for higher fertilizer application rates reflects farmers' aspirations for increased crop yields and improved livelihoods. By investing in soil nutrients and adopting optimal fertilizer practices, farmers can enhance the nutrient status of their soils, promote healthy crop growth, and achieve higher yields. However, it is essential to ensure that fertilizer application rates are aligned with agronomic recommendations and tailored to the specific needs of each farm, considering factors such as soil fertility, crop requirements, and environmental sustainability.

4.13 Qualities that influence the choice of paddy for processing

The selection of paddy for processing is a crucial step in rice milling, influencing the quality, taste, and marketability of the final rice product. In our investigation of rice processing practices in Ghana, we delved into the qualities that influence processors' choices of paddy, shedding light on the factors driving their decision-making process and the implications for rice processing in the country.

Our study revealed that 34.1% of rice processors in the study area based their choice of paddy variety on the uniformity of the grains (see Table 10). This finding underscores the importance of grain consistency in ensuring the quality and appearance of the final rice product. Additionally, 26% and 24% of processors selected paddy based on cooking characteristics and the percentage of unbroken grains, respectively. These qualities, including taste, texture, and appearance, are critical determinants of consumer satisfaction and market acceptance.

Moreover, 4.9% of processors preferred aromatic grains, recognizing the value-added attributes associated with aromatic rice varieties. Processors consider these qualities when purchasing paddy for processing, emphasizing the importance of cultivating the right rice varieties to meet market demands and consumer preferences. This finding resonates with insights from Asante *et al.* (2013), who highlighted the significance of grain quality, taste, and yield potential in the selection of rice varieties for cultivation in the Ashanti region of Ghana.

5. Conclusion and recommendation

5.1 Conclusion

Among the notable findings is the prevalence of local rice varieties among farmers, with 54.7% of them opting for varieties such as Moses, Bumbass, Mandii, Bazolgu, Salimasaa, and Assemblyman. This underscores the importance of preserving traditional varieties and promoting their cultivation alongside improved varieties to enhance agricultural diversity and resilience.

Furthermore, our study revealed that broadcasting remains the most widely practiced planting method among farmers, with 54.5% of them opting for this approach. Conversely, only 18% of farmers practiced line transplanting with well-defined

spacing, highlighting opportunities to promote more efficient planting techniques to optimize crop establishment and yield potential.

In terms of fertilizer application, our findings indicate that 44% of farmers either applied only basal application of chemical fertilizer or applied the chemical fertilizer at the recommended rate, while only a small fraction (1.5%) applied both compost and chemical fertilizer. This suggests potential gaps in nutrient management practices and opportunities to promote integrated soil fertility management approaches for sustainable rice production.

In the realm of rice processing, our study found that processors prioritize qualities such as uniformity of grains, cooking characteristics, and the percentage of unbroken grains when selecting paddy for processing. Similarly, rice marketers consider cooking characteristics, grain uniformity, and grain quality as key factors influencing their choice of paddy varieties. These insights underscore the importance of quality attributes in driving consumer preferences and market demand for rice products.

5.2 Recommendation

In light of our findings from a comprehensive study, we present a set of recommendations:

- ✓ Addressing misconceptions and Perceptions: One of the primary barriers to the adoption of improved practices in the rice value chain is the presence of

misconceptions and perceptions among stakeholders. To overcome this challenge, stakeholders must engage with farmers, processors, and marketers to understand their beliefs and concerns regarding new technologies and practices, and providing targeted education and awareness programs to dispel myths and foster acceptance.

- ✓ Targeting Key Demographic Factors: Gender, educational level, and age are critical demographic factors that influence technology adoption in the rice sector. Our study revealed that the participation of females in rice production, processing, and marketing is disproportionately low, limiting the sector's productivity and potential for growth. Similarly, the lack of formal education among a significant portion of farmers poses challenges to the adoption of modern agricultural practices.

- ✓ To address these disparities, stakeholders must prioritize training and empowerment programs targeted at female farmers, processors, and marketers. These initiatives should focus on building technical skills, business acumen, and confidence, empowering women to play a more active role in the rice value chain.
- ✓ Promoting Accessible Technologies: The affordability and accessibility of technology are key determinants of adoption rates among value chain actors. Our study revealed that cost considerations often deter farmers from using certified seeds and adopting modern cultivation techniques such as

transplanting. Similarly, processors may revert to traditional methods due to the unaffordability of modern processing equipment.

- ✓ To promote technology adoption, stakeholders should facilitate access to subsidies, grants, or credit facilities for purchasing inputs and equipment, as well as promoting cooperative initiatives and collective purchasing arrangements to leverage economies of scale.
- ✓ Investing in Research and Development: Further research is essential to inform evidence-based decision-making and drive continuous improvement in rice production, processing, and marketing.
- ✓ Ensuring Quality Standards: Finally, stakeholders must implement quality assurance measures throughout the value chain, from production and processing to packaging and distribution. By maintaining high-quality standards, Ghana can enhance the competitiveness of its rice products in domestic and international markets, driving economic growth and prosperity for all stakeholders.

REFERENCES

Adams, A., Jumpahb, E. T., Ilesanmi, K. D. and Bennind, H. D. (2019). Analysis of parboiled rice processing in the northern region of Ghana: determinants, constraints and opportunities. *Asian Journal of Agriculture and Rural Development*, Vol 9, Issue 2.

Addai, K. N., Ng'ombe, J. N., and Kaitibie, S. (2022). ADose–response analysis of rice yield to agrochemical use in Ghana. *Agriculture* 2022, 12, 1527. https:// doi.org/10.3390/agriculture12101527

Addison, M., Ohene-Yankyera, K. , Adjei, P .O. W., Mujawamariya G., Asante B. (2023). Uptake and income distribution effects of targeted farm technologies on rice farmers in forest and Guinea Savannah Zones of Ghana: Does gender matter? *Journal of Agriculture and Food Research*. Volume 11, March 2023, 100516. https://doi.org/10.1016/j.jafr.2023.100516

Addison, M., Edusah, S. E. and Sarfo-Mensah, P. (2014). Gender constraints and rice varietal characteristics preferences in lowland rice ecosystem in Ghana. Developing Country Studies www.iiste.org. ISSN 2224-607X (Paper) ISSN 2225-0565 (Online). Vol.4, No.15

Ayeduvor, S. (2018). Assessing quality attributes that drive preference and consumption of local rice in Ghana. GSSP Working Paper 48. Washington, D.C.: International Food Policy Research Institute (IFPRI). http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/132286

Azumah S. B. and Adzawla, W. (2017). Effect of urea deep placement technology adoption on the production frontier: evidence from Irrigation rice farmers in the Northern Region of Ghana. *World Academy of Science, Engineering, and Technology International Journal of Biological, Biomolecular, Agricultural, Food and Biotechnological Engineering Vol:11, No:4*

Azumah, S., Lamptey, C., Sulemana, N., Donkoh, S.,Zakaria, A. and Izideen, M. (2022). An explorative study on the adoption and dis-adoption of improved rice varieties among

farmers in the Northern Region of Ghana. Journal of Experimental Biology and Agricultural Sciences, 10, 323 – 334. DO - 10.18006/2022.10(2).323.334

File, D. J. M. and Nhamo, G. (2023). *Heliyon*. (9):11. SN 2405-8440. DO - https://doi.org/10.1016/j.heliyon.2023.e22162.https://www.sciencedirect.com/science/article/pii/S2405844023093702

Frimpong, B. N., Asante, B. O., Asante, M. D., Ayeh, S. J., Sakyiamah, B., Nchanji, E., Mujawamariya, G., Zenna, N. andnTufan H. (2023). Identification of gendered trait preferences among rice producers using the G+ breeding tools: implications for rice improvement in Ghana. *Sustainability*, 15, 8462. https://doi.org/10.3390/su15118462

Hindersah, R. K., Agusthinus M. and Talahaturuson, A. (2022). Rice yield grown in different fertilizer combination and planting methods: Case study in Buru Island, Indonesia" Open Agriculture, vol. 7, no. 1, 2022, pp. 871-881. https://doi.org/10.1515/opag-2022-0148

International Rice Research Institute (IRRI) (2013). Training Manual Paddy Drying. Postharvest Unit, CESD, Version 2, October 2013, p, 51. [8] IRRI.www.knowledgebank.irri.org at @Ebook Browse. Training Manual Paddy Drying pdf free ebook download from www.ebookbrowse.com/ trainingmanual-paddy-drying-pdf 2012; d88323894:18e20.

Koudjega K., Ablede K. A., Lawson I. Y. D., Abekoe M. K. and Owusu-Bennoah E. (2019). Assessing the effect of seedling age and time of urea supergranule application on rice growth, yield, and nitrogen use efficiency. West African Journal of Applied Ecology, vol. 27(1), 2019: 78 – 94.

Lelea, M. A. (2020). Ghana, an agricultural exception in West Africa? Stories from Northern Ghana: women in agri-food processing. Ceci est un article de la publication "n°78, publiée le 17 mars 2020. GenreGhana. Accéder au document "pages_de_interreseaux-gds-no78_gb-p23-24" (3.71MB).

Macauley, H. (2015). Feeding Africa. An action plan for West African Agricultural Transformation. Abdou Diouf International conference center Dakar Senegal. United Nations Economic Commission for Africa

Ministry of Food and Agriculture (MoFA), (2011) Crop Production estimates 2010. Published by statistics, research, and information directorate of the Ministry of Food and Agriculture, Ghana.

Ministry of Food and Agriculture (MoFA), (2019). Agriculture in Ghana. Facts and figures, issued by Ministry of Food and Agriculture (MoFA), Statistics, Research and Information Directorate (SRID) October 2019.

Ministry of food and agriculture. (2013). Agriculture in Ghana-Facts and figures. (MoFA)-statistics, research and information directorate (Accra: SRID), 1–64.

Muthayya, M., Sugimoto, J. D., Montgomery, S., and Maberly G. F. (2014). An overview of global rice production, supply, trade, and consumption. *Annals of the New York Academy of Sciences* 1324(1). DOI:10.1111/nyas.12540

Ragasa, C., and Chapoto, A. (2017). Limits to green revolution in rice in Africa: The case of Ghana. Land use policy 2017, 66, 304–321.

Ragasa, C., Dankyi, A., Acheampong, P., Wiredu, A. N., and Chapo, A. (2013). Patterns of adoption of improved rice technologies in Ghana (No. 35).

Reuben, P., Kahimba, F., Katambara, Z., Mahoo, H., Mbungu, W., Mhenga, F., Nyarubamba, A. and Maugo, M. (2016). Optimizing plant spacing under the systems of rice intensification (SRI). *Agricultural Sciences*, 7, 270-278. doi: 10.4236/as.2016.74026.

Seck, P. A., Toure, A. A., Coulibaly, J. Y., Diagne, A. and Wopereis, M. C. S. (2013). Impact of rice research on income, poverty, and food security in Africa: an ex-ante analysis. In Wopereis M. C. S., Johnson D. E., Ahmadi N., Tollens E., and Jalloh A. (Eds.), Realizing Africa's Rice Promise. CABInternational, Wallingford, UK. pp. 24-33. 36.

Tanko, M., Iddrisu, A., &Alidu, A. F. (2016). Determinants of rice yield in Northern region of Ghana, the role of policy. *Asian Journal of Agricultural Extension, Economics & Sociology*, *9*(2), 1-11.

Tanko, M., & Ismaila, S. (2021). How culture and religion influence the agriculture technology gap in Northern Ghana. *World Development Perspectives*, *22*, 100301.

Tetteh, F. M., Quansah, G. W., Frempong, S. O., Nurudeen, A., Atakora, W. K. and Opoku, G. (2002). Optimizing Fertilizer Use within the Context of Integrated. Soil Fertility Management in Ghana. CSIR-Soil Research Institute, Academy Post Office, Kwadaso-Kumasi, Ghana