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Exploring Production Constraints, Varietal Traits Preferences and Factors Influencing Adoption of Improved Rice Varieties in Nobewam, Ashanti Region

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Abstract
Identifying appropriate policy interventions to improve rice productivity is crucial to improving food security and incomes. This study used data from 73 rice farmers randomly selected from an irrigated scheme and employed Kendall's Coefficient of Concordance and multivariate regression techniques to explore production constraints, farmers' subjective varietal traits preferences and factors affecting adoption of improved rice varieties. Results showed capital acquisition, drudgery in land preparation, and weed infestation were among the constraints to rice production. Also, farmers selected rice varieties based on taste, ease of cooking, milling recovery, swelling ability and aroma. Empirical results revealed that farm size, land tenure, ease of cooking, milling recovery and percentage broken affected the selection of improved rice varieties. We suggest that rice varietal development programmes should consider grain traits preferred by end users in breeding activities. Also, government and local authorities should guarantee land tenure security across rice production areas to encourage the adoption of improved varieties.

Key words: adoption; constraints; preference; rice traits

Exploration des Contraintes de Production, des Préférences Variétales et des Facteurs Influençant L'adoption du Riz Amélioré à Nobewam, dans la Région d'Ashanti

Résumé
L'identification d'interventions politiques appropriées pour améliorer la productivité du riz est cruciale pour améliorer la sécurité alimentaire et les revenus. Cette étude a utilisé les données de 73 riziculteurs sélectionnés au hasard dans un périmètre irrigué et a utilisé le coefficient de concordance de Kendall et des techniques de régression multivariée pour explorer les contraintes de production, les préférences subjectives des agriculteurs en matière de caractéristiques variétales et les facteurs affectant l'adoption de variétés de riz améliorées. Les résultats ont montré que l'acquisition de capital, la pénibilité de la préparation des terres et l'infestation par les mauvaises herbes figuraient parmi les contraintes de la production de riz. En outre, les

agriculteurs ont sélectionné les variétés de riz en fonction de leur goût, de leur facilité de cuisson, de leur aptitude à l'usinage, de leur capacité de gonflement et de leur arôme. Les résultats empiriques ont révélé que la taille de l'exploitation, le régime foncier, la facilité de cuisson, l'aptitude à l'usinage et le pourcentage de brisures affectaient la sélection des variétés de riz améliorées. Nous suggérons que les programmes de développement variétal du riz prennent en compte les caractéristiques des grains préférées par les utilisateurs finaux dans les activités de sélection. En outre, le gouvernement et les autorités locales devraient garantir la sécurité foncière dans les zones de production de riz afin d'encourager l'adoption de variétés améliorées.

Mots Clés: adoption; contraintes; préférences; caractéristiques du riz

Introduction

Rice has become a preferred staple in almost all households in Ghana, both rural and urban, due to rapid urbanization and changes in food consumption patterns. Currently, rice is the second most important cereal after maize, and it is becoming a cash crop for many smallholder farmers and the various actors in the rice value chain. Per capita consumption of rice in Ghana has consistently increased since the 1980s, from 12.4 kg in 1984 to 52 kg in 2020 (MoFA, 2021). About 60% of rice consumed in Ghana is imported, amounting to an import bill of US$391 million (USDA, 2022). Over the years, rice consumption has been increasing, requiring a rise in rice importation due to Ghana's inability to produce to meet demand. The average rice yield of 3t/ha is far below the potential yield of 6t/ha (MoFA, 2021). Due to the importance of rice in the food systems in Ghana, a lot of effort has gone into developing the crop. Since 2015, thirty-five improved rice varieties have been officially released (GNA, 2022; MoFA, 2019). However, smallholder farmers infrequently have access to new varieties that may improve productivity and, hence, their livelihoods. A major reason for the low uptake of the new varieties is that farmers have little exposure to them, or the varieties do not satisfy their preferences and needs (Acheampong *et al*., 2018). The need for farmers to test a range of varieties under their conditions, resource levels and environment to select the ones they prefer is important.

The successes shown in identifying varieties preferred by farmers through participatory technology generation and selection are well documented (Mulatu & Zelleke, 2002; Mulatu & Belete, 2001; Joshi & Witcombe, 1996). However, selecting a variety does not guarantee accessibility. According to Louwaars & Gigi (2022), Quarshie *et al*. (2021) and Ndjeunga *et al.* (2003), the constraints limiting the performance of seed supply systems remain the lack of awareness among farmers about new varieties, poor functional seed and product markets, limited access to seed of new varieties, limited supply of breeder/foundation/certified and commercial seed. Other constraints against production are finance, land, diseases, pests, and access to inputs (Suri & Udry, 2022). Apart from the constraints against production, many socioeconomic and institutional factors prevent farmers from accepting improved varieties.

Farmers' decisions to adopt a new variety or continue with the old variety are guided by many factors, including socioeconomic and institutional factors (Addison *et al*., 2022; Acheampong *et al*., 2022). Considerable evidence exists concerning farmers adoption behaviour, including demographic traits, traits of the technology, information sources, farmers' knowledge, awareness, attitudes and group influence that affect adoption behaviour (Addison *et al*., 2022; Badal *et al*., 2007; Faturoti *et al.*, 2006). Age, gender, household size, education and experience are primarily demographic factors that affect adoption decisions (Etounde & Dia, 2008; Langyintuo & Mekuria, 2008). Land tenure, extension access, and access to credit are institutional factors that influence the acceptance of new technologies. Recently, several studies have found that the perception and traits of agricultural technologies influence farmers' adoption of crop varieties (Acheampong & Donkor-Acheampong, 2020; Tumuhimbise *et al.,* 2012).

Despite the knowledge accumulation over time on barriers to adopting improved crop varieties there remains a considerable

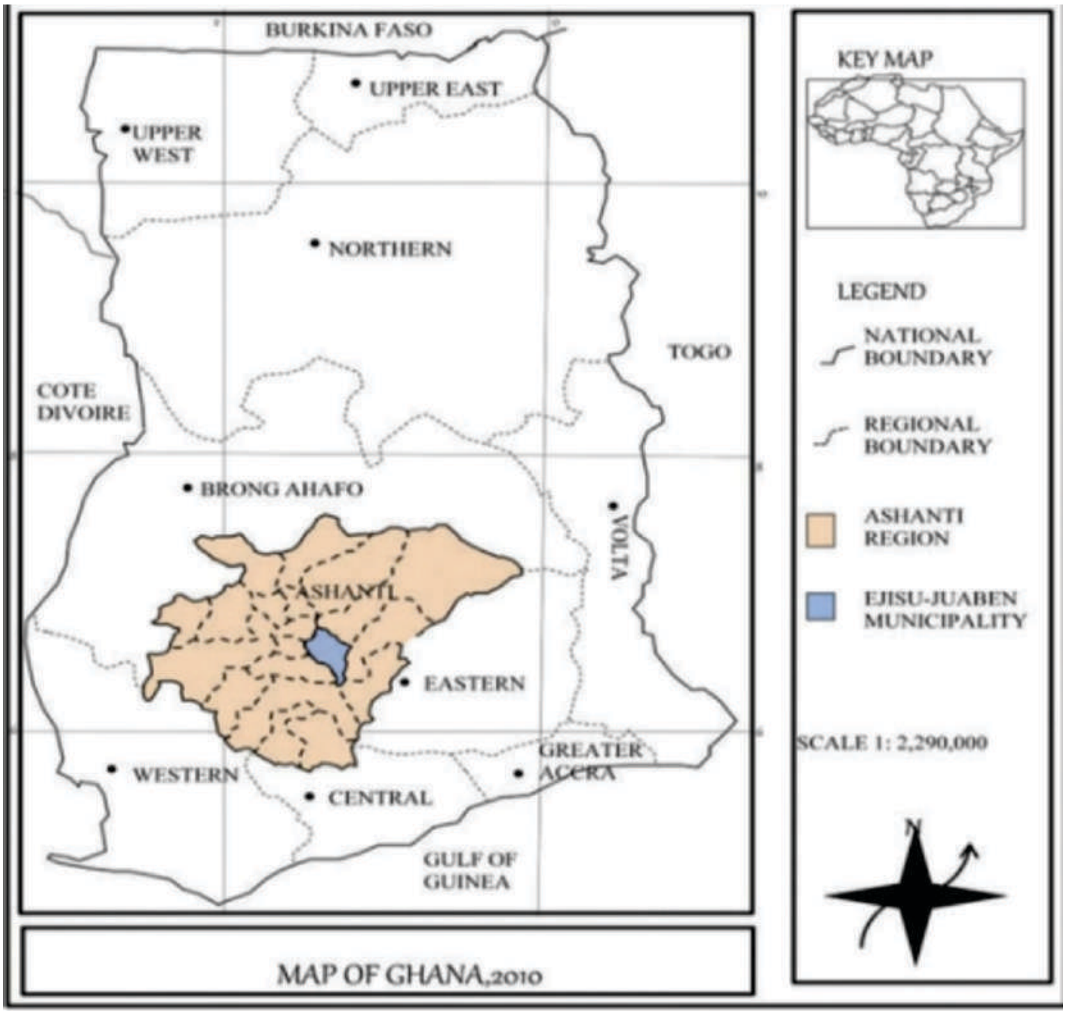

Figure 1. Map of Ghana showing the study area
Source; Adopted from Ejisu Municipal Assembly, 2010.

adoption gap in rice production in Ghana (Ragasa *et al*., 2013). Ultimately, none of these constraints alone explains the low adoption of improved rice in Ghana. The assertion is that no single constraint can explain the low adoption. Instead, knowledge of farmer and grain quality preferences may help solve the low adoption problem with resultant packages of interventions that may be the most useful approach to the adopting new agricultural technologies. Therefore, this paper investigates constraints in rice production, rice varietal traits preferences, rice grain traits preferences and social factors that affect adoption of improved rice varieties. The knowledge acquired from this study is expected to contribute to the literature on rice production. It is also anticipated that the paper will make recommendations based on the empirical results for the improvement of rice production in Ghana.

Methodology

Study Area

The study was conducted at Nobewam in Ejisu Municipality of the Ashanti region (Figure 1). The Ashanti region is in the deciduous forest agro-ecological zone. The zone is characterized by a bi-modal rainfall pattern, the major season beginning in April and ending in July and the minor one beginning in September and ending in October. The annual rainfall ranges between 1500 mm and 1600 mm, averaging about 1300 mm per annum. Temperatures are generally low throughout most of the year, with the highest of 28 °C in March and April. Lower temperatures occur during the major season in June and July. Rice, roots and tuber crops such as cassava, yam, cocoyam and plantains are the major food crops cultivated in the zone (Ejisu Municipal Assembly, 2010). Due to the irrigation scheme in Nobewam, Ejisu municipality is deemed important for rice production in the Ashanti region (Acheampong *et al*., 2017).

Sampling and data collection

The data for this study was collected from Nobewam in the Ejisu Municipality, Ashanti region. Nobewam was selected because the place is popular for rice production in the Ashanti region due to the location of an irrigation scheme established by the Ghana Irrigation Authority (GIDA) for cultivating rice all year round. Two hundred households participate in rice production in the scheme. Out of a population of 200 farm households, 76 (see equation 1) farm households were randomly selected to participate in the formal survey using structured questionnaires. However, three respondents had incomplete information and were excluded and data on 73 were used. The sample size (*n*) of 76 was estimated using the formula by Yamane (1973), as shown in Equation (1).

$$n = \frac{N}{1 + N(e)^2} \qquad (1)$$

where:
N = total population and
n = sample size.
e is the margin of error, and the margin of error was 9%

The survey collected data on farm and farmer traits and associated socioeconomic traits, institutional variables, types of rice varieties grown, areas under different varieties, seed sources, and variety traits.

Analytical frameworks

The Kendall's Coefficient of Concordance

In order to ascertain farmers' preferences for rice variety traits considered for selecting rice variety for cultivation, a list of traits was given to farmers. Farmers were then made to rank each trait on a scale of 1-3 from very good to poor, with 1= very good, 2= good and 3=poor. Similarly, ten constraints list was submitted to farmers to rank each on a scale of 1-3, 1 being very important, 2 important and 3, not important. Finally, grain traits list was provided to farmers and were made to rank each on a scale of 1- 3, 1 = very good, 2 = good and 3 = poor.

The Kendall's Coefficient of Concordance (W) was used to test for the agreement or association between sets of rankings provided by farmers. Kendall's coefficient of concordance (W) measures the degree of agreement/concordance among *m* set of *n* ranks. It is an index that measures the ratio of the observed variance of the sum of ranks to the maximum possible variance of a sum of ranks. The essence of this index is to find the sum of the ranks for each trait/factor being ranked and to examine the variability of this sum. If the rankings are in perfect agreement the variability among these sums is said to be a minimum (Mattson, 1986). Thus, according to Mattson (1986) Kendall's W is defined as:

$$W = \frac{12\sum R^{i_2} - 3N(N-1)^2}{N(\text{n-1})} \qquad (2)$$

where:
W = Kendall's value
N = total sample size
R = mean of the rank
The Kendall's W indicates the level of agreement among the farmers of the rankings obtained. Appropriately, a higher Kendall's W denotes a high level of agreement on the rankings. If the test statistic W is 1, then all the judges or survey respondents have been unanimous, and each judge or respondent has assigned the same order to the list of objects or concerns. If W is 0, then there is no overall trend of agreement among the respondents, and their responses may be regarded as essentially random. Intermediate values of W indicate a greater or lesser degree of unanimity among the various judges or respondents. Ultimately, the results from the model will indicate whether farmers agree on the constraints mentioned, varietal preference declared, and grain quality stated, leading to recommendations for rice varietal development.

Multivariate regression model
Supposing that more than one improved rice variety is introduced to farmers at a period and farmers can decide to adopt more than one improved rice variety on one or more plots, a multivariate regression becomes appropriate for identifying the factors influencing farmers' decisions to adopt these rice varieties due to the multilevel data (Green, 2003). The multivariate regression is grounded on the random utility model. Here it is assumed that a finite set of technologies where *j*=1, ..., *j* and a finite number of farmers *i* = 1 ..., *n* where *n* is the final sample size. Therefore, following a random utility model, a farmer eventually adopts the technology if:

$$u_{i,j=i} - u_{i,j=0} > 0 \qquad (3)$$

The utility U to an adopter from selecting an alternative is stated as a linear function of the farm and farmer traits (β) and the traits of that alternative (X) and a stochastic error component (ε):

$$u_{i,j=i} - u_{i,j=0} = x_i'\beta_j + \varepsilon_{ij} = \beta_{1j} + \sum_{k=2}^{k} \beta_{kj}x_{ik} + \varepsilon_{ij} > 0 \qquad (4)$$

Thus, the decision to adopt a technology is not exogenous and may depend on observable and unobservable traits of the farmers. Assuming a symmetric probability density function F for ε_{ij} we could model the probability of adoption of the jth technology:

$$Pr(Adoption_{ij}|x_{ik}) = Pr(x_i'\beta_j + \varepsilon_{ij} > 0) = Pr(\varepsilon_{ij} > -x_i'\beta_j) = F_j(x_i'\beta_j) \qquad (5)$$

where Fj is the correspondent marginal cumulative distribution function (CDF). If the error terms ε follow a joint standardized normal distribution, this leads to the j-dimensional multivariate regression (Greene, 2003). Here, it is assumed that the Farmer decides to adopt a given number of practices based on the maximization of a utility function as:

$$U_i = V_i(x_i'\tau) + \varepsilon_i \quad (6)$$

Finally, assuming ε follows a normal distribution, the probabilities of adopting each specific number of improved varieties are defined as:

$$Pr(P_i = 0|\chi_i) = \Phi(\alpha_1 - \chi_i'\Gamma),$$

$$Pr(P_i = \ell|\chi_i) = \Phi(\alpha_{\ell+1} - \chi_i'\Gamma) - \Phi(\alpha_{\ell+1} - \chi_i'\Gamma), for \ell \epsilon \{2,3\} \quad (7)$$

The empirical specification for examining the influence of explanatory variables on the choice of rice varieties (y) is given as follows:

$$Y_i = \beta_0 + \beta_1\chi_{1i} + \beta_2\chi_{2i} + \cdots + \beta_n\chi_{ni} + \varepsilon \quad (8)$$

Where:

Y is the dependent variable indicating improved varieties Sikamo, IR481 and Jasmine 85 β is coefficient *x* is covariate or independent variables, including farm and farmer traits, rice varietal traits.

Table 1 presents the description, measurement and hypotheses of variables used in the model. The adoption of agricultural innovation literature (e.g. Addison *et al.,* 2022; Acheampong *et al*., 2020; Ojo *et al*., 2021; Baksh *et al*., 2012; Chandio & Yuansheng, 2018) is replete with factors influencing the adoption of improved agricultural technologies in Ghana and elsewhere around the world. The sociodemographic factors known to influence the adoption of agricultural technologies include age, gender, household size, farm size, plot ownership, credit access and access to extension (Hoang *et al*., 2023; Addison *et al.,* 2022; Ojo *et al*., 2021; Acheampong *et al*., 2020; Baksh *et al*., 2012). These variables are selected as explanatory variables and are hypothesized to influence the adoption of improved rice varieties positively and or negatively. Rice varietal traits known to influence rice varietal adoption are milling recovery, swelling ability, good taste, broken percentage, and good taste (Asante *et al*., 2023; Asante *et al*., 2013; Diako *et al*., 2010). These qualitative variables are included in the model and are hypothesized to influence the adoption of the improved rice varieties positively.

Results and Discussion

Demographics description of respondents

Tables 2 and 3 present the description of rice farmers in the study area. The results from Table 2 indicated that more males (68.49%) than females (31.51%) engaged in rice production. The results are not surprising as females are mostly part of the production of their male counterparts (Perez *et al*., 2015). The majority (73.97%) of the respondents had formal education. Indigenes and permanent settlers comprised 53.42% and 28.77%, respectively, whilst 17.81% were migrants. Land tenure was mainly by renting (60.27%), followed by ownership (36.99%), and then sharecropping (2.74%). The mean age of farmers was 45.65 years (Table 3). The mean years of education was 7.46. The mean years of experience in farming were 15.52 years. Whereas the average members in the household was 6, the average economically active members were 2.75. The average rice farm size was 1.96 acres (Table 3).

Rice varieties cultivated by respondents

Table 4 presents the distribution of improved rice varieties grown in the study area. Results showed that farmers produced only improved varieties in the irrigation scheme. Jasmine 85 dominated (64.4%) the rice varieties cultivated by farmers in the study area, followed by IR841 (32.9%) and Sikamo

Table 1. Variables descriptions, measurements and hypotheses

Variable	Description and measurement	Hypothesis
Age	Age of a farmer in years	+/-
Sex	Dummy, 1 for male and 0 otherwise	+/-
Education	Educational level of farmer in years	+
Experience	Experience of a farmer in years	+/-
Credit access	Dummy; 1 if a farmer has access to credit; 0 otherwise	+
Farm size	Total area of rice field in hectares	+/-
Household size	Number of family members	+/-
Land owner	Dummy; 1 if a farmer owns land and 0 otherwise	+
Extension access	Dummy;1 if a farmer has contact with extension agent and 0 otherwise	+
Milling recovery	Dummy; 1 if farmer perceived good recovery when rice is milled and 0 otherwise	+
Broken percentage	Dummy; 1 if farmer perceived low percentage and 0 otherwise	+
Cooking quality	Dummy; 1 if farmer perceived excellent cooking quality and 0 otherwise	+
Swelling ability	Dummy; 1 if farmer perceived rice swells and 0 otherwise	+
Good Taste	Dummy; 1 if farmer perceived rice taste good and 0 otherwise	+

(2.7%). The results corroborate findings from Ragasa *et al*. (2013), who, studying the adoption patterns of improved rice varieties, observed that farmers in irrigated areas across Ghana planted only improved rice varieties.

Constraints to rice production

Constraints to rice production were sought from the farmers. Farmers were asked to rank a list of constraints. They were asked to rank each constraint on a scale of 1 to 3, from 1=very important… 3=not important. Table 5 shows the rank order of the various constraints presented by farmers. The test statistics show agreement (Kendall's W) of constraints ranking by the sampled population. the agreement realized (Kendall's W =0.26) was highly significant, suggesting that 26% of the rice farmers were unanimous on the constraints in rice production.

Table 2. Socio-Demographics of respondents

Variable	Frequency	Percentage
Sex		
Male	50	68.49
Female	23	31.51
Education type		
Formal education	54	73.97
Informal education	19	26.03
Residence status		
Indigene	39	53.42
Permanent settlers	21	28.77
Migrant	13	17.81
Land tenure		
Own land	27	36.99
Sharecrop	2	2.74
Rented land	44	60.27
Marital status		
Single	3	4.11
Married	57	78.08
Divorced	10	13.70
Widowed	3	4.11

Credit was ranked first among the constraints provided by farmers. Although credit is available in Ghana and even in communities, its accessibility is very difficult due to cumbersome processes and high interest rates. Interest rates in Ghana range from 26% to 32% (Bank of Ghana, 2023). Credit facility for farmers is very limited as farmers cannot meet requirements, and the Banks also see agriculture as high-risk venture.

Farmers ranked land preparation as the second most important constraint. The drudgery in rice production cannot be underestimated in Ghana and in the study area. Mechanical preparation of land is limited; and thus, farmers often resort to manual preparation of land, which can be very tedious.

Low farmgate price was ranked third, followed by weed infestations. Farmers are concerned with low prices due to poor pricing policies in the country. Food crop prices are not regulated and buyers mainly determine prices of food crops including rice. This does not favour producers as buyers do not consider price adjustments (e.g. labour cost fluctuations) in inputs for production during the season. According to Alliot & Fechner (2018), farmers typically bear the consequences of price volatility due to their position at the bottom of the rice value chain,

Table 3. Descriptive statistics of continuous variables

Variable	Minimum	Maximum	Mean	Standard deviation
Education in years	0.00	20.00	7.46	4.87
Age in years	26.00	73.00	45.65	10.94
Household size (count)	1.00	20.00	6.04	2.70
Economically active members (count)	1.00	9.00	2.75	1.61
Experience in years	2.00	50.00	15.52	10.60
Land size in acres	0.25	20	1.96	2.42

Table 4: Rice varieties grown in the study area

Variety	Frequency	Percent
Jasmine 85	47	64.4
Sikamo	2	2.7
IR841	24	32.9
Total	73	100

Table 5. Results of Kendal's estimation on constraints in rice production

Constraint	Mean rank	Global rank
Capital (credit) acquisition	2.60	1
Land preparation	4.59	2
Low farmgate price	4.99	3
Weed infestation	5.27	4
Pest infestation	5.59	5
Diseases	5.79	6
Land availability	5.92	7
Produce marketing	6.40	8
Planting material availability	6.75	9
Storage loses	7.10	10
Test statistics		
N	73	
Kendall's W	0.26	
Chi-Square	171.58	
Degrees of freedom	9	
Asymptotic significance	0.00	

implying that their negotiating power is weak, invariably forcing them to be price takers. Nonvide *et al*. (2018), studying farmers' perceptions of irrigation and constraints to rice production in Benin, found similar results with credit, unavailability of seeds and other production inputs as constraints to rice production.

Land for rice production was ranked seventh by farmers as a constraint to rice production, suggesting that access to land for rice production is not a major constraint. The study area (Anum Valley) has one of the largest inland valleys in the Ashanti Region, which GIDA has well developed. Access and security of land for rice production is assured through GIDA suggesting the importance of access to and security of land to farmers as credible security guarantees investments (Deininger, 2003). Marketing, planting materials availability and storage loses were ranked 8th, 9th, and 10th, respectively. Farmers do not experience storage loses at all. There is no need to store paddy as there are ready markets for rice throughout the year. Buyers come from bigger cities like Accra and Kumasi due to the area's accessibility.

Improved rice varietal trait preferences

Table 6 presents the results of the Kendall's Coefficient of Concordance (W) test on rice varietal traits preferences. The test statistics showed some agreement in the sample population regarding the selection of the rice varieties based on traits. The Kendall's Co-efficient of Concordance (W) for the rankings of rice traits were 0.12, 0.19 and 0.19 for Sikamo, IR481 and Jasmine 85, respectively (Table 6). Though the results indicated 11%, 18% and 19% agreement among farmers, respectively, for Sikamo, IR481 and Jasmine 85, the asymptotic distribution gave appreciable significant values (Table 6). The implication is that the null hypothesis (the rankings disagree) is rejected, while the alternative hypothesis (the rankings agree) is accepted.

Results revealed that tillering ability is the most highly ranked trait for choosing a rice variety. Prakash & Kumari (2021) opines that tillering ability enables rice to produce multiple stems (tillers) starting from the

Table 6. Rank of rice varietal trait preferences by rice varieties

Rice attributes	Rice varieties					
	Sikamo		IR 481		Jasmine 85	
	Mean rank	Global rank	Mean rank	Global rank	Mean rank	Global rank
Tillering ability (heavy panicles)	3.33	1	3.45	1	3.31	1
Good soil cover	3.72	2	3.76	3	3.73	4
Drought tolerance	5.22	6	5.39	6	5.20	7
Disease tolerance	4.25	5	4.32	5	4.77	6
Medium plant height	3.72	2	3.92	4	4.13	5
Early maturity	3.81	3	3.58	2	3.33	2
High yielding	3.94	4	3.58	2	3.54	3
Test statistics						
N	18		19		64	
Kendall's W	0.115		0.187		0.192	
Chi-Square	12.464		21.331		73.703	
Significance	0.052		0.002		0.000	

Table 7. Farmers Rankings of rice grain traits

Rice grain traits	Mean rank	Global rank
Taste	3.21	1
Ease of cooking	3.33	2
Milling recovery	3.37	3
Swelling capacity	3.62	4
Smell (aroma)	3.70	5
Percent Broken during milling	3.77	6
Test statistics		
N	73	
Kendall's W	0.31	
Chi-square	1140.17	
Degrees of freedom	5	
Asymptotic significance	0.02	

initial single seedling. Tillering ability is one of the yield-determining traits of a rice plant. High-tillering varieties have a higher number of panicles, and their contribution to yield is higher than that of low-tillering varieties. Thus, farmers' high preference for tillering ability is in order. In rice crops, more tillers would generally mean more yield. Apart from tillering ability, which ranked as the most important trait in all the varieties, other traits differed in ranking depending on the variety.

Users of Sikamo indicated good soil cover and medium plant height as their second preferred trait of it. Sritarapipat *et al.* (2014) noted that medium plant height is related to a rice plants productivity and growth rate. Hence, farmers who grew Sikamo had a high preference for medium plant height. The third and fourth ranked traits for Sikamo were early maturity and high yielding, respectively.

Traits that farmers preferred in IR841 were, in order of importance, high yielding, early maturity and good soil cover. Early maturity and high yielding are economic variables. The implication is that farmers can harvest enough in a short time. Good soil cover suppresses weeds by smothering their growth and reducing the number of weed seeds. Drought tolerance and disease tolerance were ranked 5th and 6th, respectively, by farmers who grew IR841.

Regarding Jasmine 85, high yielding, early maturity, and good soil cover were the top ranked traits. Disease tolerance and drought tolerance were ranked 6th and 7th, respectively. Farmers choose crop varieties based on traits that can overcome their production constraints and meet their consumption preferences and market requirements (Acheampong *et al*., 2018; Smale *et al*.,2001). A recent study by Asante *et al*. (2023) in some rice producing areas in Ghana found similar results in varietal preferences among rice farmers: early maturity, short and medium growth cycles, heavy panicles, and medium plant height.

Rice grain traits preferences

Table 7 presents the Kendall's Coefficient of Concordance (W) test on rice grain traits. Kendall's Co-efficient of Concordance (W) for the rankings of rice traits was 0.31, indicating 31% unanimous agreement. The asymptotic distribution was significant (p=0.02; Table 7). Thus, the null hypothesis (the rankings disagree) is rejected, while the alternative hypothesis (the rankings agree) is accepted. Rice grain traits, according to Rutsaert *et al.* (2013) can be put into three categories, namely search, experience, and credence traits. Search traits include price, appearance, brand, and packaging; experience traits include taste, texture, ease of cooking, and swelling capacity; and credence traits are traits relate to production, processing, and product contents.

The study revealed that taste was topmost preferred rice grain quality characteristic (Table 7). Previous studies in Ghana (Asante *et al*., 2023; Apori-Buabeng, 2009) reported taste as the most important organoleptic property influencing the choice of rice grains in Ghana. Other experience traits considered were swelling capacity and aroma, which ranked high. Preference for aroma is not surprising as consumers demand for fragrant rice keeps increasing. In Senegal, Diagne *et al*. (2017) also reported a high demand for fragrance rice due to increasing urban demand for rice of superior quality. Also, Asante *et al*. (2013) found in their study of grain quality preferences of farmers in Ghana that fragrance was an important trait considered by farmers. Credence traits preferred by farmers consisted of milling recovery and percent broken grains at the mills. Kangile *et al*. (2018) opined in their study of drivers of source choice for rice farmers in Tanzania that taste, aroma and milling quality affected farmers' choice of rice variety. Pant (2010) found that consumers value organoleptic properties more than other traits. These traits are embedded in the improved varieties and so concluded that farmers are likely to replace local varieties with the modern varieties. Our findings corroborate the findings of Pant (2010), as all farmers interviewed had replaced local varieties with improved varieties with preferred qualities.

Factors influencing the adoption of improved rice varieties

Multivariate regression estimates of factors influencing the adoption of improved rice varieties are presented in Table 8. The results revealed a heterogeneous effect of age on

Table 8. Multivariate regression estimates of factors influencing the adoption of improved rice varieties

	Jasmine85		Sikamo		IR841	
Variables	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
Age	0.015**	0.007	0.002	0.003	-0.011*	0.007
Education	-0.018	0.015	0.005	0.006	0.021	0.015
Marital status	0.240**	0.093	-0.008	0.036	-0.114	0.093
Household size	-0.011	0.022	-0.015*	0.009	0.046**	0.022
Economically active	-0.071**	0.036	0.022	0.014	0.059*	0.036
Experience	0.001	0.007	0.000	0.003	-0.007	0.007
Gender	0.019	0.118	-0.072	0.046	0.155	0.118
Ownership	-0.053	0.126	0.085*	0.049	-0.061	0.126
Credit	0.304**	0.152	-0.057	0.059	-0.204	0.151
Extension access	0.106	0.153	-0.025	0.060	-0.118	0.153
Field day participation	-0.289**	0.121	0.073	0.047	0.225**	0.121
Farm size	0.036	0.025	-0.013	0.010	-0.036	0.025
Milling recovery	-0.325**	0.179	0.031	0.070	0.280	0.178
Broken percentage	0.032	0.126	0.073	0.049	-0.094	0.126
Cooking quality	-0.073	0.170	-0.098	0.066	0.276*	0.170
Swelling ability	0.283**	0.140	0.032	0.055	-0.309**	0.140
Good taste	-0.120	0.170	-0.065	0.066	0.433***	0.170
No of observation	73		73		73	
R-squared	0.409		0.230		0.424	
F-value	2.240		0.968		2.388	
P-value	0.012		0.504		0.007	

Jasmine 85 and IR841. Whereas age had a positive effect on adoption of Jasmine 85, it had a negative effect on the adoption of IR841.The implications are that whereas older farmers were more likely to adopt Jasmine 85, younger farmers were more likely to adopt IR841 probably because older farmers might have known Jasmine 85 and younger farmers might have known IR841 due to age lapse in their releases (Jasmine 85 was introduced into the country during the early 2000's whilst IR481was released in 2013). Chandio and Yuansheng (2018) found that age had a negative and significant relationship with adopting improved rice varieties in Pakistan. In their study of factors affecting the adoption of improved cassava varieties in Ghana, Acheampong *et al*. (2022) established that age positively affected the adoption of improved varieties.

Therefore, age can either affect adoption positively and or negatively, as found in this study. Marital status affected adoption of Jasmine 85 positively and significantly, indicating that it was more probable for married individuals to adopt Jasmine 85. Ojo *et al*. (2021) established a negative relationship between marital status and the adoption of soil conservation practices in rice in South Western Nigeria, contrasting the results from this study probably because married couples make decisions together on rice production activities in Ghana.

The probability of adopting Sikamo was influenced negatively by household size. On the contrary, household size affected IR841 adoption positively and significantly. Therefore, depending on the variety, large or small family size can affect its production. This finding is consistent with the study of Baksh *et al*. (2012), who found that family size significantly and negatively affects the adoption of water conservation practices.

There was a heterogeneous effect of participation in field day regarding Jasmine 85 and IR841. Participation in field day had a significant positive influence on IR841 and a significant negative effect on Jasmine85. Addison *et al*. (2022), in their study on the uptake of rice technologies in Ghana, reported that participation in field day significantly affected the uptake of rice technologies. Acheampong & Donkor-Acheampong (2020) observed that participation in field day positively affected the adoption of improved cassava varieties in Ghana. The negative effect of participation in field day on Jasmine 85 implies that most farmers did not attend field days in Jasmine85 grown fields.

Grain traits such as milling recovery, good cooking quality, swelling ability and good taste significantly affected farmers' choice of a variety. Milling recovery had a negative but significant effect on the probability of adoption of Jasmine85, implying that farmers are less likely to adopt Jasmine85 based on milling recovery. Cooking quality had a positive and significant effect on the probability of adoption of IR841 suggesting that cooking quality informs the adoption of IR841. Swelling ability had heterogeneous effect on Jasmine 85 and IR841; however, the effect was positive on Jasmine 85 and negative on IR841. The implications are that the adoption of Jasmine85 is probably based on its ability to swell, whilst the ability to swell would reduce the probability of adopting IR841. Good taste had a positive and significant effect on the likelihood of adopting IR841. Therefore, depending on the variety, different grain traits dictate their adoption. Diako *et al*. (2010) reported in their study of consumer perceptions, knowledge and preferences for aromatic rice types in Ghana that cooking quality, taste and aroma are the most sought-after traits of rice which is consistent with our findings from this study.

Conclusions and recommendations

The study examined rice production constraints, varietal trait preferences, grain trait preferences and factors affecting the adoption of three improved rice varieties, i.e., Sikamo, IR841 and Jasmine85. The major constraints to rice production include capital acquisition, land preparation and low farmgate price for rice grains. It is recommended that commercial banks make special arrangements with farmers to reduce the high interest rates to enhance capital acquisition. Machinery for land preparation could be offered on hired purchase basis by both the government and private sector to increase ownership among rice farmers. There could also be some price regulations by the government regarding rice. Regarding other constraints, including pests and diseases and the unavailability of planting material, the Ministry of Food and Agriculture should collaborate more with research to make more disease-free high yielding varieties available to farmers.

Farmers' varietal adoption decisions depend on tillering ability, good soil cover, drought tolerance, disease tolerance, medium plant height, early maturity and high yield. Also, grain quality traits and organoleptic properties (e.g., taste, cooking quality, swelling capacity, aroma, milling recovery, per cent broken grains) influence adoption decisions. Therefore, the government must support plant breeders with resources to develop high yielding and grain quality varieties with farmer and consumer preferred traits. Age, household size, and participation in field days influenced the likelihood of farmers adopting Sikamo, Jasmine 85 or IR841. Depending on the variety, age could positively or negatively affect adoption; thus, researchers must target both the aged and youth during rice dissemination activities.

Based on our study, the adoption of improved rice varieties will increase if research funding is available to scientists to develop farmer- and consumer-preferred varieties, demonstrate the new varieties in rice-growing areas, and policymakers address farmers' constraints to production.

The limitation of the study

The limitation of this study is that it was carried out in only one of the irrigated schemes in Ghana. This study should be repeated in other irrigation schemes across Ghana.

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