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Assessing rice farmers' production constraints and variety preferences in areas affected by salinity

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Rice (*Oryza sativa* L.) is a strategic and priority commodity for food security in Tanzania. The objective of this study was to assess farmers' rice production problems and the preferred traits for improvement in areas affected by salinity in the country. The study was conducted in rice-producing areas of Kilosa, Iringa, and Moshi districts. Farmers were interviewed using structured questionnaires and other participatory rural appraisal (PRA) tools. A total of 206 farmers were involved in the study. Results indicated that farmers perceived soil salinity to be among the main constraints to rice production in the studied districts. The most preferred rice varieties by farmers included SARO 5, Super Shinyanga, Faya dume, and Kalubangala. Furthermore, farmers highly ranked problems were salinity, high costs of fertilizers, drought, poor soil fertility, and pests and diseases. The most preferred agronomic attributes in the new rice varieties include high grain yield, a high number of tillers, salinity tolerance, early maturity, and medium plant height. Moreover, farmers' preferences for grain quality attributes include high milling recovery, long grains, good aroma, and non-sticky. It was therefore concluded that the development of new salt-tolerant cultivars with desirable attributes could significantly contribute towards sustainable rice productivity in the studied districts.

Key words: Preferred traits, production constraints, rice varieties, salinity, Tanzania

INTRODUCTION

Rice (*Oryza sativa* L.) is a staple food for almost half (about 3.5 billion) of the global population and is an important crop for millions of people in Africa (Samal et al., 2018). It is cultivated in more than 100 countries, covering almost 158 million hectares, producing more than 700 million tons per year (Lar et al., 2021). The global population is rapidly increasing annually, and it is predicted to reach between 9.4 and 10.1 billion people by 2050 (Giller et al., 2021). This large population increase creates the need to produce more than what is currently being produced, especially for major food crops such as rice, maize, wheat, and soybeans (Kromdijk and Long, 2016). However, biotic and abiotic stresses, such as salinity, drought, heat, and cold, attributed to climate

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change are critically threatening crop production in different parts of the world (Mantri et al., 2012). Salinity, in particular, is one of the main limitations to crop production that leads to rice yield reduction in rice-growing areas that are saline, and they are in the increase due to frequent droughts (Corwin, 2021).

In Sub-Saharan Africa (SSA), rice is increasingly becoming an important crop, as shown in its increasing per capita consumption, which has doubled since 1970 (Muthayya et al., 2014). However, the average rice yield in SSA is only around 2.1 tons/ha, which is below the global average of 4 tons/ha and the records show that yield growth has been stagnant over the long period (Arouna et al., 2021; Tsujimoto et al., 2019). There are countries in Africa whose yield has been far less than the continental average, harvesting 1.5 tons/ha or less of rice grains (Barreiro-Hurle, 2012; Kilima, 2006). The low rice yields in SSA result from several reasons such as diseases, social-economic issues, labour, climate change, and soil degradation (Bjornlund et al., 2020). In addition to soil-related problems like poor soil fertility, other factors such as drought, salinity and flooding have significantly contributed to low rice yields in SSA (Dossou-Yovo et al., 2022).

Tanzania is among the largest rice producer in Sub-Saharan African, while Nigeria is the leading rice producer in the region (Magezi et al., 2023). Rice is the second most produced crop after maize in Tanzania and the leading regions are Morogoro, Mbeya, and Shinyanga (Kulyakwave et al., 2022). Rice crop value chain is one of the main sources of employment, income and food security in the country. In spite of, the increasing importance of rice in Tanzania, the mean yield of the crop is still around 1.5 tons/ha, which is far below the global yield averages of about 4 tons/ha (Evans et al., 2018). The low rice productivity in Sub-Saharan Africa, Tanzania being inclusive is attributed to different diverse socio-economic constraints, biotic and abiotic stresses including salinity and sodicity (Saito et al., 2022).

Studies show that about 3.5 million hectares of land in Tanzania are salt-affected of which 2.9 million hectares are saline and the remaining are sodic (Meliyo et al., 2017), and these are the areas that have potential for rice cultivation by rainfed or by irrigation. In many irrigation schemes, salinity stress has led to a reduction in rice yield due to salt-related problems, and some fields have been abandoned (Kashenge-Killenga et al., 2014). The issue of salt stress, arising from both natural factors and poor irrigation/drainage systems, is anticipated to worsen due to the impacts of climate change (Shrivastava and Kumar, 2014; Ullah et al., 2021). Salt-affected soils in Tanzania can be classified as sodic and saline soils, with sodic soils having an excess accumulation of Na^+ at the exchangeable sites of clay particles, and they are common in dry and semi-arid areas (Meliyo et al., 2017).

In rice production, salt stress poses significant challenges, particularly during the early seedling or the reproductive stages (Korres et al., 2022). While salt stress during the reproductive stage directly results in grain yield loss, early seedling stage salt stress is equally crucial as it determines the crop stand and, consequently, the grain yield (Amoah et al., 2020). Apart from affecting rice yield, salinity also affects the nutrient composition of rice and influences the overall quality of rice grain (Han et al., 2004). Rice quality is a complex trait and it results from complex interactions among various factors, such as rice genetics, environmental conditions, cultivation practices, milling processes, and storage methods (Han et al., 2004; Salgotra and Chauhan, 2023). Both the yield and quality of rice plays a pivotal roles in shaping consumers preferences and market prices (Cuevas et al., 2016). Consumers predominantly assess rice quality based on its physical attributes, including milling recovery, transparency, size, shape, and colour, as well as its organoleptic properties, such as cooking characteristics (Fahad et al., 2019). Rice quality encompasses several dimensions, including milling quality, visual appearance, cooking and sensory attributes, and nutritional content (Sultana et al., 2022).

Numerous approaches are currently being employed to mitigate abiotic stresses, particularly salinity and sodicity. However, the prospect of selecting and breeding crop species for improved salinity and sodicity tolerance has garnered significant interest as it represents an economically viable and effective alternative (Egea et al., 2023). A study to establish farmers' knowledge and perception on the problems encountered in rice production in the study areas was carried out using a Participatory rural appraisal (PRA). A PRA is a tool that provides the opportunity for researchers, farmers and other key stakeholders to interact in order to find out production constraints and suggest on the appropriate measures to address the problems facing farmers (Kraaijvanger 2016). Preference rating, probing, and observation are among the PRA techniques used to obtain relevant information from the respondent farmers (Efisue et al., 2008).

The participation of farmers in research have been found to improve the adoption of the developed technologies, such as new crop varieties (Wordofa et al., 2021). Additionally, the information gathered from PRA and surveys helps breeders to identify the anticipated constraints, challenges and plan for possible solutions (Mutari et al., 2021; Stathers et al., 2006). Thus, understanding farmers' preferences for rice varieties, production challenges, and recognizing the extent of the current existing salinity stress condition is very important. Moreover, the traditional coping strategies are essential steps towards enhancing farmers' adaptability and fostering sustainable rice production. In this study, a participatory rural appraisal (PRA) was conducted in three different regions of Morogoro, Iringa and Kilimanjaro representing rice-growing agro-ecologies in Tanzania, with rice irrigation schemes affected by salinity

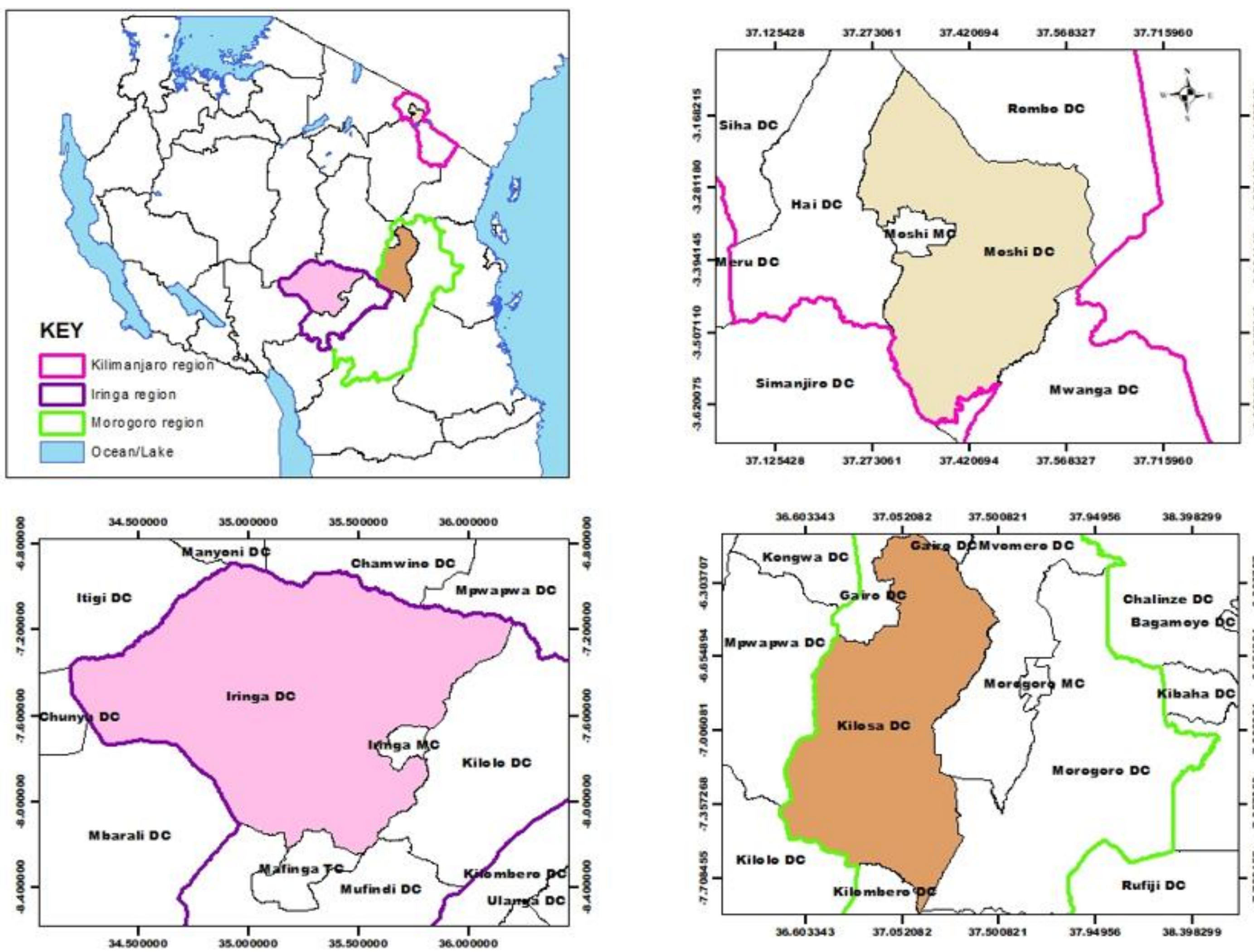

Figure 1. A map showing the study districts in the three regions of Tanzania.
Source: Field data (2023).

and sodicity.

The purpose of this study was to examine rice production constraints, coping strategies employed and farmers' rice variety preferences in salt prone areas. Insights from the study will enhance our understanding on the production constraints and farmers' preferred traits for improvement which are very important for consideration in new rice varieties development targeting salt-affected areas.

MATERIALS AND METHODS

Description of the studied areas

This study was conducted in three agroecological zones (AEZ) that are growing rice in Tanzania. The AEZ are located in Iringa (in southern highlands zone); Morogoro (in eastern zone) and Kilimanjaro (in the northern highlands zone) in Tanzania. From each region, one district was selected based on the present extent of rice production and presence of salt-affected soils in the irrigation schemes. The selected districts were Kilosa, Iringa district council and Moshi district council in Morogoro, Iringa and Kilimanjaro regions, respectively (Figure 1). Rice, maize, common beans, cowpeas, sunflower, vegetables and roots and tuber crops such as cassava are among the major crops cultivated in the surveyed areas.

The selected regions are among the largest rice producers in Tanzania. Additionally, the selected districts have several irrigation schemes that produce mainly rice and due to poor irrigation practices, they are experiencing salt-affected soil problem. Demographic characteristics of the selected districts are presented in (Table 1). These zones are characterized by different rainfall patterns, such as unimodal or bimodal. However, the bimodal is the most common rainfall pattern in the eastern and northern zones while the monomodal is common in the southern highland zone. In the northern and eastern zones, the short rain seasons usually begins from November to December, and the long rain seasons from February to May (Table 1) for the bimodal patterns whereas November to April for the Monomodal. The mean annual rainfall

Table 1. Characterization of the studied areas.

District	Geographical Location	Altitude (m above mean sea level)	Mean annual rainfall (mm)	Temperature (°C)
Kilosa	Latitude 6.8343°S and longitude 36.9917°E	500-1100	800 (November to January) short rain and (March- May) long rain	24.6°C average annual temperature
Iringa	Latitude 7.7731°S and longitude 35.6991°E	800 -1800	600-1000 from November to April	Average temperature ranges from 11°C (July) to 27°C (October)
Moshi	Latitude, 3.4622°S and longitude 37. 4254°E	750 -1500	1000 -1500 (November-December) short rain and (February-May) long rain	Average temperature ranges from 16°C (July) to 30°C (October)

ranges between 500 and 1800 mm, and varies between AEZs. The average annual temperatures are around 24.6, 27 and 30°C for Kilosa, Iringa and Moshi districts, respectively. The districts experience lower temperatures after the long rain season, between June and July, annually.

Sampling

The research sample consisted of respondent farmers who produce paddy rice in irrigation schemes which have salinity problems in Iringa, Kilosa, Moshi districts. Participating farmers were to meet the criterion for being rice farmers. The interview was held with 206 farmers from nine different irrigation schemes in all districts. To determine the study population in the three districts Cochran (1977:75) equation was used to estimate the total number of respondents according to Equation 1:

$$n_0 = \frac{Z^2 pq}{e^2} \quad (1)$$

where η_0 is the sample size, Z^2 is the abscissa of the normal curve that cuts off an area α at the tails (1 – α equals the desired confidence level, e.g., 95%), e is the desired level of precision, p is the estimated proportion of an attribute that is present in the population, and q is 1-p. The value for Z is 1.96 for the chosen confidence level.

In this study, the number of respondents farmers (n) were determined by using Z = confidence level at 95% (standard value 1.96), e = desired level of precision at 5%, and p = percentage of rice farmers in the population, estimated by the assumption that more than 84% of farmers were involved in rice farming (Equation 2):

$$n = \frac{(1.96)^2(0.84)(1-0.84)}{(0.05)^2} = 206.5 \approx 207 \quad (2)$$

Data collection

Personal interviews were conducted at household level using a structured questionnaire. Respondents were randomly selected from the list of rice farmers provided by the ward extension officers at each of the participating area in the district. With the guidance of the ward and village extension officers, selected farmers were visited and interviewed. A total of 206 rice farmers were interviewed, equal number of 69 respondents (each) were in Kilosa and Iringa districts, and 68 in Moshi district, between April and May, 2023.To verify the information obtained from personal interviews, focus group discussions (FGD) were also conducted. Two FGDs were held in each district and the farmers who participated in the FGDs were selected from the key informant/respondent farmers under supervision of ward/village extension officers in collaboration with lead farmers. Approximately 10 to 15 farmers participated in each FGD.

During selection of farmers for the FGDs, age and gender were among the key criteria. Efforts were made to ensure equal participation for both men and women farmers in the FGDs. The focus group discussions were held at ward or village offices. The Participated farmers were first briefed about the broader purpose of the study, and the importance of their contributions to the discussion. Later, the specific aspects of rice and other crops' production and productivity were discussed, including important rice varieties grown, causes of salinity, indicators for salt-affected soils, the extent of salinity in their area, availability of salt tolerant-varieties, and important attributes to consider during a new variety development. Nearby farms affected by salinity were visited to capture more information on the effect of soil salinity on the rice crop.

Data analysis

The collected data was compiled, organized, coded into quantitative terms and entered SPSS software ready for analysis. The statistical analysis was carried out using Statistical Product and Service Solutions (Hejase and Hejase, 2013) IBM SPSSversion 20. Descriptive statistics were evaluated for the collected data, including frequency, means, and percentages for all parameters used in the study. Chi-square tests at probability level of p=0.05 were conducted to analyze the relationship between variables, and the results are summarized and presented in tables and figures.

RESULTS

Demographic characterization of households

Most of the respondents 68.4% were males, while 31.6% were females. There was a significant difference (χ^2=11.11, p= 0.004 < 0.01) in the number of respondents between male and female respondents across the districts (Table 2). Based on age groups, the majority of the respondents fell between the ages of 25-50 (62.6%), and based on marital status, the largest group was married (81.1%), compared to single, divorced, and widowed individuals. The differences in the level of education attained by the farmers across the districts were not significantly different (χ2 = 7.65; p = 0.265 > 0.05). The majority of the respondents (77.2%) had attended primary school, whereas 16.5 and 3.9% had attended secondary and college education, respectively, and they are capable of reading and writing at least in kiswahili. The remaining 2.4% of respondents had not

Table 2. Description of the household characteristic of farmers in surveyed areas of Tanzania.

Variable	Class	Kilosa	Iringa	Moshi	Mean	X^2	Df	P-value
Gender	Males	56.5	82.6	68.4	68.4	11.11	2	0.004
	Females	43.5	17.4	31.6	31.6			
Age (Years)	< 25	2.9	1.4	2.9	2.4	11.53	4	0.021
	25-50	66.7	73.9	47.1	62.6			
	>50	30.4	24.6	50	35			
Marital status	Single	10.1	10.1	5.9	8.7	7.28	6	0.296
	Married	75.4	84.1	83.8	81.1			
	Divorced	2.9	4.3	4.4	3.9			
	Widowed	11.6	1.4	5.8	6.3			
Education level	No formal education	1.4	0.0	5.9	2.4	7.65	6	0.265
	Primary education	75.4	82.6	73.5	77.2			
	Secondary education	20.3	14.5	14.7	16.5			
	College education	2.9	2.9	5.9	3.9			
Farm size (Ha)	<1.6	20.4	14.5	42.6	25.7	21.34	6	0.002
	1.6-3.5	47.8	43.3	38.2	43.2			
	3.6-5	21.7	20.3	13.2	18.2			
	>5	10.1	21.7	6.0	12.7			

χ^2 =Chi-square, df= degrees of freedom, $p \leq 0.05$ indicates it is statistically significant difference.

attended any school. The size of land owned by the farmers was significantly different ($\chi2 = 21.34$; $p = 0.002 < 0.01$) across the districts. The land size used for agricultural activities by farmers for rice cultivation is summarized in Table 2. In all the districts, 43.2% of rice farmers had production fields ranging from 1.6 to 3.5 ha. About 25.7% of the respondents each owned a farm size of less than 1.6 ha, while 18.2% of the respondents owned between 3.6 and 5.0 ha of land and 12.7% had farm sizes greater than 5 ha across the districts.

Major crops grown in the studied districts

Farmers from the studied districts were actively involved in the production of different crops for food and income. Farmers listed the major crops grown in their areas, and the results for the types of crops grown in Kilosa, Iringa, and Moshi districts are summarized in Table 3. Rice and maize were the two major crops grown by the majority of the farmers in all districts, grown by 41.9 and 31.4% of the respondents, respectively. Crops such as common beans, horticultural crops, and cowpeas were commonly grown in almost all the districts. However, some crops were considered more important in one or more district and less important in other areas. For example, sunflower was considered one of the important crops in Iringa and Kilosa districts, but it was not among the main crops in Moshi district.

Types of rice cultivars grown and major sources of seeds

There was a significant difference regarding the types of rice cultivars grown by farmers across the districts ($\chi^2 = 120.14$; $p \leq 0.001$) as noticed among the respondents (Figure 2). About, 37.9% of the farmers in all districts grow improved rice cultivars, about 30.7% of farmers cultivate local cultivars or landraces and 31.6% cultivates both improved and local cultivars. However, in Moshi, majority of farmers grew the improved rice varieties because of ease of access to improved seeds available from local seed dealers; however, few farmers still use a combination of landraces and improved cultivars.

Regarding seed sources, farmers in the study districts obtain rice seeds for planting through various sources. A significant difference ($\chi2= 101.63$, $p \leq 0.001$) in seed sources was observed among the respondents across the districts. Results indicated that 37.4 % of the farmers recycled the retained seeds from the previous paddy harvest, while 30.1% sourced their seeds from agro-dealers (Seed companies). A small proportion (10.7%) obtains their seeds from government seed agency (GSA), and 6.8% acquired their seeds from the nearby research institutes (Figure 3). There were a high number of

Table 3. Percent of respondent listing crops grown across studied districts.

Crop grown	Kilosa	Iringa	Moshi	Mean respondents growing the crop
Rice	35.9	50.4	39.5	41.9
Maize	35.4	22.2	36.6	31.4
Sunflower	10.9	6.7	0	5.9
Cowpeas	5.2	0.7	0.6	2.2
Vegetables	3.6	6.7	7	5.8
Pigeon peas	0.5	0	0	0.2
Cassava	1	5.2	0	2.1
Sugarcane	0.5	0	0	0.2
Bambara nuts	0.5	0	0	0.2
Bananas	0	0.7	0.6	0.4
Groundnuts	0	0.7	0	0.2
Sesame	0	0.7	0	0.2

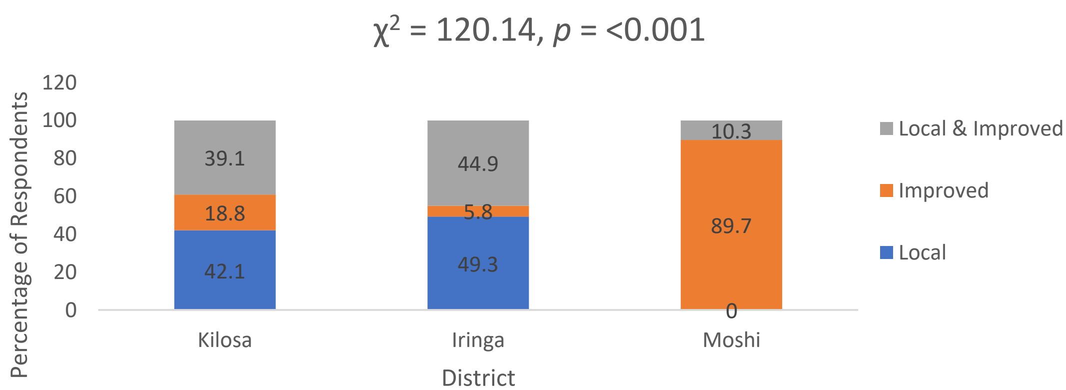

Figure 2. Types of rice seeds used by farmers in the studied districts.

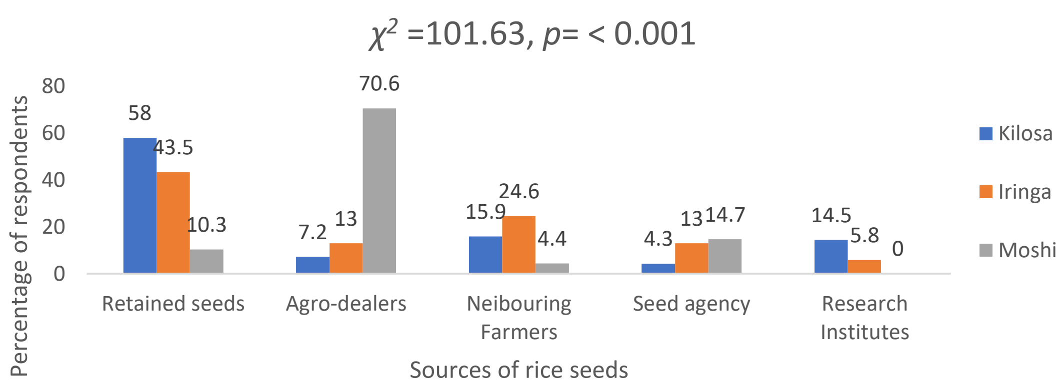

Figure 3. Main sources of rice seeds for planting.

farmers recycling seeds in Kilosa and Iringa compared to Moshi, where the majority of farmers purchase seeds from agro-dealers. Farmers use saved seeds as a way to reduce costs of production as they are not required to purchase new seeds for each planting season.

Popular rice varieties grown in studied districts

The rice varieties grown by farmers in the studied districts are summarized in Table 4. Farmers grow both improved rice varieties and landraces, either on the same or

Table 4. Percent of respondents indicating main rice varieties grown across studied districts.

Variety	Kilosa	Iringa	Moshi	Traits preferred
SARO 5	30.7	22.3	74.7	HY, MR, SARM, and ST
Faya dume	0	28	0	HY and MR
IR64	0	0	24.1	HY, MQ and MRT
Kalubangala	43.8	0	0	HY, HG, and MR
Faya jike	0	3.8	0	HY, MT
Zambia	0	10.8	0	MR, AR and MRK
Blue Y	0	12.1	0	EM, HY, MRT
Afaa Mwanza	0	4.5	0	MM, T, SARM and MRT
Bahi	0	1.9	0	AR
Super Shinyanga	5.8	6.4	0	AR, MR and ST
Shingo ya mwali	0	1.3	0	AR, and T
Loma	0	0.6	0	AR and T
Kabawa	0	5.1	0	AR, T and MKT
Bwawa mbili	10.9	1.9	0	AR and T
Wahi pesa	3.6	0.6	0	EM, and HY
Jicho la samora	0	0.6	0	AR and T
Lawama	5.1	0	0	AR
IR56	0	0	1.1	HY, MRT and ST

HY=High yielding, MR =High milling recovery, Hg= High grain weight, SARM = Semi aromatic, MRK= Marketability, ST= Stress tolerant, MT= Medium plant height, MQ= Milling quality, EM= Early maturity, MM= Medium to maturity, T= Good taste and AR=Aromatic.

different fields. Several highly preferred rice varieties included SARO 5(42.6%), Kalubangala (14.6%), Faya dume (9.3%) and IR64 (8%), which were cultivated by a significant number of respondents. There were observed variations in terms of preference of rice varieties by farmers across and within the districts. For instance, it was reported that the most preferred varieties were SARO 5 in Moshi (74.7%), Kalubangala in Kilosa (43.8%) and Faya dume in Iringa (28%). Additionally, the most preferred traits in rice varieties were, high yields (number of tillers), aroma and marketability.

Major constraints to rice production in the studied districts

Results shows that the primary rice production constraints in all studied districts (Kilosa, Iringa DC, and Moshi DC) encompass both abiotic and biotic stresses (Table 5). It was reported by 54.4% of the respondents that high fertilizer costs were the main constraints to rice production. However, there was no significant difference ($\chi^2 = 3.10$; $p = 0.55 > 0.05$) for cost of fertilizer across the studied districts, indicating it was of equal importance in all districts. Drought was the second most important constraint (34.0%) and there were no significant differences ($\chi^2 = 4.41$; $p = 0.354 > 0.05$) across the districts. Ranked third among the production constraints was salinity (29.1%), with a significance difference ($\chi^2 = 14.54$; $p = 0.006 < 0.01$) indicating that this constraint varies in importance across the districts. Other constraints such as poor soil fertility (23.5%), pests and diseases (21.4%) and flooding (10.2%) were also considered important factors affecting rice production across the studied districts.

Extent of soil salinity and factors contributing to soil salinity in farmers' fields

Farmers in Kilosa, Iringa, and Moshi districts mentioned that soil salinity as one of the main factors reducing rice yields in their respective areas. However, the extent of soil salinity in farmers' fields varied from one district to another and even between farmers within the same district. Some farmers' fields were not affected by salinity, while others have a high level of salinity affecting rice growth. About 35.9% of the respondents across the districts indicated the existence of high levels of salinity in their farms. The extent of soil salinity was higher in Iringa and Moshi, while in Kilosa a higher number of respondents reported a moderate level of salinity in their farms, indicating that not all farms were salt-affected (Figure 4).

The farmers indicated the main causes of soil salinity in their farmers to be the nature of the underlying parent materials, use of chemical fertilizers, poor irrigation infrastructures and water, and changes due to climatic

Table 5. Main constraints to rice production in the studied districts.

Variable	Class	Kilosa	Iringa	Moshi	Mean	χ^2	Df	*p*-value
	High	20.3	10.1	33.8	21.4			
Pest and diseases	Moderate	40.6	29.0	45.6	38.3	25.47	4	< 0.001
	Low	39.1	60.9	20.6	40.3			
	High	15.9	33.3	38.2	29.1			
Soil salinity	Moderate	37.7	42.0	39.7	39.8	14.54	4	0.006
	Low	46.4	24.6	22.1	31.1			
	High	40.6	33.3	27.9	34.0			
Drought	Moderate	31.9	29.0	41.2	34.0	4.41	4	0.354
	Low	27.5	37.7	30.9	32.0			
	High	0.0	14.5	16.2	10.2			
Flooding	Moderate	4.3	39.1	33.0	25.7	45.69	4	< 0.001
	Low	95.7	46.4	50.0	64.1			
	High	13.0	10.1	23.5	23.5			
Poor fertility	Moderate	17.4	13.0	27.9	27.9	13.04	4	0.011
	Low	69.6	76.8	48.5	48.5			
	High	49.3	58.0	55.9	54.4			
Costs of fertilizers	Moderate	21.7	15.9	11.8	16.5	3.10	4	0.55
	Low	29.0	26.1	32.4	29.1			

χ^2 =Chi-square, df= degrees of freedom, $p \leq 0.05$ indicates that there is statistically significant difference.

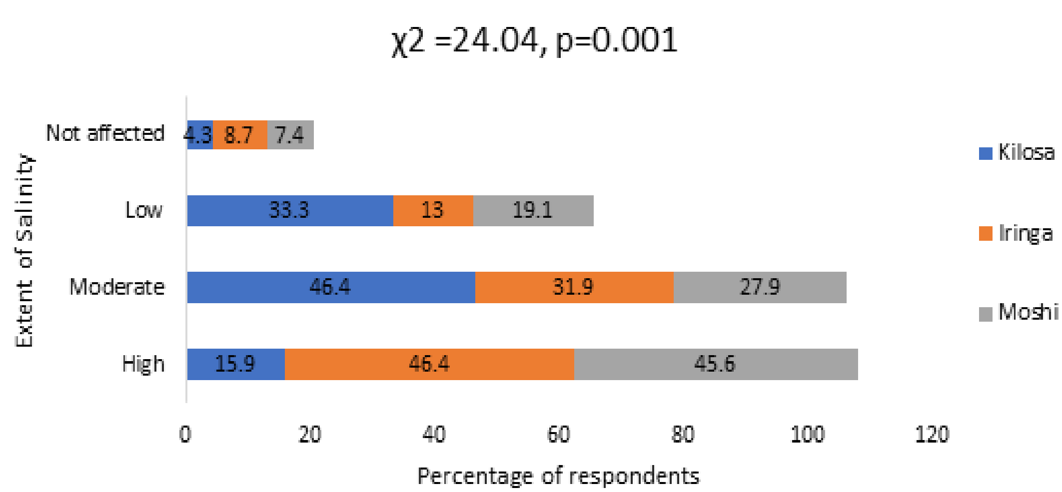

Figure 4. Famers' assessment of the extent of soil salinity in their fields.

conditions. Regarding the underlying nature of the parent materials, 54.3% of the farmers across the districts believed that the nature of parent materials was the main cause of salinity. However, a small portion of the respondents were uncertain about the causes of salinity, possibly because some of the farmers had not experienced salinity problems in their farms. It was noted that the farmers in the surveyed districts had good network of extension services from both public and private organizations, which have enhanced their

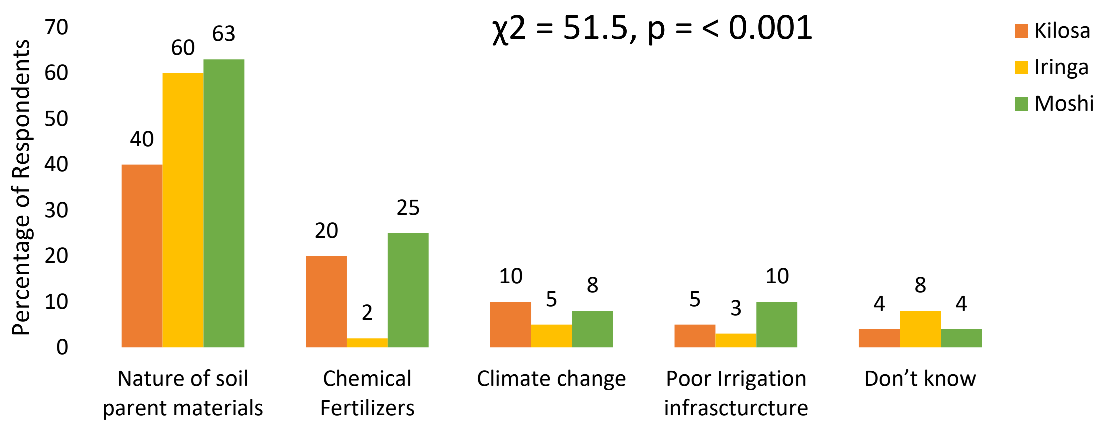

Figure 5. Farmers' perception on factors contributing to salinity in their farms.

understanding on salinity related problems (Figure 5).

Farmers main coping strategies against soil salinity

There are different methods rice cultivating farmers use to manage salt affected soils in their farms (Figure 6). Famers main coping strategies for salt effects are such as flushing with irrigation water, use of inorganic fertilizers such as ammonium sulphate (SA) for calcaric soils, animal manure, gypsum, and combination of burned and unburned rice straws and husks. There was statistical significantly difference between methods (χ^2 =39.27; $p \leq 0.001$) used as coping strategies across the districts, indicating variations of available management options. Flushing with irrigation water was the most commonly used method across the districts, but the main challenges of this method in many areas was water scarcity caused by drought. Farmers mentioned that in years with less rainfall they experienced more problems with salinity in their fields. Additionally, some farmers indicated they were not using any management options and the majority of these farmers were from Kilosa district where the extent of salinity was reported to be lower compared to Iringa and Moshi.

Farmers' preferred traits for consideration during the rice breeding process

Farmers cultivating rice in different areas have varying preferences for rice traits. The most preferred traits in the studied districts were high grain yield, early maturity, salinity tolerance, aroma, drought tolerance, and disease resistance (Table 6). High grain yield was the most preferred traits across the studied districts, and there was no statistically significant difference (χ^2 = 6.78; p = 0.148 > 0.05) among them. In general, the majority of farmers (95.1%) preferred rice cultivars with high grain yields, while a small percentage (4.9%) had preference for varieties with moderate grain yields. The preference for moderate yielding varieties is due to the benefits these varieties offer such as exhibiting greater stability in different environmental conditions. Farmers suggested that some rice varieties may not produce exceptionally high yields under optimal conditions, but they are less likely to fail or suffer significant yield losses under adverse circumstances, such biotic and abiotic stresses e.g. salinity. Results indicated that 84% of the respondents preferred rice varieties with high number of tillers, which is the second most preferred trait across the districts, and that is because tillers contribute to high production potential for a cultivar.

Salinity tolerance was the third most preferred trait by the respondent famers, and there was a significant difference (χ^2 = 24.35, $p \leq 0.001$) across the districts, indicating that this trait was more preferred in some districts compared to others. This could be attributed to the differences in the extent of soil salinity problems among the districts (Figure 4). Early maturity was the fourth most preferred trait, with 79.6% of respondents. Other important traits for consideration during variety improvement across the studied districts included aroma (78.2%), high disease tolerance (74.3%), and medium plant height (60.2%), which were fifth, sixth, and seventh preferred traits, respectively.

Preferred traits for the grain quality for rice variety improvement

Rice growing farmers have different preferences for physical rice grain quality attributes such as grain length, grain shape, milling recovery, aroma, grain colour, and overall quality. Visual characteristics of rice grain and experiential attributes, like cooking quality, are essential as they influence consumers' preferences and therefore crucial criteria for varietal improvement. High milling

Table 6. Famers' preferred trait in new rice varieties in the studied districts.

Variable	Class	Kilosa	Iringa	Moshi	Mean	X^2	Df	*p*-value
	High	91.3	95.7	98.5	95.1			
Grain yield	Moderate	8.7	2.9	4.9	4.9	6.78	4	0.148
	Low	0.0	0.0	0.0	0.0			
	High	73.9	84.1	80.9	79.6			
Early maturity	Moderate	17.4	5.9	16.2	13.1	7.46	4	0.113
	Low	8.7	10.1	2.9	7.3			
	High	60.9	97.1	76.5	78.2			
Aroma	Moderate	36.2	12.7	16.2	18.4	32.42	4	< 0.001
	Low	2.9	0.0	7.4	3.4			
	High	40.6	73.9	66.2	60.2			
Medium plant height	Moderate	44.9	20.3	25.0	30.1	17.58	4	0.001
	Low	14.5	5.8	8.8	9.7			
	High	63.8	98.6	89.7	84.0			
Number of tillers	Moderate	17.4	1.4	7.4	8.7	35.07	4	< 0.001
	Low	18.8	0.0	2.9	2.9			
	High	55.6	95.7	80.6	80.6			
Salinity tolerant	Moderate	23.2	2.9	13.6	13.6	24.35	4	< 0.001
	Low	13.0	1.4	5.8	5.8			
	High	55.2	88.4	79.4	74.3			
Disease tolerance	Moderate	37.7	11.0	17.6	22.3	22.43	4	< 0.001
	Low	7.2	0.0	2.9	3.4			

χ^2 =Chi-square, df= degrees of freedom, $p \leq 0.05$ indicates that there is statistically significant difference.

recovery was the highly preferred attribute by the respondents, as indicated in Table 7.

Regarding grain length preferences, 96.1% of respondents showed strong preference for long-grain rice across all the districts (Table 7), and although there was no significant difference (χ^2 = 2. 303; p = 0.680) between districts. Results also, indicated that 3.6% of respondents expressed preference for medium grain size, and only 0.5% indicated a preference for shorter-grains.

Preferences for grain shape across the districts revealed that 35.4% of respondents liked bold rice grain (Table 7). No statistically significant difference (χ^2 = 0.417; p = 0.981 > 0.05) for grain shape was observed among the respondents across the studied districts. About 35.3% of respondents indicated preference for slender grains, while 30.0% medium shaped grains.

Paddy rice grain colour, which is determined by the pigment in the pericarp, is one of the important attributes' farmers consider when selecting a rice variety to cultivate. Majority (84.5%) of the respondents across the districts showed a strong preference for brown colour of paddy rice (Table 7) and there was no statistically significant difference (χ^2 = 9. 754; p = 0.135 > 0.05) across the districts, indicating that famers in the studied districts had a strong preference for brown paddy rice. A small proportion of respondents (10.7%) in all the districts, expressed preference for light brown grain, while only 1.9% of the respondents preferred red coloured grain and 2.9% had no specific paddy rice grain colour preference.

Regarding rice grain length, across the districts, 96.1% of respondents expressed a strong preference for long-grain (Table 7). No statistically significant difference (χ2 = 2. 303; p = 0.680 > 0.05) for rice grain length was observed among the respondents across the studied districts. 3.6% of respondents indicated preference for medium size grains, while only 0.5% of the respondents did the same for short-grain rice. Aroma is one of the highly preferred attributes in rice by both farmers and consumers. It was noted that 97.1% of respondents expressed strong preference for aromatic rice (Table 7). No statistically significant difference (χ^2 = 1. 063; p =

Table 7. Farmers' preferences for rice grain quality for the new varieties.

Variable	Class	Kilosa	Iringa	Moshi	Mean	χ^2	Df	*p*-value
Grain length	Long	95.7	97.1	95.6	96.1	2.303	4	0.680
	Medium	2.9	2.9	4.4	3.4			
	Short	1.4	0.0	0.0	0.5			
Grain shape	Bold	34.8	36.2	35.3	35.4	0.417	4	0.981
	Medium	33.3	29.0	29.4	30.6			
	Slender	31.9	34.8	35.3	34.0			
Grain colour	Brown	78.3	91.4	83.8	84.5	9.754	6	0.135
	Light brown	11.6	5.8	14.7	10.7			
	No preference	5.8	1.4	1.5	2.9			
	Red	4.3	1.4	0.0	1.9			
Cooking quality	Non sticky	76.8	87.0	95.6	86.4	13.795	4	0.008
	Intermediate	14.5	11.6	4.4	10.2			
	Sticky	8.7	1.4	0.0	3.4			
Aroma	Aromatic	97.1	98.6	95.6	97.1	1.063	2	0.588
	Medium aromatic	0.0	0.0	0.0	0.0			
	Non aromatic	0.0	0.0	0.0	0.0			
	No preference	2.9	1.4	0.0	2.9			
Milling recovery	High	100	100	100	100			
	Medium	0.0	0.0	0.0	0.0			
	Low	0.0	0.0	0.0	0.0			

χ^2 =Chi-square, df= degrees of freedom, $p \leq 0.05$ indicates that there was statistically significant difference.

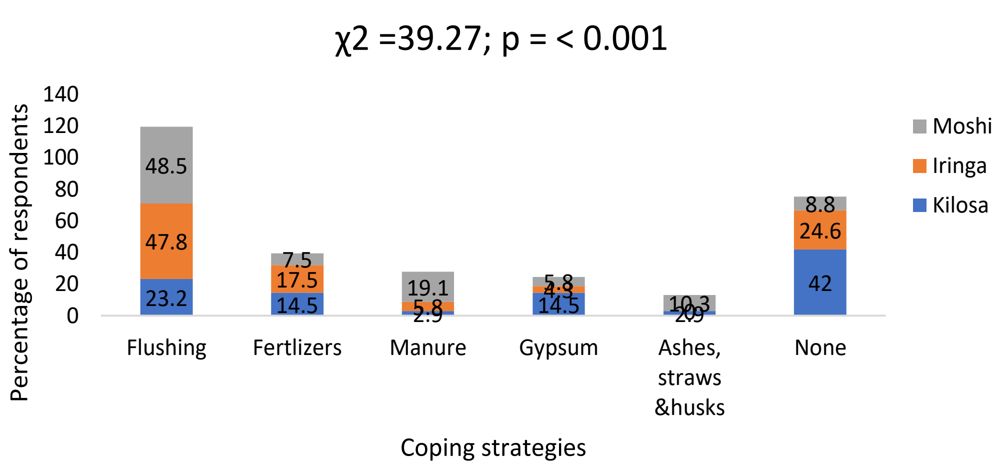

Figure 6. Coping strategies on the consequences of salt-affected soils in rice production in studied districts.

0.588 > 0.05) was observed between the respondents across the studied districts. A small portion of only 2.9% of the respondents indicated no preference for aroma.

DISCUSSION

This paper present findings of farmers perception and understanding regarding rice production and associated constraints, in Kilosa, Iringa, and Moshi districts of Tanzania. The focus centered on exploring the rich experiences of farmers with regard to rice production and challenges, preference of rice varieties and their attributes, the perception of salinity and the causes in their areas, and the strategies employed by farmers to manage salinity problem. Through the exploration, we debate thoroughly on comprehension and hurdles shared by rice farmers in the three regions and coping strategies they employ to alleviate the effects of salinity and other related problems.

Demographic information

It was health and motivating that there was an active participation from both male and female farmers although the number of male farmers was higher than that of the female farmers. When compared to other districts, Iringa had the lowest participation of female famers, this could be mainly due to male famers have control over family resources such as land rather than other factors. It has been reported that women in developing countries contributes about 43% of farm labour force, but they own only a small portion of farm land, which could affect women participation in agricultural production of some crops (Prosterman, 2013). The same reason could account for higher male participation across the districts; other factors could be men often being the heads of households are responsible for selecting crops to grow, managing farming operations, and overseeing the marketing of the produce. These findings are consistent with Medagbe et al. (2020) who showed that male farmers were more involved in rice farming compared to female farmers due inequality in ownership of productive resources. Additionally, it has been reported that male farmers control the family resources such as land, credits and have the capacity to allocate resources to their farming preferences, which could affect women's participation in rice farming (Haile et al., 2016). The dominance of male farmers in rice farming has been a common practice in most rice-producing areas and this is also because, the crop is certainly money earners as it is grown under irrigation with low or no risk of crop failures (Thapa et al., 2020). Nevertheless, Chidi et al. (2015) reported contrasting findings that indicated that in Ebony State, female farmers outnumbered males in rice farming.

It was noted that the household education played a vital role in adoption of new farming technologies. Most of the respondents had good level of education across all the studied districts. It has been reported that dissemination of new agricultural technologies through various means such as distribution of leaflets, posters and brochures to farmers depends on education to be more effective (Ndimbwa et al., 2019). Printable sources of agricultural information have been found to enrich literate (read and write) group of farmers while excluding the illiterate group of farmers (Elly and Silayo, 2013). However, this may not be the case for farmers in the studied districts as majority of the farmers have attained at least primary school level education and they were able to read and write in kiswahili which is the National language.

The most active farming aged group consisted of farmers between 25 and 50 years, indicating that in the studied districts there was an active labour force involved in farming activities. However, the lower participation of farmers under the aged of 25 years means that there were challenges hindering youth participation in agriculture, which need to be addressed in order to encourage their contribution to the economy through farming. According to Kimaro et al. (2015), youth farmers in Tanzania are dissatisfied with agriculture because there are diverse non-agricultural activities which provide alternatives funds better compared to farming. The trend of youth turning away from agriculture has been observed in many other African countries, whereby youth are turning away from agriculture, looking for opportunities in other economic sectors (Daudu et al., 2023) that possibly of less drudgery.

In the studied districts, the majority of the household farms were relatively small; the smaller farm sizes are attributed to limited land availability, as well as inadequate capital to expand the farm sizes. The current scenarios accurately portray the characteristics of rural farmers in Tanzania, who typically possess small land holdings leading to farmers engage in cultivation on a small sized-farms (Kimaro and Hieromino, 2014). Similar findings of small land ownership by rice farmers in many irrigation schemes in Tanzania have been reported due to scarcity of land by Chuan-hong et al. (2021), found similar findings in Mara region. Additionally, it was observed in the studied districts that the need for new technologies such as new tolerant rice varieties, and its adoption are influenced by farmers' experience, level of education, age and farm sizes owned, as it was also reported by Muhammad et al. (2017).

Main crops grown in the studied districts

Agriculture serves as the primary source of income for many households in the studied districts, and rice apart from being a staple crop grown across districts, serve as the income spinner although it is being cushioned by other important crops including maize, sunflower, common beans and various vegetables. Furthermore, farmers engage in the cultivation of several minor crops, such as cowpeas, pigeon pea, cassava, sugarcane, bambara nuts, bananas, groundnuts, and sesame. In many areas, particularly during the long rainy season, a significant portion of land is allocated to rice farming because the majority of rice in Tanzania is produced in lowland areas (Mtembeji and Singh, 2021). In many of rice producing areas, following the rice harvest, farmers often engage in cultivation of other crops, especially those with lower water requirements to exploit the residual moisture. The tendency of cultivating crops such as pulses after rice production is a common practice in many rice producing areas of the world (Peramaiyan et al., 2023). The practice of crop diversification and rotation practised by farmers in rice-producing areas is a strategy to control or mitigate crop production risks. Also the practices helps to disrupt the life cycles of insects and disease causing pathogens (Shah et al., 2021), and hence provides protection against abiotic and biotic stresses. The practice of crop diversification by farmers has been shown to enhance the economic and ecological benefits in rice producing farming systems (He et al., 2021).

Sources of seeds, cultivars and varieties preferences

Rice production in the studied districts had several challenges among them is inadequate availability of quality seed. However, it was observed that farmers had various sources from which they obtain rice seeds they plant, including purchasing from agro-dealers, Agricultural Seed Agency (ASA) and research institutions. Also, in some cases, farmers recycling the retained seeds from the previous harvests or obtaining from the neighbours is very common. The recycling of rice seeds is feasible because the crop is a self-pollinated one, and it is a common practice among farmers, as reported in different countries (Hubert et al., 2016) in SSA. Important to note that farmers prepare their recycled seed by selection of the best plants, harvest them separately, and store them under suitable conditions for the next season use.

The main types of rice cultivars grown by farmers are landraces and improved rice varieties. The number of farmers growing improved rice varieties across the districts is promising, and they use the improved seeds varieties due to their high yields and other consumer preferences. On the other hand, famers' preference for landraces is attributed to their resilience against biotic and abiotic stresses, good aroma and taste. Even when farmers grow improved varieties, they often cultivate landraces in small sections of their farms because landraces can provide reasonable yields under adverse weather conditions, while also offering better taste and aroma. These findings are similar with other researches that reported that even with the availability of improved rice varieties, some farmers opt for local cultivars, despite having lower yields compared to improved counterparts (Conteh et al., 2012, 2014; Louhichi and Paloma, 2014) because of the belief that they are well-suited to the prevailing farming and agro-ecological conditions (Jin et al., 2020). This is the common trend in many Sub-Saharan African (SSA) countries, Tanzania inclusive that farmers continue to grow landraces because of adaptation to adverse weather conditions and tolerance to diseases (Musila et al., 2018).

Despite the above account, the trends of farmers purchasing seeds from seed producers displays a positive sign for rice crop improvement and may indicate that new rice varieties could easily be adopted. However, in the SSA the use of improved rice varieties have been very low, causing low rice yields in many areas (Bello et al., 2020; Checco et al., 2023). It is also envisioned that the practice may have a positive impact of improving rice production, productivity and supports the sustainability of seed companies; since the formal seed sector in many developing countries has not significantly contributed to the development of small-scale farming (Kansiime et al., 2021).

Additionally, various research works reports that the informal seed sector still plays a pivotal role as a source of seeds to farmers in many African countries (Hunga et al., 2023; Okry et al., 2010), the fact that need to decline and give away to the formal seed sector if African agriculture has to make any progress to be able support the population growth and modernization of the agricultural sector.

Main rice production constraints

Rice production faces multiple stresses, among them are abiotic and biotic, representing the primary constraints in all studied districts. The main stresses were high cost of fertilizers, drought, soil salinity, poor soil fertility, pests and diseases and, flooding. These constrains have widely been documented to affect rice production in many countries in Africa and the world (Dar et al., 2021). The prevalence of diseases, pests, and environmental stresses such as drought, salinity, and flooding reduced through the use of stress-tolerant crop varieties (Muhammad et al., 2023). Due to the stated challenges, there is unrelenting need to develop rice varieties with efficiency nutrients uptake, particularly for nitrogen and other essential macro-elements to address the issue of poor soil fertility (Baligar et al., 2001; Ali et al., 2021). Therefore, during the strategic planning for the development of new rice cultivars, a priority should be given to new cultivars with multiple stress tolerances in order to address the challenges faced by farmers resulting from the combined effects of pronounced stresses.

Extent of soil salinity, influencing factors and coping strategies

Extent of salt-affected soils in Tanzania have been reported to cover more than 3.5 million hectares of land (Meliyo et al., 2017) covering lowlands where irrigated agriculture is practised, including the studied districts.

This was substantiated by farmers in the studied districts who stated that soil salinity was the main factors affecting rice yields. However, the extent of soil salinity in farmers' fields varied between districts and even farms within a district. Elevated salinity levels have been reported to reduce soil quality, restrict crop growth, hampers agricultural productivity and in severe instances, results in the abandonment of the agricultural lands in different countries in Sub-Saharan Africa (Thiam et al. 2019). The farmers in the studied districts indicated that the main causes of soil salinity in their farms were soil parent materials, use of chemical fertilizers, poor irrigation water quality and poor irrigation infrastructures in rice irrigation schemes, particular in Kilosa district (Dolo and Nchimbi-msolla, 2017). The Farmers' description in the studied districts corresponds with research findings by Eswar et al. (2021) who indicated that geochemical processes such as rocks and mineral weathering, atmospheric deposition, and the formation of soil from saline parent materials are the primary causes of salinity is various soils.

Furthermore, other significant causes of salinity in soils have been identified to include inappropriate irrigation water management without adequate drainage, resulting in soil salts accumulation (Daba and Qureshi, (2021). The major challenges facing improperly managing salinity in soils in various countries have been surrendering significant portions of agricultural lands to salts hence taking them out of production (Khasanov et al., 2023). It has been reported that salinization is expanding at a fast rate, affecting about 0.2 to 2 million hectares annually globally (Hopmansa et al., 2021; Munns and Tester, 2008), Tanzania inclusive. For instant, farmers in the studied districts have reported high rice yields under normal farming conditions, ranging from 3.2 to 3.8t/ha, while under saline conditions, the reported yields were less than 1t/ha, which was significantly lower than under non-saline condition (Omar et al., 2023). Kashenge-Killenga et al. (2014) reported that soil salinity could lead to reduced rice yield and even could result to complete crop failure, depending on the severity of soil salinity in rice farms.

There are various coping strategies which rice farmers employ to combat the problem of soil salinity. The use of tolerant rice varieties is among the best approach for management of salt affected soils in farmers' fields; however, farmers in the studied districts do not grow salt tolerant rice varieties because of unavailability of tolerant rice varieties with preferred attributes. Flushing of salt-affected soils using irrigation water has been reported to help farmers by physically washing away accumulated salts from the root zones (Cuevas et al., 2019). Leaching of sodium salts stands out as one of the prevailing and highly efficient approaches to manage the build-up of salts in soils (Ghafoor et al., 2008). The use of gypsum is another management option that farmers are using and it has also been reported to be a good source of calcium ions, that displaces exchangeable sodium ions reducing the effects of salinity in soils (Shaaban et al., 2013).

Farmers' preferred traits, in new rice varieties for improvement

Rice growing farmers have a wide range of preferences when it comes to the variety selection for cultivation, ranging from agronomic to grain quality traits. The main agronomic traits preferred by the majority of the respondent farmers across the districts were high yields, large number of tillers, and salinity tolerance. Other important traits preferred by farmers were early maturity, aroma, medium plant height, and tolerance to pests and diseases. The preference for high grain yield was observed in all districts, emphasizing the need for breeders to develop high-yielding rice cultivars adapted to salinity stress conditions. These findings align with some of the previous reported results in Tanzania and other SSA countries, where rice growing farmers had high preferences for high yield and stress tolerant rice cultivars (Bucheyeki et al., 2011; Suvi et al., 2020).

Rice grain quality encompasses numerous characteristics such as milling, physical appearance, cookability, aroma, nutritional properties and eating characteristics (Sharma and Khanna, 2019). Consumers' willingness to pay for rice grains may be influenced by homogeneity in physical qualities such as form, appearance, and size (Cuevas et al., 2016). This implies that among the most preferred rice varieties across all the districts, were the ones with good agronomic traits such as high yield, large number of tillers, and stress tolerance, as well as good grain quality. Other grain qualities of importance to farmers includes, grain colour and cooking quality, with brown rice and non-sticky attributes being highly desirable. Thus, varietal development initiatives should not solely focus on yield-enhancing traits. It has been reported that the assessment of rice grain quality parameters holds significance as it serves as a key indicator for the success in rice breeding, aligning with consumers' expectations (Custodio et al., 2023). Rice grain quality is a complex trait that encompasses various aspects such as milling, storage, cooking, eating experience, nutritional value, and market quality (Gong et al., 2023). Moreover, there is a growing global demand for high-quality rice, driven by evolving consumer preferences, with expectations of this demand continuing to rise (Sultana et al., 2022).

Conclusions

The current study revealed that rice production in Tanzania faces numerous challenges due to biotic and abiotic stresses. Drought, soil salinity, poor soil fertility, pest and diseases, and high fertilizer costs, were identified by farmers to be the primary causes of low rice yields in many irrigation schemes. The main causes of salinity in famers' fields include both primary and secondary salinization factors, such as rocks and parent materials weathering, poor irrigation infrastructures, and changes in climatic conditions. Due to the effects of salinity and other biotic and abiotic stresses, the majority of farmers have diversified crops by producing apart from rice, maize, common beans, sunflower and other minor crops to mitigate the risk against rice crop failure. Moreover, most farmers cultivate both landraces and improved rice cultivars as a way of protecting themselves against severe weather conditions or by accessing preferred attributes that may be missing in one type of cultivar.

Given the existence of soil salinity problems in the farmers' fields, they are employing different options to manage these stresses, including flushing with irrigation water, use of inorganic fertilizers such as ammonium sulphate (SA), animal manure, gypsum, and combination of burned and unburned rice straws and husks. The use of salt-tolerant rice varieties is one of the most preferred management options by farmers. However, the unavailability of salinity-tolerant rice varieties to farmers presents a significant obstacle to rice production in areas affected by salinity. The rice varieties most preferred by farmers, such as SARO 5, Super Shinyanga, Faya dume, Kalubangala, Blue Y, and IR64 were grown in salt prone areas, but they are all sensitive to salinity. Although these varieties possess important attributes such as high yield, good milling quality, and aroma, but lack salt tolerance which presents an opportunity to rice breeders to improve them for salinity tolerance. This study provides valuable guidance to rice breeders in Tanzania for developing salinity-tolerant new rice varieties by incorporating the known genes for tolerance while considering farmers preferred agronomic and grain quality traits, aiming for broader adoption.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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