Journal of Agriculture and Food Sciences
Volume 22, Number 1, April 2024, pp 167 - 176

POLYMORPHISM IN GRAIN ARCHITECTURE OF RICE LANDRACES CULTIVATED IN NORTHERN NIGERIA

[1]Muhammad, H.U., [1]Sakariyahu, S.K., [1]Indabo S.S., [2]Aliyu, A., [3]Ahmed H.O., [2]Adamu, A.K., and *[2]Aliyu, R.E.

1 Department of Biology, Faculty of Life Sciences, Ahmadu Bello University, Zaria.
2 Department of Biotany, Faculty of Life Sciences, Ahmadu Bello University, Zaria.
3 Department of Plant Science, Faculty of Agriculture, Ahmadu Bello University, Zaria.
***Corresponding author's email:** s.ramatu@gmail.com; enehezeyi@abu.edu.ng

ABSTRACT

This study investigated seed shape and size polymorphism in 70 rice genotypes from diverse ecological regions in Nigeria, including North-West, North-East, and North-Central. The aim was to profile these genotypes based on marketability and consumer preferences. Seed evaluation followed the International Rice Research Institute's (IRRI) standard protocol. Measurements of seed length and width, with and without husk, were taken using precise instruments. Descriptive statistics, ANOVA, and cluster analysis revealed significant variability in seed dimensions among landraces. Results showed that all genotypes were slender-shaped, with lengths ranging from 3.2 to 6.8 mm. Classification revealed 18.6% extra-long, 44.3% long, 25.7% medium, and 11.4% short-grained landraces. Cluster analysis grouped landraces by brown rice shape. This information is crucial for rice breeders, farmers, policymakers, and importers to develop effective strategies for future rice production and trade.

Keywords: Variability, breeding, Cluster analysis, polymorphism, Rice landraces.
https://dx.doi.org/10.4314/jafs.v22i1.13

INTRODUCTION

Rice is a resilient and vital staple food crop, consumed by more than half of the global population (National Geographic, 2024). It is highly esteemed for its culinary qualities and taste (Yves, 2012). As of 2020, Nigeria ranked as the foremost producer of rice in Africa and 13th globally (FAO, 2020). Nigeria boasts a diverse array of rice cultivars, landraces, and lesser-known varieties that have been cultivated for centuries by indigenous farmers and local entrepreneurs (Oluwaseyi et al., 2016; Aliyu 2016; Usman et al., 2022). Rice cultivation in Nigeria is predominantly found in swampy areas and controlled water terrace regions (Daudu et al., 2014). As rice cultivation and production in Nigeria expand, selection resulting from consumers' preferences for rice quality characteristics, specifically as it pertains to the effect of grain shape, beyond the simple comparison of imported versus domestic, will become more important from a food security standpoint. Consumers assign similar value to quality attributes whether the rice is locally produced or imported. Notably, imported rice often enjoys a perception of superior quality and physical attributes, contributing to the price disparity between imported and domestic rice in the country.

Agro-morphological traits, both qualitative and quantitative, are extensively used to study genetic diversity and variability in crop species (Goodman, 1972; Aliyu et al., 2013; Aliyu & Adamu, 2023). Therefore, it is essential to assess variability within and between rice seeds to enhance varietal improvement, evaluate rice grain quality, and sustainably manage rice genetic resources. This knowledge is critical for germplasm bank curators seeking to conserve genetic diversity (Olufowote et al., 1997). Understanding the factors driving rice selection preferences, both for domestic and imported varieties, is crucial for rice producers, importers, scientists, and policymakers to effectively meet the needs of Nigerian consumers. The aim of this study was to evaluate the attendant outcome of selection preferences on rice seed polymorphism cultivated in northern Nigeria.

MATERIALS AND METHODS

Collection of rice landraces

Seventy (70) landraces collected from three regions viz., North-west, north-east and north central during 2015/2016 rice growing season were used for this study (Table 1). The Collection area lies in the Guinea and Sudo-sahelsavanna ecosystem of Nigeria (Figure 1).

Data Collection and Analysis

Rice seeds were sorted according to genotypes with ten random replicate samples of seeds taken from each genotype. Seed length, width with and without husk were measured using a Vernier calliper and a micrometre screw gauge (SI unit: mm) at the Physics laboratory, Department of Physics, Ahmadu Bello University, Zaria. Length/breadth ratio for rice with and without husk was also calculated (Aliyu, et al., 2016).

Seed length was measured using a Vernier calliper and calculated with the formula:

$SL = MSR + VSR \times LC$,
Where SL- Seed Length;
MSR- Main Scale Reading;
VSR- Vernier Scale Reading;
LC- Least Count.
Seed width was measured using a micrometre screw gauge by the formula:
$SW = PSR + HSR (HSC \times LC)$
Where SW- Seed Width;
PSR- Pitch Scale Reading
HSR- Head Scale Reading
HSC- Head Scale Coincidence
LC-least count.

Data were subjected to descriptive statistics and Analysis of Variance (ANOVA) to check for significant difference among landraces using SPSS V 20.0. Cluster analysis of the landraces was done based on similarity in quantitative parameters using PAST Statistical Package.

RESULTS

The distribution pattern of rice landraces and accessions used for this study showed that the North West region has the highest concentration of landraces diversity.

Variability in Quantitative traits

The rice landraces exhibited significant variability across all quantitative traits (brown rice length, brown rice width, grain length, and grain width) measured in this study (Table 2). The Mass/osi landrace recorded the maximum brown rice length at 11.61 mm, while the Yar China landrace had the minimum at 8.10 mm.

According to the classification based on standard evaluation score of IRRI (Table 3), all landraces were slender shaped with brown rice length- width ratio ranging from 4.04 to 5.74. The brown rice shape ranged from 6.8 to 3.2 in Yarmaji and Yariana respectively while Jamila-Ng had the longest grain rice length of 8.5mm. About 18.6% of the landraces had extra-long grain length, while 44.3% and 25.7% had long and medium brown rice lengths respectively. About 11.4% were short grained (Figure 1).

The rice landraces exhibited narrow variability in quantitative traits, as evidenced by the coefficients of variation (CV) in Table 2. Among the traits examined, the ratio of length to width of grain rice showed the highest variability (CV% = 11.02), while the width of brown rice exhibited the lowest CV (CV% = 4.51).

Cluster analysis

Cluster analysis based on quantitative characters (brown rice width and grain width) of the rice landraces (Figure 2). The dendrogram grouped the landraces into three major cluster groups based on seed polymorphism in quantitative parameters (kernel size, kernel breadth, awn length and kernel weight). Major cluster – I with only a landrace (Yarmaaji) while cluster - II and III comprised of thirty nine and thirty landraces respectively.

DISCUSSION

The significant variation in quantitative traits observed among rice landraces from northern Nigeria, observed in this study, might be attributed to consumer preferences that have influenced these landraces to adapt to various ecologies in the region, where a preference for uniform, long, slender kernels predominates. Previous studies have documented the predominance of long-grain varieties in selected states of Nigeria and linked this trend to consumer preferences (Peterson-Wilhelm et al., 2022). Crop landraces are renowned for their significant variability in seed morphological traits and their ability to adapt to local environments (Frankel et al., 1995; Hore, 2005). All the seeds in this study exhibited a slender shape, which corresponds with findings from a similar study by Adu-Kwarteng et al. (2003) comparing rice grain quality in local and new varieties in Ghana. Adu-Kwarteng et al. (2003) reported that all breeding lines except one were slender. In their study, nearly all local varieties were also slender, except for two which were medium-shaped.

Rice landraces from diverse geographical locations and ecologies tended to cluster together, except for Yarmaaji, which stood out as distinct within its own region. This observation aligns with previous studies, which found that landraces from varied areas form tight clusters, whereas those from the same areas cluster separately (Semwal et al., 2014; Aliyu et al., 2013). The clustering pattern among landraces from different regions may be due to the free exchange of genetic material among farmers. In contrast, variability among landraces from the same region is likely shaped by factors such as local adaptation, selective pressures, and cultural practices (Peterson-Wilhelm et al., 2022; Aliyu & Adamu, 2023).

The findings of this study provide valuable insights for rice breeding programs in Nigeria aimed at enhancing the quality of domestic rice varieties. Continuous use older rice varieties that do not meet consumer preferences will not contribute to achieving rice self-sufficiency in Nigeria. Instead, breeding programs dedicated to improving rice varieties for domestic production should prioritize traits that match consumer preferences. For example, our study underscores a clear preference for slender kernels in northern Nigeria. Therefore, it is crucial to invest time and resources in improving kernel shape to increase the acceptability of locally grown rice, meeting the demand expressed by consumers. To move towards rice self-sufficiency, the first step should be aligning domestically used rice varieties with the quality traits desired by consumers.

CONCLUSION

The study found significant variations in seed length and width among the different genotypes, with all of them being slender-shaped. The lengths ranged from 3.2 to 6.8 mm, with 18.6% being extra-long grain, 44.3% long, 25.7% medium, and 11.4% short-grained.The cluster analysis grouped the landraces based on brown rice shape, highlighting the polymorphism in seed morphology. This information is valuable for rice breeders, farmers, policymakers, and importers to develop effective strategies for improving rice production and meeting consumer demands.

Overall, this research contributes to the understanding of rice seed diversity in Nigeria and provides insights for future crop selection and improvement programs.

ACKNOWLEDGEMENTS

The authors wish express their sincere appreciation to the Heads of Department of Physics and Department of Botany at Ahmadu Bello University, Zaria for providing us with the equipment used for the quantitative traits measurements.

Journal of Agriculture and Food Sciences
Volume 22, Number 1, April 2024, pp 167 - 176

REFERENCES

Adu-Kwarteng, E., Ellis, W. O., Oduro, I. & Manful, J. T. (2003). Rice grain quality: a comparison of local varieties with new varieties under study in Ghana. *Food Control 14*, 507-514. https://doi.org/10.1016/S0956-7135(03)00063-X

Aliyu, R.E. & Adamu, A.K. (2023) Population Specificity of Tagged 'Saltol' Markers in Rice (Oryza Sativa L.). *Nigerian Journal of Genetics, 37*(2), 194-199.

Aliyu, R. (2013). Allelic data revealing interrelatedness in rice species (Oryza sativa, Oryza glaberrima, Oryza barthii) and the interspecific hybrids (NERICA). *Journal of Plant Breeding and Crop Science, 5*(2), 12-19. https://doi.org/10.5897/JPBCS10.054

Aliyu, R., Ameh, G., Sakariyahu, S., Stanley, A., Afeez, S., & Adamu, A. (2016). Phenotypic responses of oryza species to saline condition at reproductive growth stage. *American Journal of Experimental Agriculture, 13*(2), 1-11. https://doi.org/10.9734/ajea/2016/26796

Daudu, C. K., Yakubu, A. A., Sambo, I. J., Okworie, E., Adeosun, J.O., & Onyibe. J. E. (2014). Rice production, processing, utilization and marketing in Nigeria. Extension Bulletin No: 230.

FAO (2020). https://www.fao.org/nigeria/fao-in-nigeria/nigeria-at-a-glance/en/

Frankel, O. H., Brown, A. H. D. & Burdon, J. J. (1995). The conservation of plant biodiversity. Cambridge University Press, London.

Goodman, M. M. (1972) Distance analysis in biology. *Systematic Zoology 21,* 174-186. https://doi.org/10.2307/2412287

Hore, D. K. (2005). Rice diversity collection, conservation and management in north-eastern India. *Genetic Resources and Crop Evolution 52*, 1129-1140. https://doi.org/10.1007/s10722-004-6084-2

International Rice Research Institute (IRRI) (2013). *Standard Evaluation System (SES) for rice*. 5th Edition. International Rice Research Institute, Manila, Philippines.

National Geographic (2024). https://education.nationalgeographic.org/resource/food-staple/ Accessed 8th January 2024

Olufowote, J., Xu, Y. X., Chen, X., Park, W. D., Beachell, H. M., Dilday, R. H., Goto, M., & McCouch, (1997). Comparative evaluation of within cultivar variation of rice (Oryzasativa L.) using microsatellite and RFLPs markers. *Genome, 40,* 370- 378. https://doi.org/10.1139/g97-050

Oluwaseyi, A. B., Dambaba, N. & Salihu, B. Z. (2016). Genetic improvement of rice in Nigeria for enhanced yeild and grain quality - A review. *Asian Research Journal of Agriculture 1*(3), 1-18. https://doi.org/10.9734/ARJA/2016/28675

Journal of Agriculture and Food Sciences
Volume 22, Number 1, April 2024, pp 167 - 176

Peterson-Wilhelm, B., Nalley, L., Durand-Morat, A., & Shew, A. (2022). Does Rice Quality Matter? Understanding Consumer Preferences for Rice in Nigeria. *Journal of Agricultural and Applied Economics, 54(*4), 769-791. https://doi.org/10.1017/aae.2022.38

Semwal, D. P., Pandey, A., Bhandari, D. C., Dhariwal, O. P., & Sharma, K. (2014).Variability study in seed morphology and uses of indigenous rice landraces (Oryzasativa L.) collected from West Bengal, India. *Australian Journal of Crop Science, 8*(3), 460-467.

Usman, M. H., Enehezeyi, A. R., Kasim, A. A., Dalhatu, S., Sulaiman, I. S., & Kayode, S. S. (2022). Assessment of Genetic Variability among Yield Related Traits in Some Local Rice (Oryza Sativa L.) Cultivars in Nigeria. *The Bioscientist Journal, 10*(2), 123-131.

Yves, A., Samadori, S. H. B., Sié, M., Vodouhè, R. S., & Ahanchédé, A. (2012). The African rice Oryza glaberrima Steud: Knowledge Distribution and Prospects. *International Journal of Biology, 4*(3), 158-180. https://doi.org/10.5539/ijb.v4n3p158

Journal of Agriculture and Food Sciences
Volume 22, Number 1, April 2024, pp 167 - 176

APPENDICES

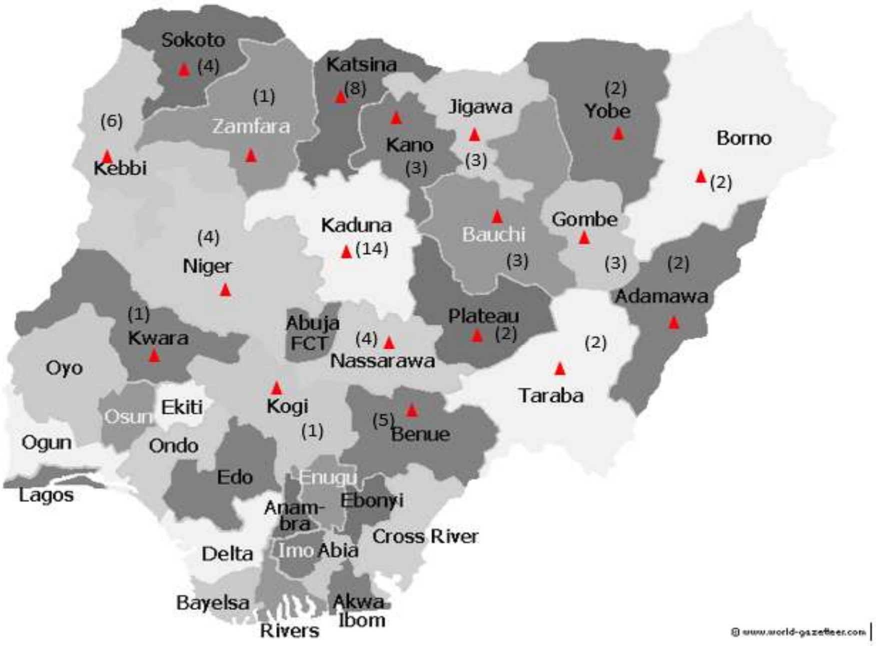


Figure 1: Germplasm collection sites of rice landraces in Northern Nigeria

Table 1: Variability studies in 70 landraces of rice from Savanna ecologies of Northern Nigeria

Geo-political Zones	State	Number	Landraces
North Central	Niger	4	Dantudu, Jamila-Ng, Sipi-Ng, Wati
	Plateau	2	Faro, Jamila-Plg
	Kwara	1	Kwara
	Kogi	1	Ochikakpa
	Benue	5	Lefe/Viu, Mass/Osi, Miruwa, Soppi
	Nassarawa	4	Biruwa, Koro-Koro, Sipi, Water Proof
North West	Sokoto	4	Baingila, Yarkabori, Yarzaiti
	Zamfara	1	Yardirya
	Kebbi	6	Bakiniri, Bayawure, Janiri, Yararina, Yarkalage, Yarmamman
	Kaduna	14	Sub-1, Doguwar, Frajalam, Gajere, Jamila kaduna, Jamila-Zaria, Kilaki, Maiadda/Kilaki' Maiallura, Maizabuwa, Maizabuwa/Biro, Yardashe, Yarkura, Yarnupawa

Journal of Agriculture and Food Sciences
Volume 22, Number 1, April 2024, pp 167 - 176

	Katsina	8	Bolaga, Jaka, Jamila katsina, Shatika, Jap, Santana(Yarruwa), Wacot 48, Yarmaaji
	Kano	3	Futia 12, Iri 119, Yargidanyarima
	Jigawa	3	Jamila-Jg, Yar Das, Yardass
North East	Yobe	2	Dankaushi, Jaton Mini
	Bauchi	3	Bakinyar China, Jamila-Ba, Maimadara
	Gombe	3	China, Cp, Jamila-Gb
	Taraba	2	Faro-Jlg, O-Tu
	Adamawa	2	Faro-Yl, Jamila-Yl
	Borno	2	Dankoydo, Janiri-Bn

Table 2: Descriptive Statistics of Rice Genotypes Collected from Northern Nigeria

Variables	Minimum	Maximum	Mean	SE Mean	CV (%)
Kernel Length with Husk (mm)	8.10	11.61	9.70	0.097	8.36
Kernel Width with Husk (mm)	1.79	2.17	1.97	0.011	4.51
Kernel Length without Husk (mm)	5.82	8.55	7.06	0.072	8.50
Kernel Width without Husk (mm)	1.10	1.95	1.77	0.014	6.53
Ratio l/b (with husk)	4.04	5.74	4.94	0.048	8.11
Ratio l/b (without husk)	3.27	6.41	4.01	0.053	11.02

Table 3: Classification of Rice Seed Shape Based on IRRI Standard (2013)

Shape	Number of Genotypes	Percentage
Slender (> 3.0)	70	100
Medium (2.1 – 3.0)	0	0
Bold (1.1 – 2.0)	0	0
Round (< 1.1)	0	0

Journal of Agriculture and Food Sciences
Volume 22, Number 1, April 2024, pp 167 - 176

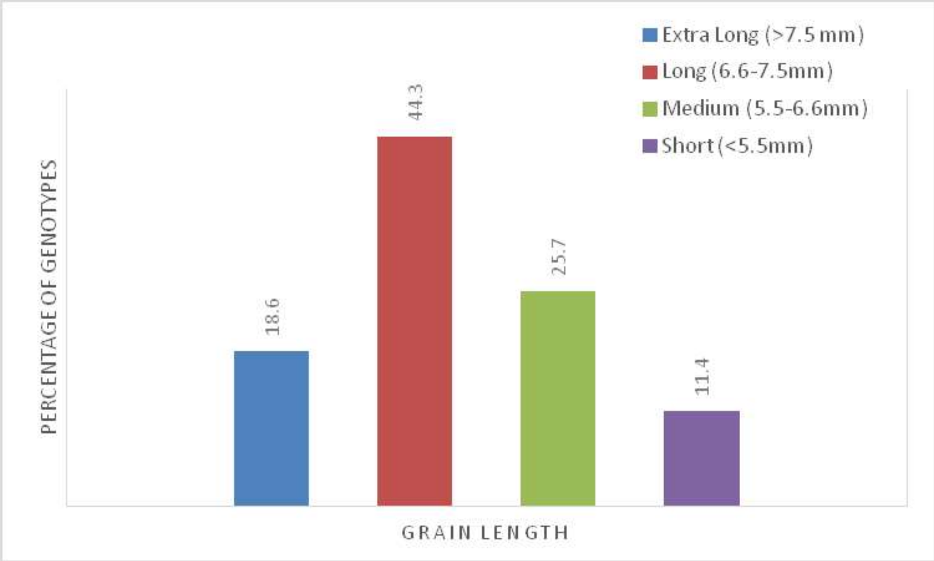
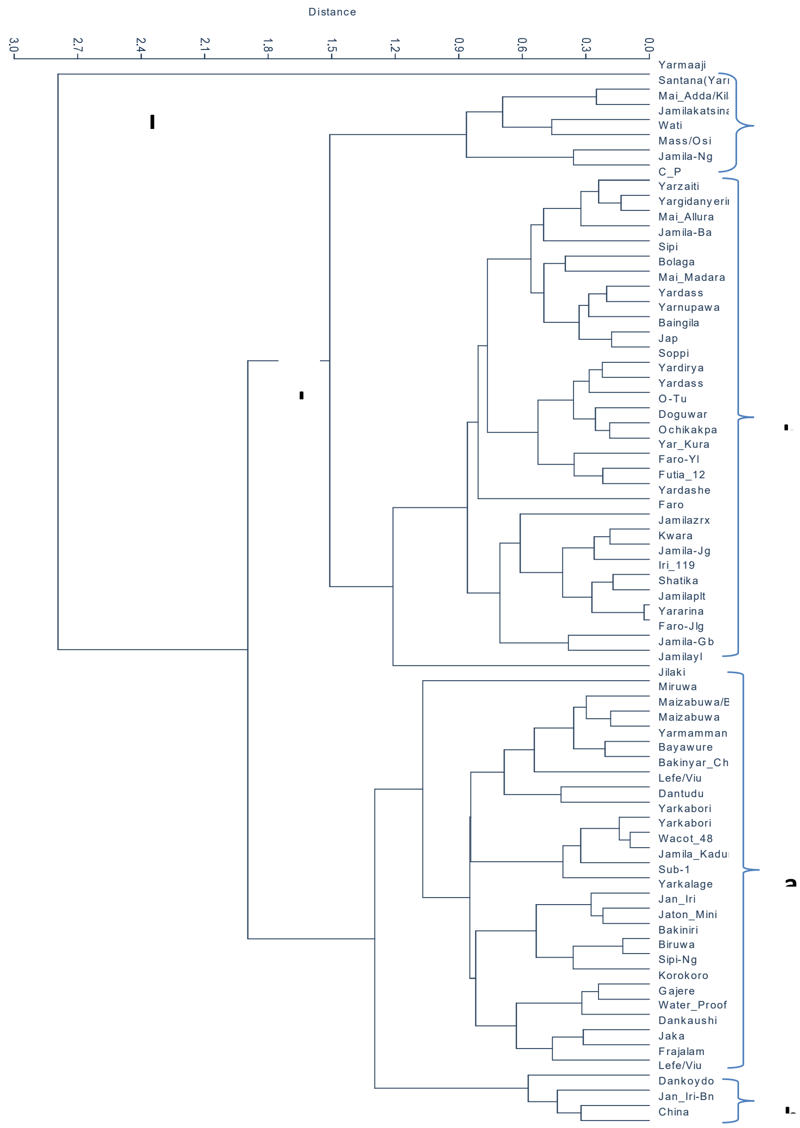


Figure 1: Seed polymorphism in grain length of the rice landrace (IRRI, 1997)



II Figure 2: Dendrogram based on similarity in quantitative parameters (kernel size, kernel breadth, awn length and kernel weight) for 70 rice landraces collected from Northern Nigeria.

III