

Comparative Analysis of Grain Quality and Technological Characteristics of Rice (*Oryza Sativa L.*) Samples under Salt Stress

Komilov Shikhnazar Davron O'g'li¹, Qodirov Baxtiyorjon Gulmuxammadovich²

Abstract

Rice (*Oryza sativa* L.) is the primary food source for more than half of the world's population and holds strategic importance in ensuring global food security. However, more than 20% of global irrigated lands, including regions with a harsh continental climate like the Khorezm region of Uzbekistan, are adversely affected by secondary salinization. The purpose of this study is to identify promising varieties that maintain stable grain quality even under salinity stress conditions through a comparative analysis of 67 different rice genotypes. The obtained results show that genotypes such as LD-2022.2 and EP-327-01 were selected for cultivation as high-yielding genotypes in the saline areas of the Khorezm region and for use in breeding work.

Keywords: Rice (*Oryza sativa* L.), Salt stress, Starch, Amylose, Vitreousness, Technological recovery.

¹PhD Student, Rice Research Institute, Uzbekistan.

²Head of Laboratory, PhD in Agricultural Sciences, Senior Researcher, Rice Research Institute, Uzbekistan.

* Correspondence: meliev.sodir@mail.ru

INTRODUCTION

Rice (*Oryza sativa* L.) serves as the primary caloric source for more than half of the world's population, playing a strategic role in ensuring global food security. However, the most significant barrier to achieving this goal is soil salinity. Currently, over 20% of global irrigated lands are under salt stress, a figure that continues to expand due to climate change (Sarangi et al., 2024; Shohan et al., 2019). Salinity induces ionic toxicity, osmotic stress, and nutrient imbalance in plants. Research indicates that resilient genotypes possess complex systems for maintaining a balanced Na^+/K^+ ratio (Aggarwal et al., 2024; Shiragudikar et al., 2023).[1]

The quality of rice grain is directly dependent not only on genetic factors but also on the cultivation environment and agrotechnical measures. Scientific sources indicate that increasing salinity levels negatively affect the physiological processes of the plant, altering the ratio of carbohydrates and proteins within the grain (Sanga et al., 2024; Wu et al., 2024). Researchers state that salinity stress suppresses the activity of enzymes responsible for starch synthesis in the grain. This, in turn, reduces grain fullness and leads to a decrease in starch content.[2]

Amylose is the key criterion determining the cooking properties of rice. Under saline conditions, a slight increase in amylose content is observed, which is interpreted as an adaptive mechanism that increases the technological hardness of the grain (Neupane, 2020; Požgajová, 2024)[3]. Grain vitreousness reflects its transparency, density, and durability during the milling process. Varieties with a high degree of vitreousness are less prone to breakage during processing, ensuring a higher yield of head rice. Scientific observations show that salinity can increase the vitreousness index due to the compaction of the grain endosperm; however, this process is accompanied by a decrease in grain weight (Sanga, 2024; Wu, 2024)[4]. As a protective reaction to salinity, an increase in grain hull thickness is observed. This is a technologically negative indicator as it reduces the overall rice recovery. A comparative analysis of these parameters enables the selection of high-market-quality genotypes specifically adapted to the saline soils of Uzbekistan[5].

MATERIALS AND METHODS

Study Site and Climate Conditions. The research was conducted between 2023 and 2025 at the Khorezm Scientific-Experimental Station of the Research Institute of Cereal and Leguminous Crops (Urgench district, Uzbekistan)[6].

Research Objects. A total of 67 rice germplasm samples were evaluated as research objects. These included samples from China (27), Vietnam (14), South Korea (5), Russia (2), and local breeding lines (19). The varieties Nukus-2, Iskandar, and Lazurny were utilized as control samples[7].

Laboratory Analysis. Salt tolerance was evaluated across nine variants simulating local chloride-sulfate salinity. Chloride levels ranged from 0.01% to >0.2% (Cl^-), while sulfate levels ranged from 0.3% to >3.0% (SO_4^{2-}), with distilled water as control. For each variant, 50 seeds were germinated at $25 \pm 2^\circ C$. Starch and amylose content were determined according to Li et al. (2017).

Statistical Analysis. Data were processed using ANOVA (Dospikhov, 1985) and specialized software for precision.

RESULTS AND DISCUSSION

Salinity levels significantly influenced the starch and protein ratios in rice grains. Among the studied germplasm, genotype LD-2022.2 (Lider) exhibited the highest starch accumulation. In variants 1–3, starch content ranged from 80.9% to 81.5%, decreasing to 79.4% in variants 7–9, while amylose increased from

17.8% to 18.6%. This genotype led in head rice yield, maintaining stability (89.1–90.4%) even under stress[8].

KC-2022.2 was characterized by high vitreousness (95.2–96.4%). Under increased salinity, its amylose content rose to 21.3%, enhancing grain hardness. However, hulling percentage increased from 18.5% to 19.3%, leading to a 1.3% decrease in total rice recovery. GG-2022.2 (Gigant), a large-grained sample, showed 80.2% starch under optimal conditions (variants 1–3)[9]. Under stress (variants 4–5 and 9), starch fell to 78.5%, while rice recovery remained stable at 64.8–66.2%. NZ-2022.2 (Yo'ldosh) maintained a balanced amylose content (18.5–19.6%). As salinity increased, its vitreousness rose from 92.8% to 94.1%, effectively reducing grain breakage during processing.

Finally, PL-2022.2 showed sensitivity in hulling percentage (increasing from 18.0% to 19.1%), though starch accumulation remained stable at 77.8%. Despite average recovery rates, it demonstrated high resistance to milling, resulting in minimal waste[10].

Table 1. Effect of salinity stress on grain quality and technological parameters of rice genotypes

Variety and Line Names	Variant Groups	Starch Content (%)	Amylose Content (%)	Vitreousness (%)	Hull Content (%)	Rice Yield (%)
LD-2022.2 (Lider)	1-3 / 4-6 / 7-9	80.9-81.5 / 79.8-80.2 / 79.4-79.6	17.8-18.2 / 18.3-18.4 / 18.5-18.6	93.5-94.1 / 94.2-94.3 / 94.4-94.6	17.6-18.0 / 18.1-18.2 / 18.3-18.4	65.8-65.2 / 65.1-64.9 / 64.8-64.5
KC-2022.2 (Manzur)	1-3 / 4-6 / 7-9	77.8-78.4 / 77.4-77.6 / 77.0-77.2	20.4-20.8 / 20.9-21.1 / 21.2-21.3	95.2-95.8 / 95.9-96.1 / 96.2-96.4	18.5-18.9 / 19.0-19.1 / 19.2-19.3	68.1-67.5 / 67.4-67.2 / 67.1-66.8
GG-2022.2 (Gigant)	1-3 / 4-6 / 7-9	79.6-80.2 / 79.1-79.4 / 78.5-78.8	18.2-18.6 / 18.7-18.9 / 19.0-19.1	94.1-94.7 / 94.8-95.0 / 95.1-95.3	17.8-18.2 / 18.3-18.4 / 18.5-18.6	66.2-65.5 / 65.4-65.2 / 65.1-64.8
NZ-2022.2 (Yo'ldosh)	1-3 / 4-6 / 7-9	78.3-79.3 / 77.9-78.1 / 77.5-77.8	18.5-18.9 / 19.0-19.3 / 19.4-19.6	92.8-93.2 / 93.4-93.7 / 93.8-94.1	18.2-18.6 / 18.7-18.9 / 19.0-19.3	64.7-64.1 / 64.0-63.7 / 63.5-63.2
PL-2022.2	1-3 / 4-6 / 7-9	77.8-78.5 / 77.4-77.6 / 77.1-77.3	19.2-19.6 / 19.7-20.0 / 20.1-20.4	93.2-93.8 / 93.9-94.2 / 94.3-94.6	18.0-18.4 / 18.5-18.7 / 18.8-19.1	65.1-64.6 / 64.4-64.1 / 63.9-63.5
OLM-2022.2	1-3 / 4-6 / 7-9	79.0-79.8 / 78.7-78.9 / 78.2-78.5	18.6-19.0 / 19.1-19.4 / 19.5-19.8	92.7-93.3 / 93.4-93.7 / 93.8-94.2	18.1-18.5 / 18.6-18.8 / 18.9-19.2	64.9-64.3 / 64.1-63.8 / 63.6-63.3
GL-2022.2	1-3 / 4-6 / 7-9	77.4-77.9 / 77.2-77.3 / 76.8-77.1	20.2-20.6 / 20.7-20.8 / 20.9-21.0	95.0-95.5 / 95.6-95.8 / 95.9-96.1	18.4-18.8 / 18.9-19.0 / 19.1-19.2	67.9-67.2 / 67.1-66.9 / 66.8-66.5

ЭП-327-01	1-3 / 4-6 / 7-9	80.8-81.4 / 80.5-80.7 / 80.2-80.4	17.2-17.6 / 17.7-17.8 / 17.9-18.0	93.1-93.5 / 93.6-93.8 / 93.9-94.0	17.7-18.1 / 18.2-18.2 / 18.3-18.3	65.4-64.8 / 64.7-64.6 / 64.5-64.4
RK-2022.2	1-3 / 4-6 / 7-9	78.0-78.6 / 77.7-77.8 / 77.4-77.5	19.1-19.5 / 19.6-19.8 / 19.9-20.1	93.8-94.4 / 94.5-94.7 / 94.8-95.1	18.3-18.7 / 18.8-18.9 / 19.0-19.1	66.0-65.4 / 65.3-65.2 / 65.1-65.0
Искандар (ст)	1-3 / 4-6 / 7-9	76.5-77.1 / 76.0-76.4 / 75.4-75.8	20.1-20.7 / 20.8-20.9 / 21.0-21.1	94.8-95.6 / 95.7-95.9 / 96.0-96.2	18.0-18.6 / 18.7-19.0 / 19.1-19.3	69.2-68.1 / 68.0-67.8 / 67.5-67.2

OLM-2022.2 showed a robust starch accumulation (not below 78.2%) under salinity, indicating an efficient grain-filling mechanism. GL-2022.2 was characterized by high amylose content (up to 21.0%), ensuring structural integrity during cooking, while maintaining high vitreousness despite an increase in hulling percentage (19.2%). The early-maturing genotype EP-327-01 demonstrated superior parameters with low hulling (17.7%) and high starch (81.4%), resulting in high milling resistance. Under salinity stress, RK-2022.2 exhibited the highest increase in vitreousness, maintaining grain transparency with starch levels between 77.4-78.6%. In contrast, the standard variety Iskandar showed significant sensitivity, with starch dropping to 75.4% and hulling increasing to 19.3%. Synthesis of the nine salinity variants revealed a general downward trend in starch and an upward trend in amylose. LD-2022.2 recorded the highest average starch (80.54%), whereas Iskandar declined to 76.32%. KC-2022.2 maintained the highest average amylose (20.83%). Regarding grain structure, KC-2022.2 (95.82%) and GL-2022.2 (95.54%) showed the highest average vitreousness. The lowest average hulling percentages were observed in GG-2022.2 (18.0%) and EP-327-01 (18.04%), indicating higher processing efficiency[11].

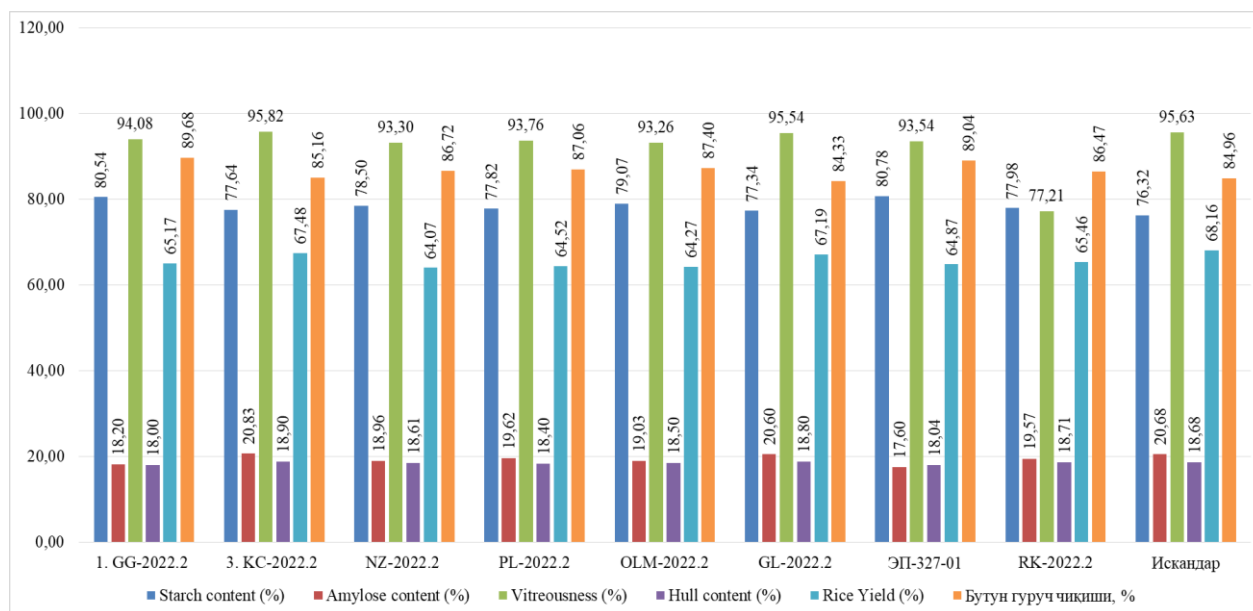


Figure 1. Comparative analysis of grain quality indicators across various rice genotypes.

The following results were obtained regarding rice yield indicators, which represent the final outcome of grain processing[12]. Head rice yield, in terms of the overall average value of head rice (whole grain) recovery across all experimental variants, the LD-2022.2 genotype recorded the highest indicator at 89.68%. Resistance to breakage, the NZ-2022.2 (86.72%) and RK-2022.2 (86.47%) samples also

demonstrated significant resistance to technological grain breakage even under saline conditions[13]. Comparative stability, synthesizing all experimental variants, the newly selected lines (LD-2022.2, KC-2022.2, GG-2022.2) exhibited a substantially more stable response to salinity stress compared to the standard variety, Iskandar. Agricultural potential, the stability of starch accumulation and the high recovery rate of head rice confirm that these genotypes are highly promising for cultivation in salt-affected lands[14].

CONCLUSION

As the salinity level increased, the amylose content increased by up to 1.0% and the hulling percentage by up to 1.4% in all samples. LD-2022.2 (Lider) and EP-327-01 samples demonstrated the best results in starch accumulation (79.4-81.4%) and low hulling percentage (17.7-18.4%). As a result, although rice recovery indicators decreased by 1.5-2.3% under the influence of salinity, the new lines (KC-2022.2, GL-2022.2) maintained their technological resistance due to high vitreousness (95.0-96.4%)[15].

REFERENCES

- [1] G. Aggarwal, P. Edhigalla, P. Walia *et al.*, “A method for screening salt stress tolerance in Indian mustard at seedling stage,” *Scientific Reports*, vol. 14, p. 12705, 2024.
- [2] K. Li, J. Bao, H. Corke, and M. Sun, “Genotypic diversity and environmental stability of starch physicochemical properties in the USDA rice mini-core collection,” *Food Chemistry*, vol. 221, pp. 1186–1196, 2017, doi: 10.1016/j.foodchem.2016.11.040.
- [3] G. Neupane, A. Dhakal *et al.*, “Management options for drought prone rainfed lowland rice in Asia: A review,” *Review of Food and Agriculture*, vol. 1, pp. 82–84, 2020.
- [4] M. Požgajová *et al.*, “Cell protection by oxidative stress mitigation,” in *The Power of Antioxidants*. London, U.K.: IntechOpen, 2024.
- [5] D. L. Sanga *et al.*, “Soil salinization under irrigated farming: A threat to food security,” *Journal of Agricultural Science and Practice*, vol. 9, pp. 32–47, 2024.
- [6] S. K. Sarangi *et al.*, “Coastal salinity management through conservation agriculture in the Ganges delta,” *Soil Systems*, vol. 8, p. 80, 2024.
- [7] S. K. Shiragudikar *et al.*, “Insight analysis of deep learning for assessing rice crop’s salt stress,” *SN Computer Science*, vol. 4, no. 3, p. 262, 2023.
- [8] M. U. S. Shohan *et al.*, “HKT1;5 transporter gene expression and salt tolerance across rice genotypes,” *Frontiers in Plant Science*, vol. 10, 2019.
- [9] Y. Wu *et al.*, “Pooled mapping of QTLs associated with salt tolerance traits in rice,” *Bangladesh Journal of Botany*, vol. 53, pp. 405–410, 2024.
- [10] A. F. Jabbar, H. F. N. Alawadi, and E. A. H. M. Ali, “Response of some rice cultivars (*Oryza sativa* L.) to spraying with a natural honey solution and effect on growth and yield characteristics,” *Revis Bionat*, vol. 7, 2022.
- [11] N. K. Fukagawa and L. H. Ziska, “Rice: Importance for global nutrition,” *Journal of Nutritional Science and Vitaminology*, vol. 65, pp. S2–S3, 2019.
- [12] A. Sharma, C. Rana, S. Singh, and V. Katoch, “Soil salinity: Causes, effects, and management in cucurbits,” in *Handbook of Cucurbits: Growth, Cultural Practices, and Physiology*, M. Pessarakli, Ed. Boca Raton, FL, USA: CRC Press, 2016, pp. 419–434.

- [13] G. S. Channa, A. R. Mahar, I. Rajpar, A. Hafeez Memon, M. A. Saand *et al.*, “Effect of salinity on growth, yield and ion contents of rice (*Oryza sativa* L.) genotypes,” *International Journal of Biosciences*, vol. 14, pp. 192–204, 2019.
- [14] L. I. R. Coca, M. T. G. González, Z. G. Unday, J. J. Hernández, M. M. R. Jáuregui, and Y. F. Cancio, “Effects of sodium salinity on rice (*Oryza sativa* L.) cultivation: A review,” *Sustainability*, vol. 15, 2023.
- [15] G. W. Harvey, “Microlayer collection from the sea surface: A new method and initial results,” *Limnology and Oceanography*, vol. 11, pp. 608–613, 1966.