J. Soils and Crops 35 (1) 54-59, June 2025

ISSN 0971-2836 (Print)
ISSN 2582-2756 (Online)

VARIETAL PERFORMANCE OF TEN HIGH YIELDING RICE CULTIVARS

Arindam Mandal

ABSTRACT

Rice is a staple crop vital for food security, and improving its yield is crucial for meeting global demand. This study was undertaken to evaluate the varietal performance of ten high-yielding rice cultivars under controlled experimental conditions in RBD in three replications. The studies were conducted in the Regional Research Station, C-Block Seed farm in the year 2022-23. The cultivars were selected based on their potential to achieve superior seed quality attributes for maximising crop production and performance. Key performance indicators, including water absorption and water holding capacity, germination and seed quality parameters along with total carbohydrate content, alpha-amylase and peroxidase activities were meticulously recorded and analyzed. Results indicated significant variations in germination, growth and seed quality parameters among the cultivars. The top-performing cultivars Gontra Bidhan 3 and Bidhan Moti 1 demonstrated a remarkable increase in seed quality and growth parameters like water absorption potential, water holding capacity, germination %, seedling length, vigour index, seedling weight, total carbohydrate contents and alpha-amylase and peroxidase activity compared to the others, highlighting its potential for higher productivity. It is inferred from the study that the Gontra Bidhan 3 and Bidhan Moti 1 cultivars exhibit superior yield performance and adaptability, offering valuable insights for breeders aiming to enhance rice production. Further research is recommended to validate these findings in diverse environmental conditions and to explore underlying genetic mechanisms.

(Key words : High yielding rice cultivars, seed quality, germination, water absorption, alpha-amylase activity, peroxidase activities, yield performance)

INTRODUCTION

Rice (*Oryza sativa* L.) is a primary cereal grain that feeds more than half of the world's population, with over 350 crore people reliant on it for their daily energy needs (Anonymous, 2022). As the world's population grows and weather patterns become progressively unpredictable, boosting rice output is critical to ensuring global food security and agricultural sustainability. Recent advances in rice breeding have resulted in the introduction of high-yielding cultivars that promise to increase productivity and fulfil the rising demand for this vital commodity (Khush, 2001). High-yielding rice cultivars are created through intricate breeding programs that prioritise features such as increased grain quantity, enhanced plant architecture, and resilience to biotic and abiotic challenges (Jena and Mackill, 2008). However, the performance of these cultivars varies greatly depending on climatic circumstances, agronomic techniques, and cultivar-specific traits (Zhao *et al*., 2020). Assessing the varietal performance of different cultivars is critical for selecting the best cultivars for certain locales and achieving maximum yield results. Seed quality is an important aspect in determining crop yield since it has a direct impact on germination, seedling vigour, and overall plant performance. Furthermore, seed quality includes a wide range of morphological, physiological, and biochemical traits, all of which are critical in determining the crops eventual yield and quality (Mandal and Bala, 2023). Photosynthesis, the process by which plants convert light energy into chemical energy, produces assimilates, which are necessary for plant growth and development. The successful absorption of photosynthates during the grain-filling stage has a significant impact on the quantity and quality of harvested seeds (Chen *et al*., 2020).

In this work, I assessed the performance of ten high-yielding rice cultivars under controlled experimental circumstances. The goal was to determine which cultivars had higher yield features and to offer information about their growth characteristics. In this work, I assessed the performance of ten high-yielding rice cultivars under controlled experimental circumstances. The goal was to determine which cultivars had higher yield features and to offer information about their growth characteristics. The current research examined the relationship between seed form, seedling characteristics, and biochemical measures such as total carbohydrate, peroxidase activity, and Q-amylase activity among rice cultivars. Seed size and shape can influence seedling establishment and early development.

1. Asst. Professor, Dept. of Botany, Bejoy Narayan Mahavidyalaya, Itachuna, Hooghly, 712147, WB, India (Corresponding author)

Morphological factors such as seed length, width, volume, and weight provide information on seed size and shape provide information on seed size and shape. Furthermore, biochemical data give insight into the metabolic processes occurring within the seeds, which are necessary for germination and subsequent plant growth. The discovery is significant because of its potential impact on breeding programs and agricultural approaches aimed at improving crop productivity and seed quality (Ali and Elozeiri, 2017).

These findings will help to broaden our understanding of how various cultivars perform under similar circumstances and provide recommendations for future breeding projects focused on increasing rice output. This work is consistent with continuing efforts to improve rice production methods and promote food security in the face of global concerns (Fujita *et al*., 2019).

MATERIALS AND METHODS

Materials

The ten (10) non-aromatic high yielding rice cultivars were obtained from Dr. M. Ghosh at the Department of Agronomy, BCKV, West Bengal. They are as follows: i) Bidhan Mashuri 1 (V1); ii) Bidhan Moti 7 (V2); iii) Bidhan Mashuri 7 (V3); iv) Bidhan Moti 34 (V4); v) Gosai Minikit (V5); vi) Satabdi (V6); vii) Bidhan Moti 4 (V7), viii) Bidhan Moti 1 (V8), ix) Gontra Bidhan 1 (V9) and x) Gontra Bidhan 3 (V10). Laboratory studies were conducted on germination, growth, and biochemical data and yield-related metrics were collected from experimentally grown seeds in the Seed Farm of the Regional Research Station, C-Block, Kalyani in 2021–2022. Using a Randomised Block Design, the experiment was conducted on comparatively low land, well-drained alluvial soil (order-Entisol) belonging to the textural class of clay loam in a plot size of 2 m × 1 m with a row-to-row spacing of 20 cm and a plot-to-plot distance of 3 m. The desired fertiliser ratio (RDF 50:25:25) was applied to the plants. The statistical analysis was performed following Panse and Sukhatme's (1967) method. The experiment was replicated three times.

Water absorption potential and water holding capacity

Fifty seeds were immersed in distilled water, and their weight was recorded at one-hour intervals for up to six hours. Each cultivar's water absorption potentiality hour^{-1} was calculated based on an average of 6 hours of water absorption for each cultivar. After 24 hours of seed soaking, the difference between the final and initial weights was calculated as water-holding capacity (Ruan *et al*., 2002).

Seedling quality parameters

Twenty-five (25) seeds were randomly chosen from each rice cultivar. Seed quality characteristics were assessed in a laboratory setup using established procedures (Dahiya *et al*., 1997). On the tenth day, the germination percentage (%) was calculated using the formula: Germination% = Number of seeds germinated leading to normal seedling/ Total number of seeds used in the experiment x 100 (Hatzade *et al*., 2022). The speed of germination (TR value) was determined using the formula Speed of germination = Ó (n/ t), where n is the number of seeds germinated and t is the time (days) from planting. The average root and shoot lengths of normal seedlings were measured and represented in centimetres (cm). The Vigour Index was determined by using the formula VI = SL × G, where VI = Vigour Index, SL = Seedling Length and G = Standard Germination Percentage (Abdul-Baki and Anderson, 1973). The weight of 10 seedlings for each cultivar was measured and expressed in grams (g) as fresh weight, whereas the weight of 10 seedlings dried at 95°C - 100°C for 2 days was considered as dry weight after 14 days.

Biochemical activity during germination

The total amount of carbohydrates in each cultivar was determined using the technique proposed by Nielson (2010). The carbohydrate content was expressed in milligrams 100 mg^{-1}. Peroxidase activity was evaluated using o-dianisidine as the substrate, as described by Nakano and Asada (1981). The absorbance was measured at 430 nm using the Systronics-105 Spectrophotometer. Peroxidase activity is measured as ÄA min.$^{-1}$ g^{-1} of imbibed seed. Where ÄA was the difference in absorbance (0 min. to 1 min.). Bernfield's (1955) approach was used to extract á- amylase and estimate enzyme activity. The enzyme activity was quantified in micrograms (mcg) of maltose produced gram^{-1} of fresh weight.

Yield and seed quality parameters

A total of 50 paddy seeds for each cultivar was randomly picked from each replication, and their average length and breadth were determined using Vernier calliper equipment. The length-to-width ratio (L/W) was calculated using the average paddy length divided by the average paddy width. To compute the weight of the seeds from each replication, 1000 seeds from each cultivar was taken into account. In a measuring cylinder, 50 seeds from each type were immersed in 10 ml of water, and the increased amount of water was equal to the volume of the 50 seeds, expressed in ml (Mandal and Bala, 2024).

RESULTS AND DISCUSSION

The appropriateness of qualitative and quantitative seed traits enhances the yield of crops, which is closely connected to the genotypic nature of the cultivar. The varying character of distinct cultivated cultivars was classified in numerous ways, with non-aromatic high-yielding and aromatic landraces being the most notable. The study of seed shape, in addition to seed quality indicators such as activity in seedling mobility and bio-molecular action specific to a particular cultivar, may be useful for qualitative upgradation of yield. Seed is the most important component in the plant life cycle and a basic input in agriculture, although its categorisation across crops has been limited.

The method of strategy in various studies, particularly in cultivation techniques and breeding programmes, was heavily reliant on seed specification since the varied character of seed on a crop cultivar should be instructive. The current study was an attempt to partially achieve the objectives for 10 high-yielding rice cultivars. The monitoring of seedlings and the activity of a few biomolecules may help to increase understanding in this area. The newly obtained seeds of twenty (10) types were taken from plants in the field. Following adequate washing, they were assessed based on seed shape, which is critical for maintaining seed purity and quality.

Water absorption potential and water holding capacity

Imbibition was a crucial step in germination and initiation of seedling development where a certain number of bio-chemical activity was detected. In this scenario, water uptake may play an important role in directing metabolic activity correctly (El-Maarouf-Bouteau, 2022). The overall mean water adequacy values differed considerably between cultivars (Table 1). The water absorption capacity of immediately harvested seeds varied greatly depending on the cultivars. The cultivars Gontra Bidhan 3 (V10) and Bidhan Moti 4 (V7) had the highest values. Bidhan Mashuri 1 (V1), Bidhan Moti 34 (V4), Gosai Minikit (V5) and Bidhan Moti 1 (V8) had moderate water absorption potential, cultivars Bidhan Moti 7 (V2), Bidhan Mashuri 7 (V3) and Gontra Bidhan 1 (V9) had the least and lowest values, respectively.

The highest water-holding capacity was found in cultivar Gontra Bidhan 3 (V10). Cultivars Bidhan Moti 1 (V8), Gontra Bidhan 1 (V9), Bidhan Mashuri 1 (V1) and Bidhan Moti 4 (V7) indicated moderately higher levels. Cultivars Bidhan Moti 7 (V2) and Gosai Minikit (V5) produced the least favourable results, with Bidhan Moti 34 (V4) performing the lowest water holding capacity.

Table 1. Germination and growth parameters of rice cultivars

Cultivars	Water absorption potential (g hr^{-1})	Water holding. capacity (g hr^{-1})	Germination (%)	TR value	Root length (cm)	Shoot length (cm)	Vigour index (VI)	Fresh weight (g)	Dry weight (g)
Bidhan Mashuri 1 (V1)	0.043	0.247	86.403	19.613	14.51	10.17	2,273.09	0.340	0.070
Bidhan Moti 7 (V2)	0.034	0.206	82.957	18.853	15.623	11.44	2,233.64	0.283	0.070
Bidhan Mashuri 7 (V3)	0.036	0.226	83.070	19.760	14.537	11.55	2,149.49	0.240	0.063
Bidhan Moti 34 (V4)	0.045	0.192	84.643	19.960	14.950	11.07	2,190.38	0.280	0.070
Gosai Minikit (V5)	0.042	0.203	84.577	18.683	14.013	10.64	2,080.79	0.330	0.073
Satabdi (V6)	0.021	0.215	83.387	18.770	15.643	10.71	2,182.86	0.237	0.063
Bidhan Moti 4 (V7)	0.050	0.236	79.977	19.593	13.643	11.51	2,007.98	0.233	0.073
Bidhan Moti 1 (V8)	0.046	0.267	86.483	19.863	19.523	11.70	2,689.57	0.363	0.080
Gontra Bidhan 1 (V9)	0.033	0.258	82.959	18.813	14.333	11.31	2,126.55	0.303	0.073
Gontra Bidhan 3 (V10)	0.050	0.286	86.527	19.860	20.880	11.96	2,685.56	0.410	0.083
SE(m) ±	0.005	0.005	1.542	0.162	0.457	0.457	44.079	0.018	0.004
CD at 5%	0.015	0.015	4.605	0.485	1.369	1.369	131.981	0.054	0.011

Table 2. Biochemical, seed quality and yield parameters of rice cultivars

Cultivars	Carbohydrate content (mg 100 mg^{-1})	Peroxidase activity (ÄA min.$^{-1}$ g^{-1})	Alpha-amylase activity (ig^{-1} min^{-1})	Seed length (mm)	Seed breadth (mm)	Length/ breadth ratio	Seed volume (ml)	1000 seed weight (g)
Bidhan Mashuri 1 (V1)	45.587	0.942	77.548	9.180	1.717	5.343	0.900	18.360
Bidhan Moti 7 (V2)	42.473	0.775	64.443	11.247	1.730	6.503	0.933	22.673
Bidhan Mashuri 7 (V3)	30.927	0.647	73.900	8.480	1.777	4.783	0.833	19.510
Bidhan Moti 34 (V4)	47.360	1.032	94.991	9.743	1.733	5.623	0.867	18.597
Gosai Minikit (V5)	46.600	1.098	79.939	9.017	1.687	5.350	0.667	16.050
Satabdi (V6)	27.893	0.725	69.143	9.510	1.770	5.373	0.867	18.613
Bidhan Moti 4 (V7)	28.480	0.670	65.841	9.627	1.610	5.980	0.833	17.023
Bidhan Moti 1 (V8)	35.480	1.148	107.618	11.670	1.723	6.777	0.833	23.273
Gontra Bidhan 1 (V9)	45.247	1.152	100.701	7.830	1.907	4.107	0.700	19.320
Gontra Bidhan 3 (V10)	47.867	0.930	121.069	7.547	1.910	3.943	0.933	19.947
SE(m)±	0.845	0.006	1.621	0.137	0.024	0.093	0.038	0.246
CD at 5%	2.530	0.017	4.854	0.411	0.071	0.278	0.113	0.736

Seedling quality parameters

The seedling traits that emerge during seed germination are influenced by the genotypic specificity of the seeds. Promising seeds performed well, demonstrating superiority in seedling characteristics observable in the laboratory (Finch-Savage and Bassel, 2016). There was a substantial difference between the cultivars utilized in the current research (Table 1). Cultivar Gontra Bidhan 3 (V10) had the greatest germination rates, followed by Bidhan Moti 1 (V8), Bidhan Mashuri 1 (V1), Bidhan Moti 34 (V4) and Gosai Minikit (V5). Cultivar Bidhan Moti 4 (V7) had the lowest germination rates, while Satabdi (V6), Bidhan Mashuri 7 (V3), Gontra Bidhan 1 (V9) and Bidhan Moti 7 (V2) had a respectable outcome. The germination % as translated to TR value for statistical computation, with cultivars Bidhan Moti 34 (V4), Bidhan Moti 1 (V8), Gontra Bidhan 3 (V10), Bidhan Mashuri 7 (V3), Bidhan Mashuri 1 (V1) and Bidhan Moti 4 (V7) having comparatively greater TR values. Cultivar Gosai Minikit (V5) indicated the lowest values. Moderately lower TR values were seen in cultivars Satabdi (V6), Gontra Bidhan 1 (V9) and Bidhan Moti 7 (V2). The potentiality of seedlings may be assessed by their seedling length, particularly in terms of the roots required for field establishment. Different cultivars exhibited substantial variability for root length, with cultivar Gontra Bidhan 3 (V10) having the greatest outcome, followed by Bidhan Moti 1 (V8). The shortest root length was found in cultivar Bidhan Moti 4 (V7). The various interacting water accessibility ratings showed considerable variation among them. In shoot length, the varied nature of cultivars exhibited considerable demarcation among them, however mean values of all cultivars were maintained parity except for cultivars Bidhan Mashuri 1 (V1) and Gontra Bidhan 3 (V10), which demonstrated the lowest and highest assessments, respectively. During the assessment of seedling strength and germination %, the quality parameter Vigour Index was used to estimate the ultimate seedling strength as well as the seed excellence. The mean value varied significantly among cultivars. The Vigour Index was highest in cultivar Bidhan Moti 1 (V8) followed by Gontra Bidhan 3 (V10) and lowest by Bidhan Moti 4 (V7). In the moderate cultivar, Bidhan Moti 7 (V2) had a greater value, while V3 had the lowest. The essential quality evaluation using seedling fresh weight revealed considerable variations across cultivars. Cultivars Gontra Bidhan 3 (V10) and Bidhan Moti 1 (V8) outperformed the other cultivars, whereas Bidhan Moti 4 (V7) performed poorly. Moderate values were scored by cultivars Bidhan Mashuri 1 (V1), Gosai Minikit (V5) and Gontra Bidhan 1 (V9). Dry weight was highest in cultivar Gontra Bidhan 3 (V10) and the lowest in Bidhan Mashuri 7 (V3). In the moderate cultivars, Bidhan Moti 1 (V8) had a greater value, while Bidhan Moti 4 (V7) scored the lowest position. Similar kinds of results have been observed in dry weight, where the highest value was noted in cultivar Gontra Bidhan 3 (V10) while the lowest position was achieved by Bidhan Mashuri 7 (V3). In moderate cultivars, Bidhan Moti 1 (V8) exhibited maximum dry weight and Bidhan Mashuri 1 (V1) showed moderately lowest value.

Biochemical activity during germination

Total carbohydrate content was a key quality biomolecule in cereal seeds, notably rice. The quantity of carbohydrates may play an important role in preserving seed quality, which may directly participate in the germination process while also keeping high storability.

The overall carbohydrate content varied significantly among cultivars. Cultivar Gontra Bidhan 3 (V10) seed had the greatest total carbohydrate content, followed by Bidhan Moti 34 (V4), Gosai Minikit (V5) and Bidhan Mashuri 1 (V1). Cultivars Satabdi (V6) and Bidhan Moti 4 (V7) performed poorly, while cultivars Bidhan Mashuri 7 (V3), Bidhan Moti 1 (V8), Bidhan Moti 7 (V2) and Gontra Bidhan 1 (V9) produced moderate results (Table 2). In the context of peroxidase activity, cultivars Gontra Bidhan 1 (V9) followed by Bidhan Moti 1 (V8) produced the highest results. The lowest activity was recorded in Bidhan Mashuri 7 (V3). All other cultivars showed moderate outcomes. The maximum alpha-amylase activity was detected in cultivar Gontra Bidhan 3 (V10). Cultivar Bidhan Moti 1 (V8) scored highest position followed by Gontra Bidhan 1 (V9), Bidhan Moti 34 (V4), Gosai Minikit (V5), Bidhan Mashuri 1 (V1) and Bidhan Mashuri 7 (V3) performed moderately. The lowest alpha-amylase activities were observed in cultivars Bidhan Moti 7 (V2), Bidhan Moti 4 (V7) and Satabdi (V6).

Yield and seed quality parameters

Under field circumstances, freshly harvested seeds from ten (10) high-yielding cultivars were gathered for analysis of yield and seed quality parameters. Seeds were assessed after being thoroughly cleaned, considering the important role that seed morphology plays in maintaining seed quality and purity. For the current study, just a few distinct features were examined, but the first degree of variability was noted in seed morphology, which included several numerical factors concerning some observable indicators (Table 2). In terms of seed length, the cultivar Bidhan Moti 1 (V8) had the longest grain size while the shortest grain size was recorded in cultivars Gontra Bidhan 3 (V10) followed by Gontra Bidhan 1 (V9) (Table 2). The cultivar Bidhan Moti 7 (V2) achieved the highest position in moderately performed cultivars followed by Bidhan Moti 34 (V4), Bidhan Moti 4 (V7), Satabdi (V6), Bidhan Mashuri 1 (V1), Gosai Minikit (V5) and Bidhan Mashuri 7 (V3). Table 2 presents seed breadth, another morphologically quantifiable metric that varies significantly and accommodates all cultivars. The highest number was seen in cultivars Gontra Bidhan 3 (V10) and Gontra Bidhan 1 (V9). Seed breath was lowest in cultivar Bidhan Moti 4 (V7) while all other cultivars showed moderate results. The length of the seed does not influence its breath. The length-to-breadth ratio of a particular cultivar served as an important quality parameter that can related to seed identifier. In cultivar Bidhan Moti 1 (V8) the length-to-breadth ratio was greatest followed by Bidhan Moti 7 (V2). The values for the cultivars Bidhan Moti 4 (V7), Bidhan Moti 34 (V4), Satabdi (V6), Gosai Minikit (V5), Bidhan Mashuri 1 (V1) and Bidhan Mashuri 7 (V3) were modest. The length-breath ratio had the lowest value in cultivar Gontra Bidhan 3 (V10) followed by Gontra Bidhan 1 (V9). Since the seed volume was observed based on the measurement of water rise while considering the exact volume, it was stated in millilitres (ml). The cultivars Bidhan Moti 7 (V2), Gontra Bidhan 3 (V10), Bidhan Mashuri 1, Satabdi (V6), Bidhan Moti 34 (V4), Bidhan Moti 1 (V8), Bidhan Moti 4 (V7) and Bidhan Mashuri 7 (V3) showed higher seed volume but the differences among them are not significant. The lowest seed volume was observed in cultivar Gosai Minikit (V5).1000 seed weight served as an early quality indicator and also served as a marker for a certain cultivar. It was combined with a genotypic marker that may be used for both qualitative seed measurements and agronomical productivity characterisation. Different cultivars significantly displayed varying natures, with cultivars Bidhan Moti 1 (V8) and Gosai Minikit (V5) exhibiting the highest and lowest impacts, respectively. The cultivar Gontra Bidhan 3 (V10) gained the highest rank among all intermediate cultivars.

The ability of a crop plant to perform photosynthesis and its appropriate absorption into plant development activities, especially during the grain-filling stage, guarantee the quality of output in any system that produces seeds. When photosynthates are accumulated into the sink correctly, their amount can improve the quality of the seed (Chen *et al*., 2020). The morphological, physiological and biochemical activity of the seed can all be indicators of proper accumulation and stabilisation, which in turn strengthens the seed's early germination action (Purane *et al*., 2020). Analysing the quality of seeds generated at various genetic and environmental backgrounds required consideration of the seedlings' characteristics (Finch-Savage and Bassel, 2016). Seed characterisation might play a significant role in future studies to standardise the cultivation schedule method and integrate other treatments that could be included in the breeding plan.

In the current study, three categories of characteristics—seedling quality, biochemical traits, and yield parameters were taken into consideration while comparing the performance of ten high-yielding cultivars. For every cultivar, the major variable nature was evident. The results showed that the cultivars under investigation varied in terms of germination, growth traits, biochemical traits, yield, and traits that contribute to yield. Based on a comprehensive analysis of all the characteristics, cultivars Gontra Bidhan 3 (V10), Bidhan Moti 1(V8) and Bidhan Moti 34 (V4) were determined to be suitable cultivars under these conditions.

REFERENCES

Abdul-Baki, A.A. and J.D. Anderson, 1973. Vigor determination in soybean seed by multiple criteria, Crop Sci. **13**(6): 630-633.

Ali, A.S. and A.A. Elozeiri, 2017. Metabolic processes during seed germination. Advances in seed biology, pp. 141-66.

Anonymous, 2022. International Rice Research Institute. Rice facts. Retrieved from https://www.irri.org/overview-rice

Bernfeld, P. 1955. Amylase á and â, Meth. Enzymol. **1**: 149-158.

Chen, J., F. Cao, H. Li, S. Shan, Z. Tao, T. Lei, Y. Liu, Z. Xiao, Y. Zou, M. Huang and S.F. Abou-Elwafa, 2020. Genotypic variation in the grain photosynthetic contribution to grain filling in rice, J. Plant Physiol. **253**: 153269.

Dahiya, O.S., R.P.S. Tomer and A. Kumar, 1997. Evaluation of viability and vigour parameters with respect to field emergence in chickpea (*Cicer arietinum* L.), Seed Res. **25**: 19- 24.

El-Maurouf - Bouteau H., 2022. The seed and metabolism regulation. Biol. **11** (2) : 168 .

Finch-Savage, W.E. and G.W. Bassel, 2016. Seed vigour and crop establishment: extending performance beyond adaptation. J. Exp. Bot. **67**(3): 567-591.

Fujita, D., N. Nakata and Y.Sasaki, 2019. Advances in high-yielding rice cultivars: Breeding and agronomic practices. Crop Sci. **59(5)**: 2382-2392.

Hatzade, R.V., S.S. Mahajan, E.G. Lal, S.A. John and P.K. Shukla, 2022. Correlation and regression analysis of standard germination and field emergence with various viability and vigour tests in tetraploid and diploid cotton, J. Soils and Crops. **32**(2): 305-311.

Jena, K. K. and D.J. Mackill, 2008. Molecular markers and their use in marker assisted selection in rice. Crop Sci. **48**(4): 1266-76.

Khush, G. S. 2001. The role of plant breeding in the green revolution. Nat. Rev. Genet. **2**(7): 505-515.

Mandal, A. and N. Bala, 2023. Influence of electrotherapy and salt priming to improve germination and vigour of wheat seeds, J. Soils and Crops. **33**(2): 317-323.

Nakano, Y. and K. Asada, 1981. Hydrogen peroxide is scavenged by ascorbate-specific peroxidase in spinach chloroplasts, Plant Cell Physiol. **22**: 867-880.

Nielson, S.S. 2010. Phenol-Sulfuric Acid method for total carbohydrates, Food analysis laboratory manual, Edn 4, Springer, New York. pp. 47-53.

Panse, V.G. and P.V. Sukhatme, 1967. Statistical Methods for Agricultural Workers, 2nd Edition, Indian Council of Agricultural Research, New Delhi.

Purane, A.A., S.B. Amarshettiwar, R.D. Deotale, P.M. Manapure and P.V. Shende, 2020. Performance of rice cultivars for morpho-physiological parameters and yield in summer season, J. Soils and Crops. **30**(2): 332-339.

Ruan, S., Q. Xue and K. Tylkowska, 2002. Effects of priming on germination and health of rice (*Oryza sativa* L.) seeds, Seed Sci. Technol. **30**(2): 451-458

Zhao, H., Z. Mo, Q. Lin, S. Pan, M. Duan, H. Tian, S. Wang and X. Tang, 2020. Relationships between grain yield and agronomic traits of rice in southern China. Chil. J. Agr. Res. **80**(1): 72-79.

Rec. on 13.08.2024 & Acc. on 26.08.2024