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Assessment of Performance of Rice Genotypes for Quality Traits

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ABSTRACT: The quality of the rice grain is very important from the consumer point of view as it is food crop. Genetic variability of 4 quality parameters in a set of 12 medium slender rice genotypes were evaluated at the Plant Molecular Biology Laboratory, Department of Genetics and Plant Breeding, College of Agriculture, University of Agricultural Sciences, Raichur. Grain length, grain width and grain L:B ratio revealed low GCV, PCV, and high heritability with low genetic advance, according to variability studies. Quality parameters such as gel consistency and gelatinization temperature showed a higher value of GCV and PCV. The quality parameters like gel consistency, gelatinization temperature and amylose content exhibited high heritability in combination with a high GAM.

Keywords: Variability, genotypic coefficient of variance, phenotypic coefficient of variance, genetic advance, amylose content

INTRODUCTION

Rice is the source of life which is often recognized as the most important source of human sustenance on the planet by directly feeding a vast number of people. It contributes about 42 and 45 per cent of our country's total food grain and cereal production respectively (Nirubana *et al*., 2019). Rice is central to the lives of billions of people around the world. About 3.5 billion people dependent on rice as a daily staple food for 20 per cent of their calories (Bitew *et al*., 2016). It is the world's most important food crop and a main staple food for more than half of the global population. Rice was chosen as a model plant for studying genetics of cereals because of its small genome size (430 Mb).

Rice grain quality has a great impact on consumer acceptance. Since rice is primarily consumed as a whole grain, particularly in Asia. Rice is a primary source of nutrition in many developing countries. Fe-induced anaemia, zinc deficiency and vitamin A deficiency are the most common forms of malnutrition in those countries. While Type II diabetes, cardiovascular disease and certain malignancies are the most common chronic diseases. Rice breeding initiatives might concentrate on creating new cultivars with higher levels of either protein or carbohydrates. Rice is a major source of income in rural Asia, increased productivity can decrease malnutrition by both increasing the incomes of the poorest rice producers and by increasing the availability of rice and the stability of rice prices (Juliano, 1993).

Quality of rice is not always easy to define as it depends on the consumer and the intended end use for the grain. All consumers want the best quality that they can afford (Pushpa *et al*., 2019). Mario *et al.* (2019) revealed that out of 16 segregating populations, three rice families namely WAB-56- 104 x NERICA 4, MWUR 4 x NERICA 4 and NERICA 4 x NERICA 1 had better cooking and physico-chemical quality. The check variety Basmati 370 was outstanding for physical grain quality and aroma compared to the non-Basmati rice genotypes suggesting that Basmati 370 has implication for future breeding.

Tamu *et al.,* (2017) revealed that varietal variability existed considerably in all the physical and chemical properties of the different rice varieties studied. Also, varietal differences were evident among the rice accessions for sensory and cooking characteristics. The difference in these traits could be exploited in rice breeding programs to improve grain quality traits. Hence, this study needs to be repeated using molecular markers to show diversity among all the grain quality traits studied.

Khorasany *et al.* (2020) aimed to study the quality of different rice genotypes in different environments and to identify the genotypes with desirable quality. The results of the experiment showed that line 2 (Sepidrood/IR58025A) has a higher quality than the other lines, because it has a moderate amylose (22%), moderate gelatinization temperature (score 3) and high gel consistency (71/5 mm) under two environments. However, yield of these three lines in contrast to the rest of the investigated lines based on two environments had a lowest mean (3925 kha^{-1}). Therefore, when the yield was increasing, the quality has been decrease.

Naik *et al*. (2020) reported the presence of higher GCV and PCV observed alkali spreading value, gel consistency and amylose content, which signifies the additive genetic control in inheritance of that trait. The presence of high scale of GCV and PCV for observed traits suggested having better possibility for the enhancement through simple selection procedure.

The grain quality traits of rice that determine its acceptability by the end user can be grouped into two main categories, (i) grain appearance and (ii) cooking and eating qualities. The appearance quality is determined by grain length, breadth, length-breadth ratio, and translucency of the endosperm. The eating and cooking quality traits include volume expansion, fluffiness, cooked kernel elongation, firmness/stickiness (related to amylose content), gelatinization temperature (also measured as alkali spreading value), mouth feel and a pleasant aroma. Each of these traits is determined by the physico-chemical properties of the rice grain which in turn are genetically controlled with some modulation of expression by the growth environment (Wadbok *et al.,* 2019).

Nanda *et al*. (2021) evaluated twenty nine rice genotypes along with three checks with an objective to determine the nature and magnitude of genetic variability for yield and grain quality characters. Results showed that most of the genotypes had long slender grain type with kernel length ≥6 mm, L/B Ratio ≥3.0, and showed an intermediate range of amylose content, gelatinization temperature and medium to soft gel consistency.

Umarani *et al*. (2017) carried out an experiment to assess the variability, heritability and genetic advance in seventy landraces of rice for sixteen agro-morphological and grain quality parameters. The quality parameters *viz*., amylose content and gel consistency exhibited high heritability coupled with high genetic advance as a per cent of mean.

Rice is main cereal crop in North Eastern Dry Zone (Zone 2) and Northern Dry Zone (Zone 3) of Karnataka state (Mainly in Hyderabad-Karnataka region) and the paddy varieties of medium slender grain type are popular among the farmers because of its excellent cooking quality and premium price in the market. Identification of high yielding and stable varieties along with good quality traits can highly benefit the farmers cultivating paddy and would have major impact on both economic and health conditions of the farmer.

MATERIALS AND METHODS

The experimental material for the current study comprised of 12 medium slender genotypes developed at Rice breeding division, ARS Gangavati. 12 rice genotypes along with five checks *viz*., BPT-5204, GNV-10-89, Gangavati sona, Gangavati emergence and RNR-15048 were evaluated for physico-chemical properties like grain length, breadth, L/B ratio, gel consistency (GC), gelatinization temperature (GT) and amylose content (AC).

The observations on various physico-chemical and cooking quality characters were recorded.

Quality parameters analyzed were

- Grain L: B ratio
- Gel Consistency
- Gelatinization Temperature
- Amylose Content

Grain length (mm). Ten grains were chosen at random and placed on a digital image analyzer without the hull removed. The mean length of seed was calculated using data from ten samples and given in millimetres. Based on seed length genotypes were classified as follows (Rosta, 1975).

Short : < 7.5 mm
Medium : 7.5 – 9.0 mm
Long : > 9.0 mm

Grain breadth (mm). Ten grains were chosen at random and placed on a digital image analyzer without the hull removed. The average of the data from ten samples was used to get the average seed width in millimetres. Based on seed breadth, the genotypes were categorized as follows (Ramaiah and Rao, 1953).

Slender : < 2.2 mm
Medium : 2.3 - 2.8 mm
Bold : > 2.8 mm

Grain L/B ratio. The genotypes were divided into four categories based on the length to width ratio, according to the Standard Evaluation System (SES) IRRI, 2002.

Slender : > 3.0
Medium : 2.1 to 3.0
Bold : 1.1 to 2.0
Round : < 1.1

Gel consistency. The tendency of the cooked rice to solidify after chilling was measured by the gel consistency. The gel consistency test determines the consistency of rice paste by boiling a tiny amount of rice in a dilute alkali solution. Consistency was measured by the length in a culture tube of the cold gel held horizontally for 30 minutes to 1 hour. The varietal differences in gel consistency exist among varieties of similar amylose content (> 25%). A rapid, simple test complementary to the test for amylose content, was developed based on consistency of milled rice paste in 0.2 N KOH (Cagampang *et al*., 1973).

Table 1: Gel consistency.

Length of gel (mm)	Gel consistency
40 mm or less	Very flaky rice with hard gel consistency
41 to 60 mm	Flaky rice with medium gel consistency
More than 61 mm	Soft rice with soft gel consistency

Gelatinization temperature. The time required for cooking was determined by gelatinization temperature. The gelatinization temperature of rice varieties were classified as low (55°C to 69°C), intermediate (70°C to 74°C), and high (> 74°C). The alkali digestion technique was used extensively for estimating gelatinization temperature. The process for determining alkali spreading values was determined by a procedure described by Little *et al*., 1958.

Amylose content (%). The amylose content of starch usually ranges from 15 to 35 per cent. The amylose content in each rice sample was determined by using spectrophotometrical techniques according to modified method of Juliano (1971).

Table 2: Amylose content (%).

Category	Amylose content (%)
Low	Less than 10
Intermediate	20-25
High	More than 25

Statistical analysis of data collected from present study was used to calculate mean, variability parameters using software packages like, MS-EXCEL and r-software.

RESULTS AND DISCUSSION

Grain quality of rice plays an important role in consumer preferences since rice is mainly consumed as whole grain especially in Asia (Nagaraju *et al*., 2020). The appearance quality is determined by grain length, breadth, length-breadth ratio. Cooking and eating quality of the rice grains is determined by the factors like gel consistency, gelatinization temperature, amylose content, *etc*. Present genotypes used in this study can be utilized in hybrid rice improvement programme as parents. Over this, present study carried out using 12 rice genotypes selected based on their medium slender trait similar to check BPT 5204 and had higher yield than BPT-5204, along with other four checks were evaluated for physico-chemical properties like, grain length, breadth, L/B ratio, gel consistency (GC), gelatinization temperature (GT) and amylose content (AC).

The mean performance of selected rice genotypes along with minimum and maximum values, coefficient of variation, and critical difference (at 5% and 1% level of significance), Variability parameters: GCV, PCV, heritability and genetic advance as per cent of mean estimated for various grain quality parameters of rice genotypes are represented in Table 3 and the results are discussed hereunder. The genetic advance is a helpful metric for estimating the amount of advancement that may be expected as a result of applying selection to the relevant population. The combination of heritability and genetic mean would yield a more accurate indicator of selection value.

Grain length (mm). The low GCV and PCV appear to suggest that there is less variation in grain length among genotypes; as all the genotypes included in the study were medium slender genotypes. The results are in accordance with Rafii *et al*. (2014), Ogunbayo *et al*. (2014), Patel *et al.* (2014), Sharifi (2019), Nandeshwar *et al*. (2010), Palaniyappan *et al.*, (2020). High heritability also recorded by the same authors as mentioned for GCV and PCV. High heritability coupled with low GAM reported by Ogunbayo *et al*. (2014), Palaniyappan *et al.* (2020). A high heritability score in the broad sense combined with a low GAM value indicates non-additive gene action. The high heritability is attributable to the positive influence of the environment rather than genetics, therefore selecting for such traits may not be worthwhile.

Grain breadth (mm). The magnitude of phenotypic coefficients of variation (PCV) was higher than genotypic coefficients of variation (GCV) for the character, signifying the slight influences of the environmental forces on the expression of this trait. The results are in accordance with Rafii *et al*. (2014), Ogunbayo *et al*. (2014), Patel *et al.* (2014), Sharifi (2019), Nandeshwar *et al*. (2010), Palaniyappan *et al.* (2020). High heritability was also reported by the similar authors as mentioned for GCV and PCV. Low GAM for the trait recorded by Nandeshwar *et al*. (2010). High heritability coupled with low GAM reported by Ogunbayo *et al*. (2014).

Grain L:B ratio. Low values of GCV, PCV were reported by Rafii *et al*. (2014). There was no significant variation across the genotypes for the trait as genotypes chosen for study were medium slender it shows that genotypes included in the study exhibit narrow range of diversity so that selection for the trait in these genotypes might not be effective. High heritability for the trait reported by Rafii *et al*. (2014), Patel *et al.* (2014), Nandeshwar *et al*. (2010). Genotypes under study exhibited low GAM.

Gel consistency. All genotypes under study were exhibited soft rice with soft gel consistency with more than 61 mm gel length except MS-GP 3010 genotype which showed flaky rice with medium gel consistency (55 mm). Rice with soft to medium gel consistency is usually preferred.

Table 1: Genetic analysis of rice genotypes for grain quality parameters.

Treatments	GL (mm)	GB(mm)	Grain L:B(mm)	GC (mm)	GT (Spreading scale scores)	AC (%)
MS-GP 3001	7.85	2.11	3.73	124.50	6.00	20.90
MS-GP 3010	7.76	2.08	3.72	55.50	2.50	20.37
MS-GP 3037	7.95	2.14	3.72	114.00	4.00	33.05
MS-GP 3038	7.79	2.08	3.75	84.00	3.00	26.75
MS-GP 3039	7.88	2.14	3.70	102.00	5.00	23.57
MS-GP 3040	8.04	2.15	3.75	97.50	4.50	34.07
MS-GP 3045	7.80	2.08	3.76	71.50	1.00	32.20
MS-GP 3051	7.76	2.08	3.73	91.50	3.00	29.74
MS-GP 3052	7.76	2.08	3.73	102.00	6.00	18.02
MS-GP 3057	7.76	2.09	3.71	82.00	3.50	31.85
MS-GP 3063	8.03	2.17	3.70	69.00	3.00	25.60
MS-GP 3064	8.15	2.18	3.74	89.50	5.00	29.73
BPT 5204	7.79	2.09	3.73	95.50	6.00	24.96
Gangavathi sona	7.86	1.99	3.95	102.50	1.00	22.73
GNV 10-89	7.99	2.17	3.68	130.50	5.00	24.57
RNR 15048	7.68	1.90	4.05	75.50	2.00	23.18
Gangavathi emergence	7.86	2.05	3.83	86.00	4.00	20.76
S.EM	0.011	0.008	0.015	0.254	0.306	0.129
CD(5%)	0.034	0.023	0.045	0.760	0.918	0.387
CD(1%)	0.047	0.032	0.061	1.048	1.265	0.533
CV (%)	0.203	0.519	0.558	0.388	1.325	0.701
MAXIMUM	8.15	2.18	4.05	130.50	6.00	34.07
MINIMUM	7.68	1.90	3.68	55.50	1.00	18.02
MEAN	7.86	2.09	3.76	92.53	3.82	26.06
GCV	1.62	3.33	2.54	21.15	35.50	19.27
PCV	1.63	3.37	2.60	21.16	37.26	19.28
H (BS)	98.45	97.63	95.38	99.97	90.76	99.87
GAM	3.31	6.78	5.11	43.57	69.66	39.67

Abbreviations: GCV- Genotypic coefficient of variance; **PCV**- Phenotypic coefficient of variance; **H**- heritability in broad sense; **GAM**- Genetic advance as percent of mean; **GL**- Grain length in mm; **GB**- Grain breadth in mm; **Grain L:B**- Grain Length: breadth ratio; **GC**- Gel consistency in mm; **GT**- Gelatinization temperature; **AC**- Amylose content in percentage.

The GCV and PCV values were high with the values of 21.15 and 21.16 respectively, indicating the presence of greater variability for the trait. The small variation between GCV and PCV denoted the lesser magnitude of environmental control on the trait. The trait had also noted higher heritability (99.97%) and GAM (43.57) representing that the trait is dominated by additive gene actions and we can straight away go for direct selection for this trait. Umadevi *et al*. (2010), Dhanwani *et al*. (2013), Bandi *et al*. (2018), Jan *et al.* (2020), Prasad *et al*. (2021) also described the similar results for the trait. High heritability coupled with high GAM shows that heritability is due to additive gene effects and selection may be effective. Variation in gel consistency is shown in Plate 1.

Gelatinization temperature. Higher GCV (35.50) and PCV (37.26) were recorded signifying the occurrence of significant amount of variation for the trait in the group of genotypes considered for study. High GCV and PCV values for the trait were also reported by Nirmaladevi *et al.* (2015), Bhinda *et al*. (2017) and Rani (2017), Prasad *et al.* (2021).

Heritability (90.76) and genetic advance as per cent of mean (69.66) were also highest showing the prevalence of additive gene action in controlling this trait and thus one can go for direct selection of this trait. The results are in accordance with Kurmanchali *et al.* (2019), Prasad *et al.* (2021). Variation in gelatinization temperature is shown in Plate 2.

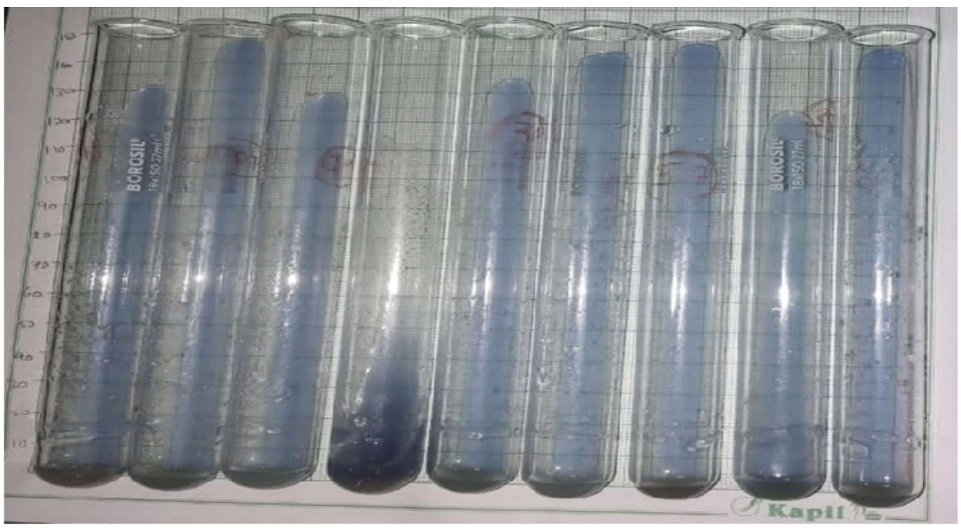
Amylose content. Amylose is one of the major essential factors affecting eating and cooking quality of rice as it reveals the functionality of rice grain's starch *i.e.*, flakiness and stickiness. The trait shows GCV, PCV values of 19.27 and 19.28 respectively, High heritability (99.87%) with high genetic advance over mean (39.67) indicating that the trait is influenced by additive gene effects hence selection is effective. The results are identical with Bandi *et al*. (2018), Patel *et al.* (2014). Variation in amylose content is shown in Plate 3.

The genotypes were clustered based on the association between GT (Gelatinization temperature) and AC (Amylose content) which shows that most of the genotypes studied have high amylose content (>25%) with intermediate cooking temperature requirement of 70-74 °C (Table 2). Whereas, other scientists like Xu *et al.* (2013), Yang *et al.* (2014) and Kong *et al.* (2015) also established non-random combinations of AC and GT in rice research materials.

Prasad *et al.* (2021) revealed that high genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) coupled with high heritability and high genetic advance as a percentage of mean were recorded for gel consistency, gelatinization temperature and amylose content indicating additive gene action. The results of this study provide vital information on amylose content gel consistency and gelatinization temperature of various rice genotypes which can be utilized in a breeding programme directed towards improving the cooking and eating quality. Genotypes with high amylose content can be further studied for identifying genotypes with high resistant starch and low Glycaemic Index.

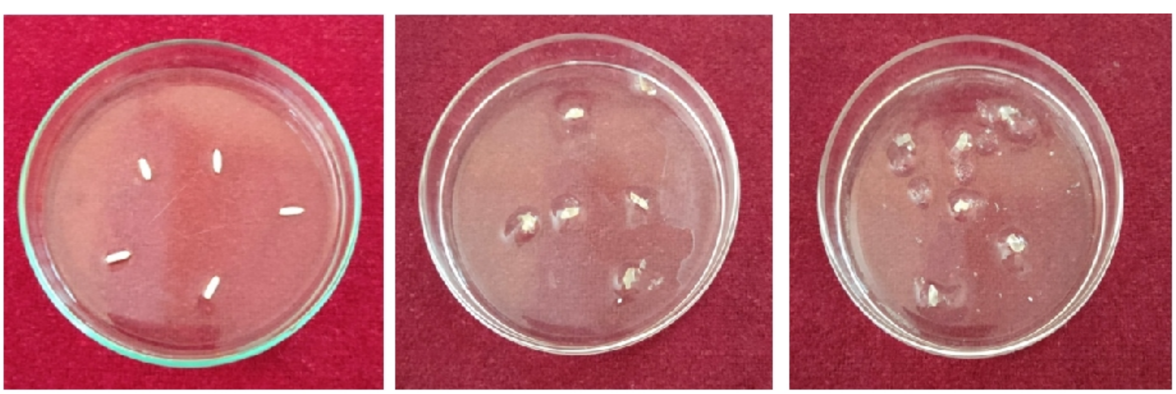
Table 2: Grouping of genotypes based on relationship between AC and GT.

		Amylose Content		
		Low (10-20%)	**Intermediate (20-25%)**	**High (>25%)**
Gelatinization Temperature	**Low (55-69^{0}C)**	None	Gangavathi sona, RNR-15048	MS-GP 3045
	Intermediate (70-74^{0}C)	None	MS-GP 3010, MS-GP 3039, GNV 10-89, Gangavathi emergence	MS-GP 3037, MS-GP 3038, MS-GP 3040, MS-GP 3051, MS-GP 3057, MS-GP 3063, MS-GP 3064
	High (>74^{0}C)	MS-GP 3052	MS-GP 3001, BPT-5204	None



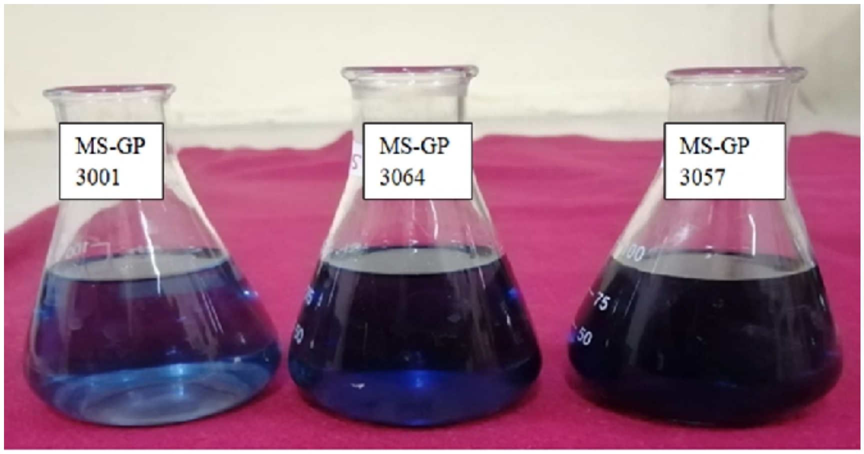
Genotypes	MS-GP 3064	MS-GP 3037	MS-GP 3051	MS-GP 3010	MS-GP 3040	MS-GP 3039	MS-GP 3052	MS-GP 3058	MS-GP 3001
Length of gel	89.5 mm	114 mm	91.5 mm	55.5 mm	97.5 mm	102 mm	102 mm	84 mm	124.5 mm

Plate 1: Variation in gel consistency.



MS-GP 3045	MS-GP 3037	MS-GP 3001

Plate 2: Variation in gelatinization temperature.



Genotypes	MS-GP 3001	MS-GP 3064	MS-GP 3057
Amylose content	20.90 %	29.73 %	31.85 %

Plate 3: Variation in amylose content.

Tamu *et al.* (2017) evaluated of 87 rice varieties for grain appearance, cooking and eating qualities. They determined gelatinization temperature (GT) based on alkaline spreading score, 64% of the rice varieties showed intermediate GT (70-74 ºC), 20% exhibited low GT (55-69 ºC), and only 16% of the rice varieties showed high GT above 74ºC. Hard gel consistency was observed in 71% of rice varieties evaluated, 22% recorded medium gel consistency, and only 7% of the rice varieties recorded soft gel consistency. Based on the L/B ratio, 33 of the rice varieties had long slender grain type, 45 recorded medium slender grain and only 9 varieties recorded short bold grain. The characteristics of the various grain types make them suitable for different food preparations and meet the preferences of majority of consumers.

CONCLUSION

Among all physico-chemical characteristics of rice grains grain characters like grain length, breadth, amylose content (AC), gel consistency (GC) and gelatinization temperature (GT) are key indices of rice grain quality. 12 rice genotypes selected based on their medium slender trait similar to check BPT 5204 were analysed for these quality traits. For gel consistency character MS-GP 3010 genotype had flaky rice with medium gel consistency and a gel length of 55 mm, all other genotypes under study had soft rice with soft gel consistency and more than 61 mm gel length. For gelatinization temperature only three genotypes were having low GT (55 ˚C to 69 ˚C), 11 genotypes were having medium (70 ˚C to 74 ˚C) and rest three were having highest GT (>74 ˚C). One genotype was having low (<20%) amylose content, eight genotypes were having intermediate (20-25%) amylose content which is desirable and other eight genotypes were having highest amylose content (>25%). Desirable cooking characteristics were observed in the high yielding genotypes MS-GP 3010 and MS-GP 3039. These may be tested in many locations to determine the impact of the environment on grain yield and the best-performing stable variety might be released for commercial cultivation. The genotypes which were exhibited superior performance for cooking quality traits can be further subjected for micronutrient (Iron and zinc) analysis, protein content estimation and Gamma Amino Butyric Acid (GABA) analysis.

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