

# Genetic variability for micronutrients under an aerobic condition in local landraces of rice from different agro-ecological regions of Karnataka, India

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**Abstract.** *Thuy NP, Nhu TTT, Trai NN, Nhu NK, Thao NHX, Phong VT, Khoa BD, Luan NT. 2023. Genetic variability for micronutrients under an aerobic condition in local landraces of rice from different agroecological regions of Karnataka, India. Biodiversitas 24: 1-10.* Genetic variability is a fundamental reference for the innovative development of breeding programs to improve varieties and desirable traits. This study aimed to assess genetic variability for micronutrients (iron and zinc) and protein content under an aerobic condition in local landraces of rice (*Oryza sativa* L.) from different agroecological regions of Karnataka, India. Fifty-five local landraces of rice from India were studied. High phenotypic and genotypic coefficient of variation was observed for grain yield per plant and moderate for the remaining traits. Heritability was high for most of the traits observed while moderate for harvest index and grain yield plant<sup>-1</sup>. The genetic advance (GA) was high for the majority of yield and its attributing traits. GA as mean was high for grain yield per plant. Based on D<sup>2</sup> value, 50 genotypes were grouped into 8 clusters. Clusters VI and VIII are the largest and had accessions with the highest protein and zinc content. Marabatta, Jeerige Batta, Neerguli, Mugadh Sughanda, and Kesarnellu genotypes contained high grain protein and zinc content, whereas Naga Batta genotype has high iron content. Among the superior nutrient landraces, Neerguli, Jeerige Batta, DBN, Kesarnellu, and Doddiga genotypes had high grain yield plant<sup>-1</sup>.

**Keywords:** Genotype, grain yield, heritability, micronutrients, *Oryza sativa*, phenotype

## INTRODUCTION

Rice (*Oryza sativa* L.) belonging to the family Poaceae, is a cultivated and inbreeding species. Rice is the staple cereal crop, which serves as a major carbohydrate source for more than half of the world's population (Fukagawa and Ziska 2019). It has been reported that rice is low in protein and other micronutrients which may cause malnutrition problems that are widely prevalent in the rice-eating population (Dipti et al. 2012). More than 20% of total calorie intake is from rice sources (Fukagawa and Ziska 2019) and more than 90% of the world's rice is produced and consumed in the Asia region. As a result, rice production is a major contributor to food security (Bishwajit et al. 2013). It has been reported that more than two billion people are affected by protein and micronutrient malnutrition (Fanzo and Glass 2018). For instance, iron deficiency anemia has been proven as one of the most common nutritional disorders issues in developing countries where rice is a staple food (Palanisamy 2018). Thus, the demand for increasing the quality of rice is a need and has become an attraction in the field of study. Rice varieties are often recognized by several features regarding growth, morphology, grain decomposition, and grain yield (Custodio et al. 2019).

The development of high-yielding cultivars with high nutrient content is also important to enhance the nutritional quality of major food crops (Gearing 2015). It has been reported that an increase in protein content would result in a substantial increase in protein intake by a large number of consumers provided the quality of protein is not impaired (Poutanen et al. 2022). The enhancement of total protein in rice is of immense importance for nutritional security. Vanitha et al. (2015) evaluated 60 rice genotypes for zinc deficiency tolerance and yield traits under aerobic conditions to find out nine rice genotypes with increased yield and suitable for zinc deficiency tolerance. The selected lines had acceptable agronomic traits, hence providing a foundation for future improvement in the dual goals of increasing the yield and nutritional value of rice. Local landraces harbor great genetic potential for rice improvement (Dwivedi et al. 2016). Landraces that endowed with tremendous genetic variability support the adaptation of landraces to wide agro-ecological niches. Landraces are precious genetic resources because they contain rich variability of agronomical important and complex quantitative traits, which have not been widely utilized or incorporated into modern varieties (Rao et al. 2018; Zahra et al. 2020). Assessing genetic variability for growth, yield, and grain quality characters among the local

landraces is an important step before starting a crop breeding program to incorporate traits of interest.

Breeding in rice is mainly focused on grain yield rather than the nutritional enhancement to feed the large rice-eating population. A substantial quality improvement in rice production has been reported to be achieved by rice breeding programs and management (Chanakan and Rerkasem 2020). Specific traits have been studied and selected for breeding. However, the basic and background data for rice breeding have been limited and have become big challenges (Khanh et al. 2021).

The genetic foundation of cultivated rice has been narrowed these days (Swain et al. 2017). The relationship and population structure have been studied for different purposes including the selection of parental combinations for creating progenies with significantly higher potential compared to their parents (Ndjiondjop et al. 2018). Following these rationales, this study aimed to assess genetic variability for micronutrients (iron and zinc) and protein content under an aerobic condition in local landraces of rice (*Oryza sativa* L.) from different agro-ecological regions of Karnataka, India. Plant growth, grain morphology and yield were also studied to identify the important characteristics attributing to the grain quality. The study provides the essential reference for innovative breeding-selection strategies and the design of new rice varieties with high quality.

## MATERIAL AND METHODS

### Plant materials

The plant materials used in the study consisted of 50 local landraces and 5 checks of rice, collected from different agro-ecological regions of Karnataka, India and maintained in the Department of Genetics and Plant Breeding, University of Agricultural Science (UAS), Bangalore (Table 1). These landraces were evaluated for genetic variability parameters for grain yield and its component traits at the experimental plots of the Department of Genetics and Plant Breeding, 'K' block, UAS, Gandhi Krishi Vignna Kendra (GKVK), Bengaluru.

### Procedures

#### Experimental layout

The 50 landraces and 5 checks (MAS 946-1, MAS 26, HP1, HP7, and HP9) were sown in Randomized Complete Block Design with two replications. The spacing of 25 cm between rows and 20 cm between plants was followed.

#### Parameter observations

Observations were recorded from each plant and means of the five plants for each trait (IRRI 1980). The 16 characters observed are as follows: Date of sowing, days to 50% flowering, plant height at 60 days after sowing (cm), plant height at 90 days after sowing (cm), number of tillers per plant at maturity, number of productive tillers per plant, panicle traits, panicle length (cm), number of spikelets per panicle, grain quality traits, grain length (mm), grain breadth (mm), grain L: B ratio, test weight (g), harvest

index (%), grain yield per plant (g). The crude protein, Iron, and zinc content were estimated by Near-infrared reflectance spectroscopy (NIR system, Broker, Denmark) (Yuan et al. 2013).

### Data analysis

The analysis of variance for 14 characters of 50 local landraces as well as check entries was computed by Panse and Sukhatme (1954). Analysis was done using the "Windostat" computer program. Phenotypic and genotypic components of variance were estimated by using the formula given by Cochran and Cox (1957). Both phenotypic and genotypic coefficients of variability for traits were estimated using the formula of Burton and Devane (1953).

Broad sense heritability for all the characters was calculated as per the method outlined by Lush (1949). Genetic advance was calculated as per the method outlined by Johnson et al. (1955). Cluster analysis was estimated by using Unweighted Pair Group Method with Arithmetic Mean (UPGMA) by Sneath and Sokal (1973).

## RESULTS AND DISCUSSION

### Analysis of variance

Creation and utilization of genetic variability are important factors for crop improvement. Thus, variability generated is a prerequisite for any breeding program aimed for improving the yield and other characters. The mean sum of squares for 14 morphological traits among 55 local landraces under aerobic conditions is presented in Table 2. The data of 14 traits were used to estimate the genetic variability, heritability, and genetic advance (GA). It is evident from the table that highly significant differences among the genotypes were observed for all the characters ( $P < 0.05$ ).

**Table 1.** List of 55 local landraces and checks used for the study

	Landraces	
Alibulla	Jaddu Batta	Naga Batta
Alugidda	Jeerige Batta	Navasali
Anthrasali	Kadullite	Sampigae Batta-1
DBN	Kaduvepe	Sampigae Batta-2
Biliakki	Kalajeera	Sanesali
Biliakki-1	Kalu Mottaga	Mattalaga
Bilidoddi Marthayala	Karihasali	Mugadhsughanda
Rajmudi	Kari Kondaga	Sannakki Batta
Bilidoddi	Kanakasali	Neermullare
Budda	Karjaddu	Sanna Mulla
Coimbatore Sanna	Karidoddi	MAS 946-1
Dodda Batta	Rajmudi-1	MAS 26
Dodda Mullare	Kesarnellu	HP 1
Dodda Mullare-1	Kirwana	HP 7
Doddiga	Marabatta	HP 9
Gowri Sanna	Neergoli	
Gidda Rajakamala	Malligae	
Gud Batta	Mysore Malligae	
Halu Gidda	Putta Batta	
Howne Kattu	Raj Bhog	

The results showed that there is a presence of an acceptable amount of variability among the local landraces. This behavior was responsible for the wide range of variability among the genotypes. This gives a scope for rice breeders to improve these traits through selection and hybridization to improve the desired traits (Ndukauba et al. 2015).

### Mean performance of genotypes, variability, heritability, and genetic advance

The mean performance, variability parameters of genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), broad sense heritability ( $h^2$ ), genetic advance (GA), and genetic advance as percent of mean (GAM) of 14 characters in local landraces grown under aerobic conditions are presented in Table 3. Plant height ranged from 66.6 cm (HP9) to 155.6 cm (Kanakasali) among the local landraces with an average of 117.58 cm. Moderate PVC and GCV of 15.73% and 14.9%, high heritability of 97.5% and high GAM of 29.09% were observed in local landraces. Plant height is a

central part of rice ecology which has variety with environmental conditions and high heritability degree (Masum et al. 2008; Moles et al. 2009; Islam et al. 2015). Among the genotypes, the range of variation for days to 50% flowering was from 87 days (Coimbatore Sanna) to 117 days (Gowri Sanna) with an average of 103 days. Low PCV of 9.41%, low GCV of 9.30%, high broad sense heritability of 98.8% and GAM of 18.91% respectively were recorded for days to 50% flowering. An average value of 157 days with a range of 135 (Coimbatore Sanna, Doddiga) to 169 (Kadullite) days was recorded. Low PCV of 6.93%, low GCV of 6.52%, high heritability of 88.4% and moderate GAM of 12.62% were recorded in these genotypes for this trait.

Total number of tillers per plant ranged from 12.2 tillers in Dodda Batta to 26.2 tillers in Karijaddu with an average of 17.7. Moderate PCV of 17.54%, moderate GCV of 15.25%, high heritability of 75.6% and high GAM of 27.31% was recorded for this trait. An average of 16.6 productive tillers was observed with a range of 11 (Dodda Batta) to 24.6 (Karijaddu).

**Table 2.** ANOVA for growth and yield attributing characters in local landraces of rice

Source of variation	Degrees of freedom	Mean sum of squares						
		Plant height (cm)	Days to 50% flowering	Days to maturity	Total no. tiller	Productive tillers plant <sup>1</sup>	Spikelet fertility (%)	Flag leaf length (cm)
Replication	1	4.01	77.88	8.18	1.73	0.35	63.5	1.14
Genotypes	54	98.67***	1121.62***	142.8***	17.06***	15.19***	71.99*	78.25***
Error	54	2.38	34.95	13.39	2.37	2.06	12.3	6.81
C.V		5.23	5.03	1.48	2.36	8.67	8.64	4.41
C.D. 5%		2.39	11.85	3.09	7.48	3.09	2.88	7.03
C.D. 1%		3.18	15.78	4.12	9.96	4.11	3.83	9.37
Replication	1	0.27	0.01	0.003	0	12.25	0.025	16.71
Genotypes	54	8.37***	1.01**	0.293***	0.48***	40.47***	0.015**	47.08***
Error	54	1.42	0.001	0.001	0.002	0.078	0.007	17.32
C.V		5.23	0.37	1.15	1.64	1.14	15.29	23.18
C.D. 5%		2.39	0.06	0.07	0.09	0.56	0.17	8.34
C.D. 1%		3.18	0.08	0.09	0.12	0.74	0.22	11.11

Note: \*: Significance at 5%, \*\*: Significance at 1%, \*\*\*: Significance at 0.01%

**Table 3.** Estimation of genetic parameters for growth and yield attributing characters in local landraces of rice

Characters	Mean	Range		Variances			Coefficient of variation (%)		$h^2$ (%)	GA (%)	GAM (%)
		Min	Max	$\sigma^2_e$	$\sigma^2_g$	$\sigma^2_p$	GCV	PCV			
Days to 50% flowering	103.49	87.00	117.00	34.95	94.41	96.79	9.30	9.41	98.80	34.20	18.91
Plant height (cm)	117.58	66.60	155.60	2.38	307.00	341.94	14.90	15.73	97.50	19.77	29.09
Days to maturity	156.56	135.00	169.00	13.92	106.46	120.39	6.52	6.93	88.40	19.99	12.62
Total no. tiller	17.77	12.20	26.20	2.37	7.34	9.72	15.25	17.54	75.60	4.85	27.31
Productive tillers/plant	16.60	11.00	24.60	2.06	6.57	8.63	15.44	17.69	76.10	4.61	27.74
Spikelet fertility (%)	79.58	63.27	93.76	12.31	29.85	42.15	6.87	8.16	70.80	9.47	11.90
Panicle length (cm)	22.79	16.52	32.50	1.42	3.47	4.89	8.18	9.71	71.00	3.24	14.19
Flag leaf length (cm)	32.27	22.15	51.85	6.81	35.72	42.53	18.52	20.21	84.00	11.28	34.97
Grain length (mm)	8.32	6.20	10.30	0.00	0.51	0.51	8.54	8.54	99.80	1.46	17.57
Grain breadth (mm)	3.03	2.20	3.75	0.00	0.15	0.15	12.61	12.66	99.20	0.78	25.87
Length/breadth ratio	2.80	2.17	4.37	0.00	0.24	0.24	17.48	17.56	99.10	1.00	35.86
Test weight (g)	24.36	12.60	34.90	0.08	20.20	20.27	18.45	18.48	99.60	9.24	37.93
Harvest index	0.55	0.29	0.74	0.01	0.00	0.01	11.72	19.27	37.00	0.08	14.68
Grain yield plant <sup>1</sup> (g)	17.95	5.82	33.34	17.32	14.88	32.20	21.48	31.60	46.20	5.40	30.09

Note:  $\sigma^2_e$ : Environmental variance;  $\sigma^2_g$ : Genotypic variance;  $\sigma^2_p$ : Phenotypic variance; PCV: Phenotypic coefficient of variation; GCV: Genotypic coefficient of variation;  $h^2$  (BS): Heritability percentage; GA: Genetic advance; GAM: Genetic advance as per mean

Moderate PCV of 17.69% and GCV of 15.44%, high heritability of 76.1%, and a high GAM of 27.74% were recorded for this trait in local landraces. Spikelet fertility percent ranged from 63.27% in Kari Kondaga to 93.76% in Bilidoddi with an average of 78.52%. Low PCV of 8.16%, low GCV of 6.87%, high heritability of 70.80% and moderate GAM of 11.90% were recorded for this trait. Flag leaf length among genotypes ranged from 22.15 cm (Biliakki) to 51.85 cm (Jeerige Batta) with an average of 36.98 cm. A high PCV of 20.21% and moderate GCV of 18.52%, high heritability of 84.00%, and a high GAM of 34.97% were recorded for this trait. Average value for panicle length recorded was 24.51 cm with a range of 16.52 cm (Kalajeera) to 32.50 cm (Gidda Rajakamala). Low PCV of 9.71%, low GCV of 8.18%, high heritability of 71.00%, and moderate GAM of 14.19% were recorded for this trait.

Grain length ranged from 6.20 mm (Dodda Mullare) to 10.30 mm (Anthrasali) with an average of 8.25 mm. Low PCV of 8.54%, low GCV of 8.54%, high heritability of 99.8%, and moderate GAM of 17.57% were recorded for this trait. Grain breadth ranged from 2.20 mm (Rajmudi) to 3.75 mm (Jaddu Batta) with an average of 2.98 mm. Moderate PCV of 12.66%, moderate GCV of 12.61%, high heritability of 99.20%, and high GAM of 25.87% were recorded for this trait. Grain length to breadth ratio among local landraces ranged between 2.17 (Kirwana) and 4.37 (Anthrasali) manifesting an average of 3.01. Moderate PCV of 17.56%, moderate GCV of 17.48%, high heritability of 99.10% and high GAM of 35.86% were recorded for this trait.

Test weight among local landraces ranged from 12.60 g (Kadullite) to maximum of 34.9 g (Jaddu Batta) with an average of 23.75 g. Moderate PCV of 18.48%, moderate GCV of 18.45%, high heritability of 99.60% and high GAM of 37.93% were recorded for this trait. Harvest index ranged from 0.29 (Kari Kondaga) to 0.74 (Navasali) with an average of 0.52. Moderate PCV of 19.27%, moderate GCV of 11.72%, moderate heritability of 37.00% and moderate GAM of 14.68% were recorded for this trait. Average value of grain yield per plant recorded was 20.21 g/plant with a range of 5.82 g/plant (Kari Kondaga) to 33.34 g/plant (Kalu Mottaga). A high PCV of 31.60%, high GCV of 21.28%, moderate heritability of 46.20% and high GAM of 30.09% was recorded for this trait. Typically, the analysis of variance showed highly significant differences among the observed characteristics. Great variation of traits indicates the promise of desirable genotypes for breeding programs (Malek et al. 2014). Traits having a high value of GCV are highly heritable and have good potential for perfect selection (Kumar et al. 2017).

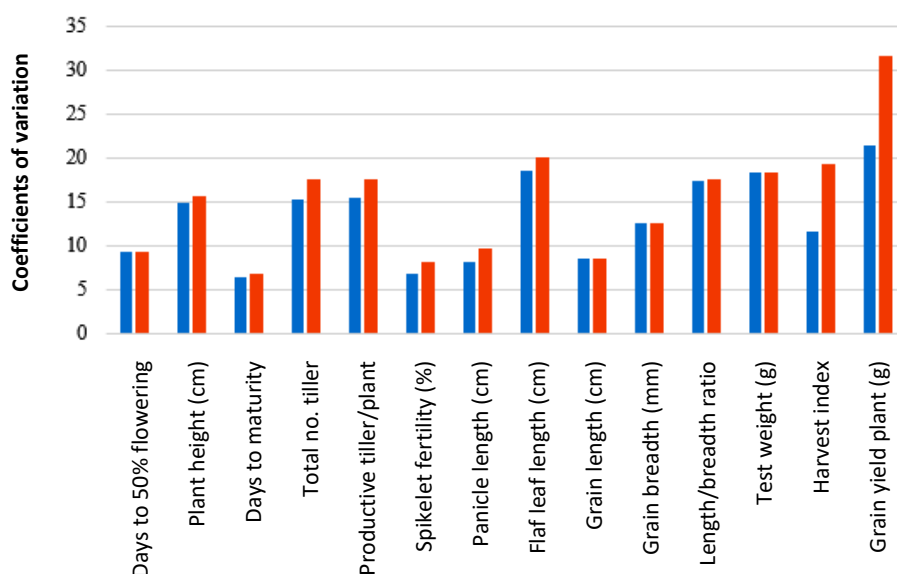
The genotypic coefficient of variation measures the range of variability in rice and also enables the comparison of the amount of variability present in different characters. The PCV estimates were higher than GCV for all the characters studied among the 55 local landraces, indicated that the substantial influence of the environment in the expression of these characters (Figure 1). The GCV value was almost smaller than the PCV values indicating that the

characters were influenced by the surrounding environment. The highest GCV was obtained for grain yield (21.48%), and the lowest GCV was obtained for days to maturity (6.52%). The highest PVG also was observed for grain yield (31.60%), followed by the flag leaf length (20.21%) and harvest index (19.27%). The result is in agreement with the previous report which shows a high PCV on grain yield (Abebe et al. 2017). Similar findings were observed by Fathelrahman et al. (2015) that high PCV was observed for stem diameter and high GCV was observed for grain yield. Heritability gives information on the magnitude of inheritance of characters, while genetic advance helps formulate suitable selection procedures. High heritability coupled with high expected GAM indicated the effectiveness of selection for plant height, the total number of tillers, productive tillers per plant, flag leaf length, grain breadth, L/B ratio, and test weight (Figure 2).

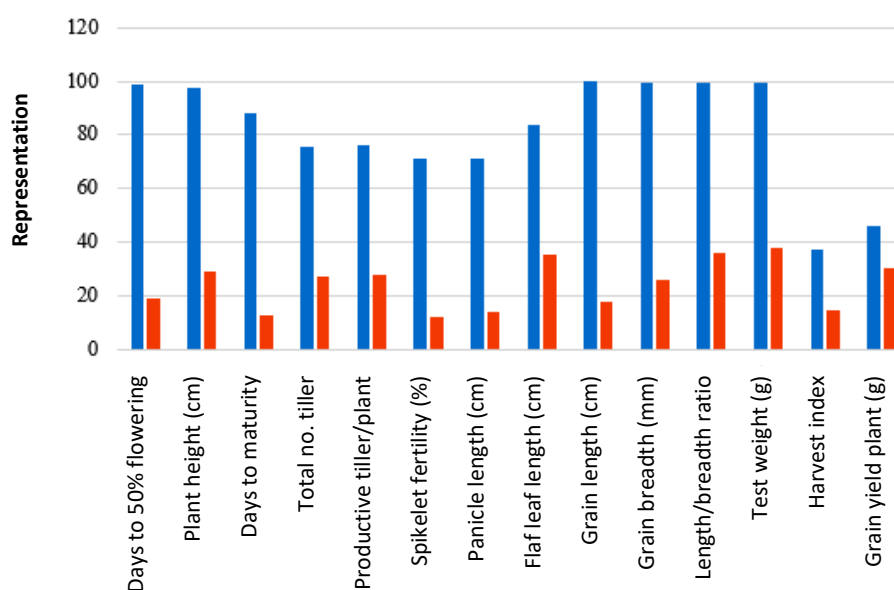
Similar reports were presented by Abacar et al. (2016), Tiwari et al. (2019), and Adjah et al. (2020). Moderate heritability coupled with moderate GAM was observed for days to 50% flowering, days to maturity, spikelet fertility, panicle length, grain length, harvest index, and grain yield per plant. The traits such as plant height, productive tillers per plant, L/B ratio, and test weight with high genotypic variance, high heritability coupled with high expected genetic gain would be responsive to selection. High heritability along with high genetic advance is an important factor for predicting the resultant effect for selecting the best individuals (Ogunniyan and Olakojo 2014; Ongom et al. 2021). Heritability and genetic advance are important selection parameters. The estimation of genetic advance is more useful as a selection tool when considered jointly with heritability estimates (Bekele and Rao 2014). In contrast, the low heritability means that the selection will be relatively less effective, because the appearance of phenotypic variance of plants is more influenced by environmental factors. Breeding for traits with low heritability is difficult because low heritability means that the phenotype is not highly correlated with the genotype. In other words, the contribution of environmental conditions is relatively high in such traits. The most important function of heritability in the genetic study of quantitative characters is its predictive role to indicate the reliability of the phenotypic value as a guide to breeding value (Abarshahr et al. 2011).

### Cluster analysis

Analysis of variance showed significant differences for all the 14 characters studied among the local landraces of rice. Based on  $D^2$  value, 50 genotypes were grouped into 8 clusters (Table 4). The maximum number of genotypes (12 genotypes) were grouped in cluster VI and cluster VIII indicating genetic proximity of observed genotypes grouped in analyzed clusters. Cluster I consisted of 11 genotypes. Cluster II and cluster V had 5 genotypes each, cluster IV had 4 genotypes, cluster II consisted of 2 genotypes while cluster VII had only 1 genotype.



**Figure 1.** Representation of phenotypic (PCV) (■) and genetic (GCV) (■) coefficients of variation



**Figure 2.** Representation of heritability (h<sup>2</sup>) (■) and genetic advancement as percentage of mean (GAM)(■)

**Table 4.** Clustering pattern of 55 local landraces of rice

Cluster	Number of landraces	Name of genotypes
I	11	Alugidda, Biliakki, Rajmudi, Dodda Batta, Halu Gidda, Kalajeera, Karidoddi, Rajmudi-1, Raj Bhog, Mattalaga, Mugadhsughanda
II	3	Anthrasali, Sampigae Batta-1, Sampigae Batta-2
III	2	Jaddu Batta, Sanesali
IV	4	Bilidoddi Marthayala, Dodda Mullare, Kadullite, Karihasali
V	5	Biliakki-1, Howne Kattu, Kaduvelpe, Karijaddu, Putta Batta
VI	12	DBN, Bilidoddi, Budda, Coimbatore Sanna, Gidda Rajakamala, Gud Batta, Kalu Mottaga, Kari Kondaga, kesarnellu, Marabatta, Neergoli, Navasali
VII	1	Kirwana
VIII	12	Alibulla, Dodda Mullare-1, Doddiga, Gowri Sanna, Jeerige Batta, Kanakasali, Malligae, Mysore Malligae, Naga Batta, Sannakki Batta, Neermullare, Sanna Mullu

The results of cluster mean showed that cluster III had the highest mean value for days of 50% flowering (145.75%), spikelet fertility (84.51%), panicle length (48.21%), flag leaf length (25.30%), grain breadth (3.73%) and test weight (34.03%), while the lowest mean value for plant height (91.5%). Clusters I and II had genotypes with high plant height, but short panicle length and flag leaf length. Cluster IV had genotypes with the highest mean value for iron content (13.79%) and the lowest test weight (17.25%). Cluster V had genotypes with the highest plant height (107.6%), days to maturity (159.8%) and the lowest flag leaf length (21.77%). Cluster VI had genotypes with the highest mean value for protein content (15.30%).

Cluster VII had genotypes with the highest harvest index (0.69%) and grain yield per plant (29.01%) and clusters VIII with genotypes that had the highest mean value for zinc content (27.89%) (Table 5). Similar findings were also reported by Girma et al. (2018), Iqbal et al. (2018), and Islam et al. (2020). These results might assist the rice breeder in their selection strategies to improve grain protein, zinc, iron content, and grain yield for the breeding program. Thus, the present results concluded that traits such as spikelet fertility, panicle length, test weight, and grain yield plant<sup>1</sup> were useful for higher grain yield. Some genotypes such as Marabatta, Neermullare, Naga Batta, and Kirwana should be used for crossing to develop new rice varieties of India grown under aerobic conditions.

Cluster analysis helps in grouping genotypes sharing similar characters in different clusters and identifying genetically diverse as well as desirable genotypes. On the whole composition of the clustering, pattern showed that genotypes collected from the same places of origin were distributed in different clusters. Similar findings of non-correspondence of geographic origin with genetic diversity were also reported by Shamim and Sharma (2014). There was none of the clusters contained genotypes with all the desirable traits which could be directly selected and utilized. All the maximum and minimum clusters' mean values were distributed in relatively distant clusters.

However, cluster III recorded desirable mean values for days to 50% flowering, spikelet fertility percentage, panicle length, grain breadth, and grain yield. Bose and Pradhan (2006) also reported similar results for studying the divergence in deep water rice genotypes, thereby underlining the fact that the hybridization between genotypes of different clusters is necessary for the development of desirable genotypes. Based on the per se performance of genotypes among different clusters, they may be directly selected or may be used as potential parents in the hybridization program.

#### Identification of local rice landraces

Variations in grain protein, zinc, and iron content were presented in Table 6. Among the local landraces of rice, the range of variation for rice protein content was observed from 10.36% (Mattalaga) to 13.97% (Marabatta) with an average value of 13.02 mg kg<sup>-1</sup>. The check variety HP9 has recorded a high protein content of 15.67% compared with another genotype. Zinc content in local landraces ranged from 12.22 ppm (Biliakki) to 30.17 ppm (Neermullare) with an average value of 21.19 ppm. The check variety HP1 has recorded high zinc content of 31.34 ppm compared to other local landraces of rice. Among the local landraces, the range of variation for rice iron content was from 11.03 ppm (Mattalaga) to 15.72 ppm (Naga Batta) with an average value of 13.38 ppm. The check HP7 has recorded high iron content of 15.21 ppm compared with other genotypes from local landraces.

The performance of best genotypes having high grain protein coupled with high iron and zinc rich for selected agronomic traits was assessed (Table 7). Among the local landraces majority of them had lower protein (13.97%) and zinc (30.17 ppm) content compared with check variety HP9 (15.67% protein) and HP1 (31.34 ppm zinc), but this protein and zinc content was higher than high yielding check variety like MAS 26 (11.82% protein and 16.08 ppm zinc) and MAS 946-1 (11.92% protein and 18.60 ppm zinc).

**Table 5.** Cluster means for growth and yield attributing characters in local landraces of rice

Characters	Cluster								F	Sig.
	1	2	3	4	5	6	7	8		
Days to 50% flowering	111.25	102.46	145.75	112.2	126.42	118	127.30	123.43	58.74	0.00
Plant height (cm)	104.75	104.4	91.5	103.88	107.60	102.13	93.00	104.04	15.67	0.00
Days to maturity	157.00	157.9	142.75	157.13	159.80	155.13	160.00	157.42	12.61	0.00
Total No. tiller	18.03	17.07	14.60	17.43	19.31	17.77	14.30	18.06	2.76	0.02
Productive tillers/ plant	16.83	16.03	13.60	16.35	18.11	16.59	13.30	16.83	3.09	0.01
Spikelet fertility (%)	78.09	81.24	84.51	81.99	79.09	80.66	83.45	77.80	7.01	0.00
Panicle length (cm)	29.95	26.89	48.21	33.04	30.76	33.91	37.71	32.82	18.13	0.00
Flag leaf length (cm)	22.41	22.41	25.30	23.20	21.77	23.25	22.63	22.83	1.72	0.13
Grain length (mm)	8.38	9.82	9.05	7.07	7.85	7.95	8.13	8.53	1.56	0.17
Grain breadth (mm)	2.63	2.73	3.73	2.89	3.11	3.35	3.73	3.14	5.50	0.00
Length/Breadth ratio	3.21	3.68	2.43	2.45	2.53	2.38	2.18	2.72	5.08	0.00
Test weight (g)	20.05	27.48	34.03	17.25	22.87	27.28	33.75	25.76	3.56	0.00
Harvest index	0.52	0.55	0.65	0.65	0.53	0.54	0.69	0.53	7.80	0.00
Protein (%)	13.65	13.07	13.02	12.36	13.12	15.30	12.14	12.10	5.17	0.00
Iron (ppm)	13.65	12.55	13.00	13.79	13.56	11.99	12.29	12.52	4.59	0.01
Zinc (ppm)	21.50	22.30	22.23	26.81	27.54	17.04	19.22	27.89	5.43	0.00
Grain yield plant <sup>1</sup> (g)	15.73	16.36	22.82	18.24	16.07	19.79	29.01	18.34	7.09	0.00

**Table 6.** Mean values of grain nutrient and grain yield parameters in local landraces of rice

Landraces	Protein (%)	Zinc (ppm)	Iron (ppm)	Carbohydrate (%)	Moisture (%)	Grain yield plant <sup>1</sup>
Alibulla	12.69	21.50	14.34	82.50	12.02	22.03
Alugidda	13.04	20.46	12.89	78.12	11.91	15.85
Anthrasali	13.03	20.60	13.08	76.31	12.19	21.57
DBN	13.30	27.54	14.16	76.74	12.60	21.34
Biliakki	13.05	28.31	14.67	76.88	11.54	19.50
Biliakki-1	12.52	12.22	11.45	79.65	12.16	16.60
Bilidoddi Marthayala	11.19	17.37	11.16	86.42	11.78	20.80
Rajmudi	11.85	17.13	11.35	77.48	11.74	19.40
Bilidoddi	11.72	20.17	11.56	82.31	12.27	21.95
Budda	12.25	23.61	13.36	83.29	11.98	27.29
Combatore Sanna	11.09	16.13	12.96	82.14	11.88	18.22
Dodda Batta	11.28	12.65	11.23	79.57	12.28	12.65
Dadda Mullare	11.31	15.49	12.02	78.39	12.06	11.69
Dadda Mullare-1	10.71	24.16	12.75	87.02	11.88	21.61
Doddiga	13.12	20.93	13.57	75.51	12.11	20.03
Gowri Sanna	12.22	22.34	13.30	80.37	12.06	15.52
Gidda Rajakamala	13.04	24.29	12.33	79.49	12.24	11.51
Gud Batta	12.10	29.34	12.77	81.58	12.13	19.07
Halu Gidda	12.41	27.05	13.51	86.49	12.31	14.56
Howne Kattu	12.09	28.26	14.51	77.38	12.01	13.66
Jaddu Batta	13.03	25.78	15.09	72.51	11.99	17.96
Jeerige Batta	13.75	20.70	12.31	81.95	11.42	22.16
Kadullite	11.95	23.78	12.56	78.26	11.93	17.70
Kaduvelpe	12.95	29.43	14.24	82.17	12.10	14.86
Kalajeera	12.46	13.46	11.27	80.39	11.99	16.95
Kalu Mottaga	12.11	23.47	12.80	84.95	12.03	22.73
Karihasali	11.00	13.09	11.36	82.49	11.87	15.53
Kari Kondaga	12.48	20.75	14.22	79.02	12.13	7.34
Kanakasali	12.71	27.39	13.54	76.26	12.12	11.67
Karijaddu	12.36	20.10	13.02	80.19	12.00	15.24
Karidoddi	12.44	18.86	12.33	82.23	12.03	20.96
Rajmudi-1	12.94	19.28	12.44	73.39	12.07	15.10
Kesarnellu	13.63	23.63	13.62	82.16	12.35	20.31
Kirwana	11.23	22.98	13.11	84.89	12.20	29.01
Marabatta	13.97	22.06	13.47	79.71	11.93	13.88
Neergoli	13.66	21.13	11.83	84.13	11.78	25.42
Malligae	13.36	16.69	12.60	84.08	11.79	18.45
Mysore Malligae	12.25	21.87	12.18	82.49	12.17	23.26
Putta Batta	12.47	19.49	12.51	79.90	12.23	17.66
Raj Bhog	10.55	18.98	11.23	74.56	11.88	14.45
Naga Batta	13.56	25.25	15.72	82.11	12.21	13.04
Navasali	11.50	18.16	12.66	80.65	11.90	28.39
Sampigae Batta-1	13.63	19.46	13.50	77.19	11.89	12.39
Sampigae Batta-2	12.77	27.02	13.26	83.65	12.44	15.80
Sanesali	12.46	19.24	13.36	84.10	12.10	27.67
Mattalaga	10.36	14.12	11.03	83.37	12.08	15.44
Mugadhsughanda	13.64	18.20	11.90	80.17	11.73	16.34
Sannakki Batta	11.90	24.44	12.19	82.87	12.27	15.35
Neermullare	11.98	30.17	14.98	82.58	12.39	23.25
Sanna Mullu	11.59	27.98	12.47	81.38	12.34	18.75
MAS 946-1	12.08	18.60	11.82	77.86	11.91	16.50
MAS 26	11.66	16.08	11.03	80.61	12.39	15.70
HP 1	12.84	31.34	12.51	76.84	11.64	21.90
HP 7	11.73	17.90	15.21	81.35	11.71	14.04
HP 9	15.67	14.99	12.64	71.80	12.19	14.37

**Table 7.** Performance of top ten high grain protein, zinc, iron content, and carbohydrate local landraces were grown under aerobic condition

Landraces	Protein (%)	Iron (ppm)	Zinc (ppm)	Carbohydrate (%)	DDF	PH	PL	TNT	GL	GB	LB	TW	GY
Marabatta	13.97	13.47	22.06	79.71	114.50	110.70	23.10	16.30	7.93	3.37	2.36	25.35	13.88
Jeerige Batta	13.75	12.31	20.70	81.95	100.50	122.30	23.68	15.40	8.36	3.26	2.57	26.20	22.16
Neergoli	13.66	11.83	21.13	84.13	100.50	99.75	20.99	13.65	7.85	3.14	2.50	27.20	25.42
Mugadhsughanda	13.64	11.90	18.20	80.17	110.50	120.60	24.33	15.70	8.64	2.73	3.16	23.20	16.34
Kesarnellu	13.63	13.62	23.63	82.16	110.00	118.40	22.94	16.10	7.99	3.32	2.41	26.10	20.31
Sampigae Batta-1	13.63	13.50	19.46	77.19	102.00	117.70	22.53	16.60	9.54	3.23	2.95	25.95	12.39
Naga Batta	13.56	15.72	25.25	82.11	114.00	119.30	21.08	15.80	8.15	3.03	2.69	26.05	13.04
Malligae	13.36	12.60	16.69	84.08	113.00	111.80	22.26	20.20	8.45	3.17	2.67	25.85	18.45
DBN	13.30	14.16	27.54	76.74	100.50	109.90	23.38	16.00	7.69	3.44	2.24	23.35	21.34
Doddiga	13.12	13.57	20.93	75.51	90.00	117.90	22.71	19.70	8.54	3.12	2.74	24.95	20.03
MAS 26 (check)	11.66	11.03	16.08	80.61	102.00	72.60	20.73	15.45	10.26	2.35	4.37	26.25	15.70
MAS 946-1 (check)	12.08	11.82	18.60	77.86	103.50	74.30	21.73	20.70	9.84	2.38	4.14	27.75	16.50
HP 1 (check)	12.84	12.51	31.34	76.84	90.00	114.60	20.94	21.05	8.32	2.66	3.13	20.69	21.90
HP 7 (check)	11.73	15.21	17.90	81.35	101.50	122.60	21.38	17.20	7.77	2.24	3.48	18.40	14.04
HP 9 (check)	15.67	12.64	14.99	71.80	90.00	67.40	18.80	24.40	7.82	2.47	3.17	19.80	14.37
Mean	13.56	13.22	21.56	80.38	105.55	114.84	22.70	16.55	8.31	3.18	2.63	25.42	18.34
Minimum	13.12	11.83	16.69	75.51	90.00	99.75	20.99	13.65	7.69	2.73	2.24	23.20	12.39
Maximum	13.97	15.22	27.54	84.13	114.50	122.30	24.33	20.20	9.54	3.44	3.16	27.20	25.42
SE	0.08	0.34	1.03	0.97	2.54	2.15	0.33	0.62	0.17	0.06	0.09	0.40	1.37

Note: DFF: Days to 50% flowering (days), PH: Plant height (cm), TNT: Total numbers of tillers, PL: Panicle length (cm), GL: Grain length (mm), GB: Grain breadth (mm), L/B ratio: Length/Breadth ratio, TW: Test weight (g), GY/P: Grain Yield per Plant (g)

Naga Batta has high iron content (15.72 ppm) compared to check HP7 (15.21 ppm). Babu et al. (2012) reported that grain Zn can act as selection criteria simultaneously to increase grain yield per plant, a similar finding was also reported by Bekele et al. (2013). Therefore, selection based on other traits such as plant height, number of productive tillers, and test weight would prove effective to enhance grain yield per plant and nutritional quality. These findings were supported by Anuradha et al. (2012).

Local landraces provided a valuable resource for plant breeding as well as for the preservation of genetic diversity. They are precious genetic resources because they contain huge genetic variability which can be used to complement and broaden the gene pool of advanced genotypes. The extent of genetic diversity in a crop population depends on recombination, mutation, selection, and random genetic drift. Mutation and recombination bring new variations to a population, whereas selection and genetic drift remove some alleles, often from important agronomical lines. The use of adapted rice landraces, as the primary source of variation into which desired characters present in modern cultivars are introgressed, may be an effective strategy for producing cultivars adapted to difficult production environments (Hanamaratti et al. 2008).

In conclusion, Analysis of variance revealed that there was significant variation for the characters studied. Significant variation was observed for 14 traits in the 55 rice landraces of Karnataka, India. The GCV and PCV coupled with high heritability and genetic advance were recorded for the number of tillers per plant, the number of productive tillers per plant, and grain yield per plant. The high GCV and PCV coupled with high heritability and genetic advance as percent mean were recorded for all the characters studied except plant height, total productive tillers per plant, panicle length, test weight, and grain yield per plant among local landraces. The total set of genotypes was grouped into 8 clusters. Clusters VI and VIII are the largest and had accessions with the highest protein, and zinc content. Local landraces were selected Marabatta, Jeerige Batta, Neergoli, Mugadhsughanda, and Kesarnellu had high protein (13.63-13.97%) and zinc (30.17 ppm) content compared to yield checks like MAS 946-1 and MAS26, but less than nutrient checks like HP1 (Zn), and HP9 (Protein). Naga Batta has high iron content (15.72 ppm) compare with check HP7 (15.21 ppm). Among the top high-yielding landraces Neergoli (25.42), Jeerige Batta (22.16g), DBN (21.34g), Kesarnellu (20.31g), and Doddiga (20.03g) had high grain yield per plant. Hence, it gave scope for the selection of suitable local landrace as parents in the crossing program.

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