Consumer Preference: Crucial in Determining the Grain type-richness in Rice Varieties Grown across Kerala, India

A Suma[1*], RM Francies[2], VV Radhakrishnan[2], C Beena[2] and IS Bisht[3]

[1] *ICAR-National Bureau of Plant Genetic Resources, Regional Station, Vellanikkara, KAU, P.O, Thrissur–680656, Kerala, India*
[2] *College of Horticulture, Kerala Agricultural University, Vellanikkara, KAU.P.O, Thrissur–680656, Kerala, India*
[3] *ICAR-National Bureau of Plant Genetic Resources, Regional Station, Bhowali–263132, Nainital, Uttarakhand, India*

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Popularity, preference and acceptability of a variety are dependent on grain qualities among other aspects. With emphasis on development of rice varieties with consumer acceptable grain qualities is gaining momentum, an attempt was made to assess the variability in grain characteristics of traditional as well as high yielding rice varieties grown across Kerala. The analysis of variance revealed existence of highly significant differences among the genotypes for all the grain characteristics studied. Low influence of environment on trait expression was evident from narrow difference observed between phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV). The results of cluster analysis and Principal Component Analysis (PCA) proved that the varieties were diverse in their grain characteristics. The cluster analysis indicated remarkable homogeneity among the traditional rice varieties for the grain characteristics evaluated. The cooking parameters were best expressed by the short-grain high yielding variety Varsha.

Key Words: Amylose content, Cooking quality, Elongation ratio, Grain characteristics

Introduction

Rice (*Oryza sativa* L.) is the most important cereal crop in India and Kerala in particular. The diverse rice agro-ecological niches in Kerala demands cultivation of an array of varieties. Until recently, development of varieties with high yield, pest and disease resistance was of prime importance. In view of these considerations, several high yielding varieties have been developed. However, in recent times a major shift in focus has occurred in rice breeding programmes. Emphasis on quality as well as quantity of rice produce is being stressed. Development of varieties with preferable cooking qualities and consumer acceptance is gaining momentum.

Commercially, grain size, shape, kernel colour and appearance are important physical features that determine both market value and consumer preference of rice. The choice of a variety is highly dependent on its cooking quality, grain colour, aroma and grain yield along with other grain quality attributes. White kernelled fine grained rice is widely consumed throughout India. However, unlike in other parts of India, the preference of rice grain type in Kerala differs significantly. Keralites prefer bold, red kernelled and non-sticky parboiled rice. The grain colour of rice varieties grown in Kerala vary from straw gold to brown tinged to complete brown to black and grain shape varies from round to short bold to long bold to long slender kernelled grains (Leenakumary, 2011). The red rice preferred by Keralites undergoes minimal milling and polishing.

Success in crop improvement generally depends on the magnitude of genetic variability and the extent to which the desirable characters are heritable (Vanaja and Babu, 2006). Heritability and genetic advance are important selection parameters in plant breeding. Heritability estimates along with genetic advance are generally more helpful in predicting the gain under selection than heritability estimates alone (Bisne *et al.,* 2009). Grouping or classification of genotypes based on suitable scale is quite imperative to understand the usable variability existing among them (Shahidullah *et al.,* 2009). Thus cluster analysis that groups the genotypes based on standardized euclidean distance and ordination Principal Component Analysis (PCA) are highly informative. Genetic diversity along with the information on genetic parameters of the traits helps in deciding the selection criteria for generating valuable

*Author for Correspondence: Email- sumaagri@gmail.com

genotypes (Majumder *et al*., 2011). The traditional and high yielding rice varieties grown in the varied agro-ecological niches of Kerala is a rich cafeteria of variability with respect to morphological, physico-chemical and organoleptic qualities. However, the rich diversity of forms available in the rice germplasm of Kerala has been evaluated only on a limited scale. Hence, as a prerequisite towards breeding for improved grain attributes, the present study was undertaken to assess the variability and phylogenetic diversity among varieties grown across Kerala with respect to grain quality and cooking characteristics.

Materials and Methods

A varietal evaluation trial with fifty rice varieties was laid out in a randomized block design with two replications at the Department of Plant Breeding and Genetics, College of Horticulture, Vellanikkara, Kerala Agricultural University (KAU). The varieties included thirtyseven high yielding varieties and thirteen traditional rice varieties grown across Kerala. Variety Jarwa from Andaman and Nicobar Islands was included as a check to elucidate the correctness of grouping of varieties based on distinctness. Good agronomic management of the crop was done as per standard package of practices recommendation (KAU, 2011).

The grain characteristics were recorded on two random samples drawn from a seed lot of ten plants selected at random in each replication of an entry. Observations on grain length (GL), grain breadth (GB), GL/GB, kernel length (KL) and kernel breadth (KB) were measured using grain caliper on ten representative grains from each of the ten selected plants. 1000 grain weight, grain density (GD), elongation ratio (ER), volume expansion after cooking (VE) and amylose content were determined as per standard procedure (Shobha Rani *et al.*, 2004). Freely downloadable OPSTAT Package developed by CCS Haryana Agricultural University, Hisar, India was used for statistical analysis (http://www.hau.ernet.in/opstat.html). Clustering of genotypes and principal component analysis (PCA) were done using software Windostat Version 9.2 from Indostat Services, Hyderabad, India.

Results and Discussion

The analysis of variance revealed the presence of highly significant differences among the genotypes for all the characters studied (Table 1), which might be due to diverse source of materials as well as environmental influence affecting phenotypes. Table 2 Summarises the mean values recorded for the characters studied. Grain length varied between 6.36 mm (Chomala) and 9.56 mm (Sulochana) with a mean value of 7.9 mm while grain breadth ranged from 1.79 (Chomala) to 3.28 mm (Samyuktha) with a mean value of 2.55 mm.

According to DUS descriptor for rice (Shobha Rani *et al.*, 2004), grains can be classified as very short (<6.0 mm), short (6.1-8.5 mm), medium (8.6-10.5 mm), long (10.6-12.5 mm) and very long (>12.5 mm) based on grain length and as very narrow (<2.0 mm), narrow (2.1-2.5 mm), medium (2.6-3.0 mm), broad (3.1-3.5 mm) and very broad (>3.5 mm) as per the grain breadth. In accordance with this classification, 44 genotypes were of short and seven medium grain type while three genotypes were very narrow, 26 narrow, 21 medium and one broad grain type. This point out that during crop improvement efforts undertaken, selection for grain type was by far unidirectional, focussing on bold seeded grain type in tune with the grain type preference of Keralites. Grain length to breadth ratio was maximum for Sulochana (4.05) and minimum for Samyuktha (2.29) with a mean value among varieties being 3.13. The value of kernel length ranged from 2.75 mm (Varsha) to 5.98 mm (Aathira) with a mean value of 4.53 mm. Kernel breadth exhibited a mean value of 2.01 mm with a range of 1.25 mm (White Ponni) to 2.77 mm (Navara 11-2). Based on kernel length and kernel length to breadth ratio, the varieties were classified following Shobha Rani

Table 1. Analysis of variance for grain quality characters of rice varieties

		Mean sum of squares									
Source of Variation	DF	GL (mm)	GB (mm)	GL/GB	GD (g/mm^3)	TGW (g)	KL (mm)	KB (mm)	VER	ER	AC (%)
Replication	1	0.102	0.005	0.052	0.062	0.00003	0.114	0.002	0.004	0.012	0.038
Treatments	50	0.816**	0.156**	0.292**	0.274**	0.225**	0.865**	0.186**	0.880**	0.103**	17.839**
Error	50	0.032	0.003	0.029	0.016	0.00083	0.038	0.009	0.125	0.005	0.329

DF= Degrees of freedom; ** Significant at 1% level
GL= Grain length; GB= Grain breadth; GD= Grain density; KL= Kernel length; KB= Kernel breadth; TGW= 1000 grain weight; AC= Amylose content; VER= Volume expansion ratio; ER= Elongation ratio

Table 2. Mean performance of rice genotypes for grain characteristics

S. No	Varieties	GL (mm)	GB (mm)	GL/ GB	GD (g/mm^3)	KL (mm)	KB (mm)	VER	ER	AC (%)	TGW (gm)
1	Vaisakh	8.87	3.11	2.86	0.78	3.65	2.24	4.00	2.01	16.65	28.40
2	Uma	7.20	2.71	2.66	1.06	3.61	2.26	2.33	2.00	16.14	25.00
3	Jyothy	9.09	2.63	3.45	0.93	5.32	2.02	2.00	1.51	15.53	28.50
4	Aiswarya	8.72	2.57	3.39	1.19	4.61	2.10	1.67	1.64	17.82	28.10
5	Harsha	7.76	2.57	3.02	1.08	3.99	2.17	1.88	2.03	22.50	24.10
6	Annapoorna	8.32	2.44	3.46	0.80	3.98	2.12	2.21	1.79	13.57	24.90
7	Matta Triveni	8.32	2.70	3.09	0.75	4.52	2.06	2.04	1.66	17.68	27.10
8	Swarnaprabha	8.77	2.75	3.19	0.90	4.85	2.09	3.75	1.75	20.87	26.20
9	Samuyktha	7.34	3.28	2.30	0.90	5.04	2.36	4.00	1.76	17.54	23.70
10	Kairali	8.30	2.48	3.34	1.29	4.23	1.85	2.04	1.85	13.29	24.20
11	Jayathi	7.74	2.51	3.08	0.88	4.09	2.14	2.13	1.98	14.60	23.70
12	Kanchana	7.82	2.58	3.03	0.70	4.80	1.78	1.88	1.64	14.92	28.80
13	Triveni	8.98	2.54	3.53	0.67	5.00	1.95	1.93	1.72	15.77	28.30
14	Makom	7.94	2.28	3.48	0.54	4.42	1.67	1.63	1.68	11.51	23.80
15	Varsha	6.76	2.77	2.44	0.99	2.75	2.31	4.08	2.31	16.75	25.90
16	Thekkencheera*	7.72	2.61	2.96	0.54	3.74	2.16	1.92	1.87	14.88	22.20
17	Cheriyaaryan*	8.24	2.62	3.15	0.97	3.93	2.28	2.28	1.84	15.58	27.80
18	Ahalya	7.33	2.49	2.94	0.80	3.47	2.24	1.50	2.07	15.67	24.10
19	Parambuvattan*	7.75	2.37	3.28	1.00	4.25	2.20	1.88	1.71	16.80	26.60
20	Aruna	7.67	2.53	3.04	0.81	4.11	1.93	1.92	1.83	13.94	27.90
21	Onam	7.32	2.33	3.14	0.92	4.94	1.87	1.68	1.51	20.21	25.00
22	Revathi	7.36	2.24	3.29	0.92	5.26	1.62	1.38	1.41	13.85	24.20
23	Jarwa	8.00	2.63	3.04	0.89	5.69	1.94	3.13	1.67	17.59	24.20
24	Ponmani	6.81	2.51	2.72	0.66	4.44	2.12	3.19	1.52	10.71	21.50
25	Mahsoori	8.00	2.00	4.05	0.90	4.80	1.62	1.83	1.70	11.32	16.70
26	MangalaMahsoori	7.55	2.04	3.71	0.85	5.21	1.67	1.84	1.36	22.41	18.80
27	Nila	7.18	3.09	2.33	0.61	4.81	2.64	2.57	1.44	21.33	22.90
28	Aathira	7.81	2.65	2.95	0.86	5.98	2.32	1.63	1.33	18.06	26.20
29	Anaswara	7.70	2.68	2.88	0.66	4.96	2.10	2.13	1.51	22.04	24.70
30	White ponni	7.47	1.95	3.83	0.82	4.57	1.24	1.88	1.54	10.67	16.80
31	Thulasi	7.65	2.99	2.56	0.79	5.53	2.42	2.29	1.33	15.49	24.20
32	Sulochana	9.57	2.36	4.06	1.55	3.47	1.94	2.38	1.23	14.83	24.00
33	KAU-M-87-1	7.21	2.52	2.86	1.45	4.85	1.98	2.00	1.45	13.33	23.40
34	Krishnanjana	8.29	2.42	3.43	0.69	5.23	2.12	1.63	1.50	19.13	24.90
35	M-20	8.44	2.21	3.82	0.82	5.56	1.74	1.54	1.41	13.89	21.70
36	Karthika	7.08	2.37	2.99	1.30	4.79	1.98	1.63	1.43	17.82	20.40
37	Remanika	7.43	2.46	3.02	0.78	5.17	2.09	1.48	1.36	18.06	23.40
38	Prathyasa	7.73	2.67	2.89	1.13	5.37	2.04	1.88	1.50	21.80	26.80
39	Arimodan*	8.23	2.44	3.38	1.06	4.38	1.43	1.88	1.70	14.55	26.60
40	Thottacheera*	8.30	2.74	3.03	0.94	4.22	2.29	1.50	1.66	14.32	27.70
41	Kalladiaryan*	7.91	2.82	2.81	0.89	3.75	2.48	2.14	1.83	17.08	27.30
42	Navara 11-2	8.23	2.77	2.98	1.56	4.27	2.77	1.63	1.71	11.74	29.20
43	Kunjukunju Varna	7.56	2.58	2.93	0.98	3.69	1.80	1.75	1.95	15.91	24.50
44	Paramban Kayama*	8.86	2.80	3.17	1.03	4.54	2.16	1.88	1.74	20.12	31.70
45	Chuvannamodan*	8.69	2.60	3.35	1.01	4.49	1.82	1.97	1.82	16.00	27.70
46	Chomala*	6.36	1.80	3.54	3.04	4.37	1.69	1.63	1.38	18.29	15.20
47	Karuthamodan*	7.79	2.48	3.14	1.08	5.38	1.48	1.67	1.40	18.15	26.90
48	Karanavara*	8.44	2.81	3.01	0.98	4.31	1.77	2.20	1.74	16.94	29.50
49	Karuthadukkan*	7.85	2.68	2.93	0.93	4.30	1.79	1.70	1.70	14.41	27.90
50	Kunjukunju*	7.62	2.35	3.25	0.86	4.69	1.58	2.67	1.71	15.02	26.60

*= Traditional varieties

GL= Grain length; GB= Grain breadth; GD= Grain density; KL= Kernel length; KB= Kernel breadth; TGW= 1000 grain weight; AC= Amylose content; VER= Volume expansion ratio; ER= Elongation ratio *et al.* (2004). Six varieties namely Revathy, Mangala Mahsoori, White Ponni, M-20 in addition to traditional rice varieties Arimodan and Karuthamodan possessed short slender grains (having KL<6 mm and KL/KB ratio>3.0). Eleven varieties including traditional rice varieties Chomala and Kunjukunju were medium slender (KL< 6 mm and KL/KB 2.5-3.0) while the remaining 34 varieties (66.67%) were of short bold type (KL< 6 mm and KL/KB< 2.5). Eight out of the 13 traditional varieties in the study possessed short bold kernels. This may be the consequence of selection by the farmers for the bold seeded type of grains.

The range of variation for grain density ranged between 0.54 (Thekkencheera) to 3.04 (Chomala) with a mean value of 0.97. The mean value for test weight of grains (1000 seeds weight) ranged from 15.2 g (Chomala) to 31.65 g (Parambankayama). Based on 1000 grain weight, the genotypes can be classified as very low (<15.0 g), low (15-20 g), medium (21-25 g), high (26-30 g) and very high (>30 g). Hence, there were five genotypes under the class low, 23 under medium class, 21 under high and one genotype under very high class.

During cooking, rice kernels absorb water and increase in volume through increase in length or breadth (Hogan and Plank, 1958). The physical characteristics of kernel recorded after cooking were volume expansion ratio (VER) and elongation ratio (ER). The Volume Expansion Ratio (VER) ranged from 1.38 (Revathy) to 4.08 (Varsha) with a mean value of 2.10. Kernel elongation ratio on cooking is considered as a desirable character in most of the rice consuming areas in the world. The range of variation for ER was 1.33 (Sulochana) to 2.31 (Varsha) with a mean value of 1.66.

Consumer preference for rice around the world, when compared as intact grain, is largely dependent on a desire for its cooked texture to be either firm or non-sticky or soft and sticky (Abeysekera *et al*., 2008). Amylose content is the key determinant of the different cooking, sensory and processing properties of rice (Chen *et al*., 2008). Cooked rice becomes moist and sticky due to low amylose content. Based on the Amylose content, rice can be classified into very low amylose content (3-9%), low amylose content (10-19%), medium amylose content (20-25%) and high amylose content (26-30%) (Shobha Rani *et al*., 2004). In the present investigation, 42 varieties possessed low amylose (10-19%) while remaining eight were medium (20-25%) for amylose content.

The genetic parameters for grain quality characters of 50 rice varieties are enumerated in Table.3. PCV was greater than GCV for all the traits studied while the difference between the two was low pointing to influence of environment on trait expression, though at a lower magnitude. Similar results were reported by Rathi *et al*. (2010), Subbaiah *et al*. (2011) and Pathak *et al*. (2016). According to Johnson *et al.* (1955), a combined interpretation of the estimates of PCV, GCV, heritability and genetic gain prove to be more useful in a breeding programme rather than an individualistic approach. The low per cent of PCV (8.23) and GCV (7.91) coupled with high heritability (92.39) but moderate genetic gain (15.67) registered by grain length suggested that the trait can be improved by intermating superior genotypes of segregating population developed from combination breeding as reported by Samadia (2005).

Similar to grain length, grain breadth had also registered high heritability value (76.16) and moderate genetic gain (18.28 %) but only moderate PCV (11.66) and GCV (10.17). This suggests that these traits are primarily under non-additive genetic control and therefore simple selection based on their phenotypic performance alone will not achieve the desirable improvement in these traits. Hybridization followed by selection in the resulting progenies would prove more useful in this case. In contrast to the study, Rathi *et al.* (2010) had recorded high heritability with low genetic advance for this trait.

Genetic gain is a valuable indication to the possible improvement in a trait that can be expected from a breeding programme. All traits except grain length and breadth registered high genetic gain while these two traits had exhibited moderate genetic gain. The results were in consonance with the findings of Vanaja and Babu (2006) for GL/GB ratio, amylose content and volume expansion ratio. Devi *et al.* (2016) reported high heritability estimates coupled with moderate genetic gain for kernel length and width. In contrast to the above findings Pathak *et al.* (2016) had reported low genetic gain for grain length and breadth.

Assessment of diversity in a population is essential for an attempt for varietal improvement. The grain characteristics of 50 rice genotypes were subjected to multi-variate analysis. Cluster analysis of the eleven

Table 3. Statistical and genetic parameters for grain characteristics of 50 rice varieties under study

Traits	Range		Mean	PCV (%)	GCV (%)	h^2 (%)	Genetic advance	Genetic gain (%)
	Minimum	Maximum						
GL (mm)	6.36	9.57	7.90	8.24	7.92	92.40	1.24	15.68
GB (mm)	1.79	3.28	2.55	11.66	10.17	76.16	0.47	18.29
GL/GB	2.30	4.06	3.13	12.80	11.56	81.55	0.67	21.50
GD (g/mm^3)	0.54	3.04	0.97	39.09	36.88	89.01	0.70	71.68
KL (mm)	2.75	5.98	4.54	14.81	14.17	91.52	1.27	27.92
KB (mm)	1.24	2.77	2.01	15.57	14.77	90.02	0.58	28.88
VER	1.48	4.08	2.10	33.74	29.25	75.17	1.10	52.25
ER	1.23	2.31	1.67	14.00	13.28	89.98	0.43	25.94
AC (%)	10.67	22.50	16.34	18.44	18.11	96.37	5.98	36.62
TGW (g)	15.20	31.65	25.04	13.43	13.38	99.26	0.69	27.45

GL= Grain length; GB= Grain breadth; GD= Grain density; KL= Kernel length; KB= Kernel breadth; TGW= 1000 grain weight; AC= Amylose content; VER= Volume expansion ratio; ER= Elongation ratio

physico-chemical characters (Table 4) based on standardised euclidean distance indicated the presence of five clusters. The analysis permitted separation of red kernelled medium slender grained traditional variety Chomala (Cluster V) from the rest of the genotypes. The cluster II was also a monogenotypic cluster, comprised of variety Jarwa from Andaman and Nicobar Islands. As this variety was from a distinct geographical location, totally separated from Kerala, it was expected that there would not be any introgression of genes between this variety and rice gene pool of Kerala comprising of the wild relatives, landraces, traditional rice varieties and the high yielding varieties available in the state. Hence, the distinctness of this variety as evident from the result confirms the correctness of grouping of varieties based on distinctness. However, several earlier reports of non-correspondence of geographic origin with genetic diversity is also evident (Shanmugasundaram *et al.*, 2000; Nayak *et al.*, 2004; Banumathy *et al.*, 2010). Cluster I comprised of five short bold grained varieties. The fourth cluster comprised of 16 varieties, which included a mix of short bold to short slender and medium slender grains. Karuthamodan with short slender grains was the only traditional variety included in this cluster. Cluster III with twenty seven varieties was the largest cluster among the five. All the traditional varieties except Karuthamodan and Chomala were grouped in this cluster. Similarly, all the traditional varieties except Arimodan included in cluster III, possessed short bold grain indicating remarkable homogeneity for the grain characteristics studied. It was evident that majority of the varieties released from Regional Agricultural Research Station, Pattambi, Kerala were grouped under cluster III. This point out that during crop improvement efforts undertaken at the centre, selection for grain type was by far unidirectional, focussing on bold seeded grain type in tune with the grain type preference of Keralites. Clustering based on grain characteristics were earlier done by Sanni *et al.* (2010) using 434 landraces accessions of *O. sativa* L. germplasm from Cote d'Ivoire.

The result of principal component analysis (PCA) implies the importance and contribution of each component to total variance. The criterion used by Clifford and Stephenson (1975) and corroborated by Guei *et al.* (2005) suggest that the first three principal components are often the most prominent in reflecting the variation pattern among accessions and the characters associated with these are more useful in differentiating

Table 4. Distribution of 50 rice varieties in to different clusters

Cluster numbers	Number of varieties	Varieties included
I	5	Vaisakh, Swarnaprabha, Samyuktha, Nila, Varsha
II	1	Jarwa
III	27	Jyothi, Triveni, Aiswarya, Chuvannamodan, Matta Triveni, Karanavara, ParambanKayama, Annapoorna, Kairali, Parambuvattan, Aruna, Karuthadukkan, Kanchana, Arimodan, Makom, Sulochana, Jayathi, Kunjukunjuvarna, Thekkencheera, Ahalya, Uma, Harsha, Cheriya Aryan, Kalladi Aryan, Thottacheera, Kunjukunju, Navara 11-2
IV	16	Onam, Remanika, Krishnanjana, Anaswara, Prathyasa, Aathira, Thulasi, KAU-M-87-1, Karthika, Ponmani, Revathi, Karuthamodan, M-20, MangalaMahsoori, Mahsoori, White Ponni
V	1	Chomala

Table 5. Eigen value and eigen vectors of the first three principal components

	1 vector	2 vector	3 vector
Eigen value	3.57	1.81	1.67
% variance	32.41	16.49	15.21
Cumulative variance of total variance	32.41	48.90	64.10
GL (mm)	0.08	0.33	0.85
GB (mm)	0.85	0.38	-0.00
GL/GB	-0.74	-0.15	0.50
TGW (gm)	-0.56	0.37	0.55
GD	-0.28	-0.39	-0.24
KL (mm)	-0.49	0.79	-0.21
KB (mm)	0.31	0.29	-0.27
VER	0.61	0.01	-0.23
ER	0.69	-0.49	0.21
AC (%)	0.16	0.48	-0.35

GL= Grain length; GB= Grain breadth; GD= Grain density; KL= Kernel length; KB= Kernel breadth; TGW= 1000 grain weight; AC= Amylose content; VER= Volume expansion ratio; ER= Elongation ratio

accessions (Sanni *et al.,* 2010). Accordingly, the first three principal components accounted for about 64.1% of total variance observed (Table 5).The variable contributing most positively for the first component was grain breadth. Among the property vectors of PC1 (Principal component), weight of 1000 grains, volume expansion ratio and elongation ratio registered higher values. The second principal component that accounted for 48.89% of total variance is positively correlated by the variable kernel length (mm). Similarly, third PC accounted for 64.10% of total variance and is significantly contributed by grain length (mm). Hence, it can be concluded that grain length and breadth and kernel length are the main contributors of variability in grain quality characteristics. The results from cluster analysis and PCA revealed that the clustering pattern gathered complemented each other with slight inconsistencies.

The results of the study suggest that there was considerable genetic variation among rice varieties grown in Kerala for grain cooking and biochemical qualities. This variation offers broad opportunities in breeding program to develop varieties with locally acceptable cooking quality. Among the varieties studied, cooking parameters were best expressed by the high yielding variety Varsha as evident from the high value for elongation ratio and volume expansion ratios. Most of the varieties fall under the category of short bold seeded type. Boldness of the grains being the primary selection criterion of Kerala farmers is confirmed from the results. The distribution of traditional varieties among farmers through informal seed exchange system and their practice of informal selection for bold grained genotypes in addition to gene flow among these genotypes might have contributed to the prevalence of bold seeded types in Kerala.

The indigenous land races in Kerala are invariably semi-tall to tall, poor tillering, lodging with low yield unlike the high yielding varieties. However, the poor productivity of the landraces was not detrimental to their acceptance and popularity in the region, owing mainly to their bold grain type. Maintaining the diversity of forms in cultivated varieties is important not only to overcome genetic erosion but also to avoid monopoly of forms *i.e*., uniformity of a trait among the cultivars. The narrowing genetic base of cultivars predominantly grown in a location is a reason leading to yield loss due to pest and disease outbreak. However, unlike this, grain quality preference in a geographical location is quiet unique and cannot be altered to large extent to preserve diversity. Local preference will continue to decide the grain characteristics in varieties bred in future. Hence, the assessment of variability and diversity for these traits are crucial in any attempt of crop improvement.

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