Genetic performance of medicinal landraces in comparison with improved cultivars for nutritive and grain quality traits in rice (*Oryza sativa* L.)

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Received : Accepted : 23 March 2016 Published : 20 July 2016

ABSTRACT

Rice (Oryza sativa L.) is the most important food crop in South and South East Asian countries, particularly in developing countries like India. The nutritive and grain qualities cooking of the rice is one of the most serious problems in many rice producing areas of the world. The experimental material used were four traditional medicinal land races and six improved high yielding varieties of Tamil Nadu raised in Randomized Block Design during Kharif, 2012-2013. Observation were recorded and analysed for variability parameters moderate values of PCV, GCV were observed for L/B ratio (mm), L/B ratio after cooking (mm), kernel length after cooking (mm), volume expansion ratio, kernel breadth (mm) and amylose content (%) while high PCV, GCV recorded for biochemical characters viz., magnesium (mg/100g), calcium (mg/100g), copper (ppm), zinc (ppm) and crude protein (%) indicated large extent of genetic variability for these traits in the materials studied. The estimates of genotypic variances showed a considerable range of variation for most of the characters. High values of heritability coupled with high genetic advance as per cent of mean were observed for L/B ratio (mm), L/B ratio after cooking (mm), volume expansion ratio, kernel length after cooking (mm), kernel breadth (mm) and amylose content (%) along with high values of all the biochemical traits indicating involvement of additive gene action for these traits and phenotypic selection based on these traits in the future generations would likely to be more effective. When compared with the high yielding varieties, the landraces Veeradangan and Kavuni recorded very high nutritive values viz., calcium, iron and zinc content.

Key words: *Rice, Genetic components, grain quality, nutritional quality, heritability, genetic advance, gene action.*

Rice (*Oryza sativa* L.), the staple food of the Indian population has prime importance in food and nutritional security. Globally, rice meets the daily calories requirement for most of the population, resulting in poverty alleviation. Brown rice is one of the most popular health produce due to its rich nutrients and bioactive components (Houston *et al.* 1970) that prevent a variety of diseases. During cooking, the physical properties and nutritional qualities change depending on the type of rice variety (Mahadevamma *et al.* 2007). When considering dietary refinement, bioavailability of minerals and micro nutrients have increased in field of nutrition. Elements which are required in trace amounts are Ca, Fe, Zn, Mn, Mg and Cu *etc.* because higher concentration can be harmful. All these elements are essential for normal growth and development because, they play important role in nerve functioning, sugar metabolism, activity of numerous enzymes and in cardiac function (Milena *et al.* 1993). The mineral composition of rice differs with variety. Micro nutrient malnutrition affects over three billion people worldwide, mostly in developing countries (Welch *et al.* 2004). Biofortification is a genetic approach which aims at biological and genetic enrichment of food stuffs with vital nutrients (vitamins, minerals and protein). Ideally, once rice is biofortified with vital nutrients, the farmer can grow indefinitely without any additional input to produce nutrient packed rice grains in a sustainable way. This is also the only feasible way of reaching the malnourished population in India. In this context, breeders are now focusing on nutritional enhancement to overcome the problem of malnutrition (Nagesh *et al.* 2012). The quality means the chemical properties not alone, but comprises the physical, milling, cooking and nutritional qualities *etc*. Further, most of the rices are milled and the important physical properties are determined by the milled grains (Manonmani *et al*. 2010). Hence it is possible to develop rice varieties for acceptance nutritional and grain quality. With view to improve the physical and biochemical qualities in improved rice cultivars attempt had been made to measures of variability, heritability and genetic advance for grain quality and nutritional traits in indigenous medicinal land races and high yielding varieties of rice.

MATERIALS AND METHODS

The experimental material consisted of four medicinal landraces *viz.*,Veeradangan Kavuni, Kathanellu and Navara which were collected from Tamil Nadu and Navara is a medicinal landrace of Kerala. These landraces are having superior nutritional grain qualities and low yielder and six improved semi-dwarf high yielding varieties *viz.*, IR 72, ADT 39, ADT 45, ASD 16 and TPS 4 of medium grain quality along with standard check ADT 43 raised in Randomized Block Design replicated thrice by adopting a spacing of 30 x 10 cm at Department of Plant Breeding and Genetics, Agricultural College and Research Institute, Madurai during *Kharif*, 2012. The recommended packages of practices were followed. Data were recorded on thirteen grain quality characters *viz.*, hulling per cent (%), milling per cent (%), head rice recovery (%), kernel length (mm), kernel breadth (mm), L/B ratio (mm), kernel length after cooking (mm), kernel breadth after cooking (mm), L/B ratio after cooking (mm), linear elongation ratio (mm), volume expansion ratio, gelatinization temperature and amylose content (%) as per the Standard Evaluation System (SES, 1996) descriptor suggested by IRRI. Seven mineral contents *viz.*, crude protein content (%), calcium content (mg/100g), magnesium content (mg/100g), iron content (ppm), zinc content (ppm), copper content (ppm) and manganese content (ppm) were also estimated for eleven genotypes. The mean data for each character individually was subjected to statistical analysis. Standard statistical procedures were used for the analysis of mean variance, genotypic and phenotypic coefficients of variation (Burton 1952), heritability (Lush 1940) and genetic advance.

RESULTS AND DISCUSSION

Analysis of variance for grain quality revealed significant differences among the genotypes for characters studied indicating the existence of significant amount of variability for the characters (Table 1). The mean values indicated considerable variation for all grain quality traits (Table 2) (Fig 1). The range for hulling per cent varied from 78.30 to 89.11 per cent and the maximum was recorded by IR 72 (89.11%), ADT 39 (89.10%) and TPS 4 (86.30%). The range for milling per cent varied from 64.09 to 77.83 per cent and the maximum was recorded by IR 72 (77.83%), TPS 4 (76.10%), ADT 39 (74.71%) and Navara (73.54%). The range for head rice recovery varied from 51.38 to 68.13 per cent among the landraces, Navara registered maximum (68.13%), followed by Kavuni (63.13%), Kathanellu & TPS 4 (61.82%). The entries, IR 72 (6.82 mm), ADT 43 (5.63 mm) showed high mean value for kernel length while Kathanellu (2.81 mm), Veeradangan (2.63 mm), TPS 4 (2.62 mm) and Kavuni (2.41 mm) recorded the highest kernel breadth. The range for L/B ratio varies from 1.83 to 3.39 mm and the maximum was recorded by ADT 45 (2.76 mm), ASD 16 (2.66 mm) and ADT 43 (2.50 mm). The entries, ADT 39 (8.53 mm), ADT 45 (8.52 mm), ADT 43 (7.58 mm), IR 72 (7.50 mm) and ASD 16 (6.70 mm) showed high mean value for kernel length after cooking while Kathanellu (3.00 mm), ADT 39 and Navara (2.90 mm), IR 72 (2.89 mm), TPS 4 (2.80 mm) and ADT 43 (2.77%) recorded the highest kernel breadth after cooking. The range for L/B after cooking ratio varies from 2.06 mm to 3.38 mm and the maximum was recorded by ADT 39 (2.94 mm) and Veeradangan and ADT 43 (2.79 mm). Linear elongation ratio less than

Table.1. Analysis of variance for various grain quality traits in rice

Source	H %	M %	HRR %	KL	KB	L/B	KLAC	KBAC	L/BAC	LAR	VER	GT	AC
Replication	0.060	0.481	0.014	0.001	0.002	0.0003	0.054	0.010	0.018	0.005	0.001	0.433	0.924
Treatment	40.625	57.451	90.674	0.829*	0.227*	0.658*	2.525*	0.154*	0.0447*	0.046*	1.057*	0.800*	18.739*
Error	1.602	1.242	1.385	0.025	0.004	0.002	0.049	0.014	0.003	0.0009	0.013	0.322	0.475

*Significance at 5% level

Table. 2 Mean performance of grain quality traits in rice

Entries	H %	M %	HRR %	KL	KB	L/B	KLAC	KBAC	L/BAC	LAR	VER	GT	AC
Veeradangan	78.30	68.50	56.51	5.52	2.63*	2.09	6.41	2.30	2.79*	1.65*	4.59	3.66	25.09*
Kavuni	79.90	70.10	63.15*	5.10	2.41*	2.11	6.20	2.49	2.48	1.53*	3.40	4.33	27.19*
Kathanellu	83.14	72.39	61.82*	5.16	2.81*	1.83	6.20	3.00*	2.06	1.49	5.39*	3.33	24.59*
Navara	82.35	73.54*	68.13*	5.54	2.36	2.35	6.30	2.90*	2.17	1.41	4.90*	3.66	20.12
IR 72	89.11*	77.83*	53.19	6.82*	2.01	3.39	7.50*	2.89*	2.59	1.72*	5.29*	4.66*	21.10
ADT 39	89.10*	74.71*	51.38	5.19	2.31	2.25	8.53*	2.90*	2.94*	1.63*	4.79*	3.66	20.11
ADT 45	81.90	66.07	54.67	5.71	2.07	2.76*	8.52*	2.51	3.38	1.49	4.21	3.66	22.32
ASD16	83.90	72.30	62.16*	5.38	2.02	2.66*	6.70*	2.60	2.58	1.34	4.10	3.33	20.11
TPS 4	86.30*	76.10*	61.82*	4.96	2.62*	1.89	6.60	2.80*	2.36	1.48	4.39	4.66*	20.52
ADT 43	82.69	64.09	53.51	5.63*	2.25	2.50*	7.58*	2.77*	2.79*	1.38	4.32	4.33	21.79
Mean	83.59	71.56	58.63	5.50	2.34	2.38	7.50*	2.71	2.61	1.51	4.54	3.93	22.29
S.E.D	1.03	0.91	0.96	0.13	0.05	0.04	0.18	0.06	0.04	0.02	0.09	0.46	0.56
CD (P <0.05)	2.17	1.91	2.01	0.27	0.11	0.08	0.38	0.11	0.10	0.05	0.19	0.97	1.18

*Significance at 5% level

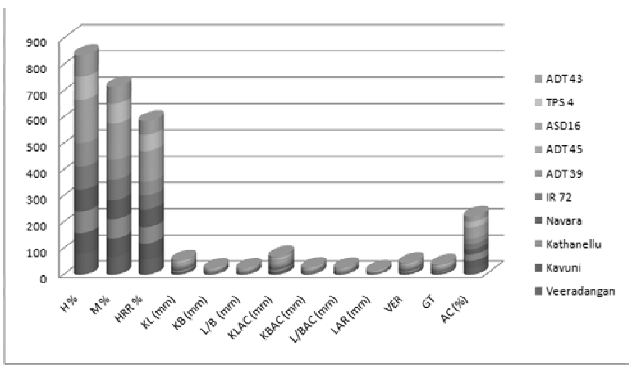

Fig. 1. Mean performance of grain quality traits in land races and varieties in rice

1.32 is undesirable (Dipti *et al.* 2003). In the present study, all the entries recorded highest linear elongation ratio. The entries, Kathanellu (5.39 mm), IR 72 (5.29 mm), ADT 39 (4.79 mm) and Navara (4.90 mm) showed high mean value for volume expansion ratio followed by IR 72 & TPS 4 (4.66 %) recorded the highest gelatinization temperature. The range for amylose content varies from 20.11 to 27.19 per cent and the maximum was recorded by land races *viz.*, Kavuni (27.19%), Veeradangan (25.09%).

Analysis of variance for nutritional traits revealed significant differences among the genotypes for all the characters studied indicating the existence of significant amount of variability for the characters studied (Table 4). The mean values indicated considerable variation for all grain nutritional traits (Table 5) (Fig 3). The range for crude protein content varies from 5.43 to 11.46 per cent and the maximum was recorded by Veeradangan (11.46%), Kathanellu (10.57%), Kavuni (9.71%), IR 72 (9.01%) and ADT 43 (8.58%). The entries, Veeradangan (4.79 mg/100g), ADT 39 (2.60 mg/100g), Kavuni (2.59 mg/100g) and ASD 16 (2.40 mg/100g) showed high mean value for calcium content while IR 72 (1.92 mg/100g) recorded the highest magnesium content. The range for iron and zinc were 61.23 to 99.61 ppm and 14.23 to 61.15 to ppm respectively. Among the landraces, Veeradangan registered maximum Iron (99.61 ppm) and zinc content (61.15 ppm). The range for copper and manganese were 15.96 to 47.79 ppm and 16.86 to 26.56 ppm respectively. The line ADT 43 (47.79 ppm), TPS 4 (44.29 ppm) and ASD 16 (30.53 ppm) recorded the highest copper content. Among the landraces, Navara (27.38 ppm) registered maximum manganese content followed by Veeradangan (26.56 ppm) and TPS 4 (22.94 ppm).

The estimates on genotypic co-efficient of variation, phenotypic co-efficient of variation, heritability and genetic advance as per cent of mean for the traits studied are furnished (Table 3 & Table 6). In general, the PCV was higher than the corresponding GCV. In the present investigation, for all the traits studied, the phenotypic co-efficients of variation were higher than the genotypic co-efficients of variation. Since heritability is also influenced by environment, the information on heritability alone may not help in pin pointing characters for enforcing selection. Nevertheless, the heritability estimates in conjunction with predicted genetic advance will be more reliable (Johnson *et al*. 1955). Heritability gives the information on the magnitude of quantitative

Table 4. Analysis of variance for various nutritional quality traits in land races and varieties in rice

Source	Crude Protein (%)	Calcium (mg/100g)	Magnesium (mg/100g)	Iron (ppm)	Zinc (ppm)	Copper (ppm)	Manganese (ppm)
Replication	0.081	0.001	0.0000	5.907	0.117	0.746	0.023
Treatment	10.320*	3.709*	1.1042*	704.75*	695.92*	455.199*	41.782*
Error	0.032	0.004	0.0009	1.396	0.563	0.420	0.468

*Significance at 5% level

Table 5. Mean performance for nutritional quality traits in land races and varieties in rice

Entries	Crude Protein (%)	Calcium (mg/100g)	Magnesium (mg/100g)	Iron (ppm)	Zinc (ppm)	Copper (ppm)	Manganese (ppm)
Veeradangan	11.46*	4.79*	1.44	99.61*	61.15*	17.74	26.56*
Kavuni	9.71*	2.59*	1.69	96.88*	57.66*	17.11	17.98
Kathanellu	10.57*	1.19	1.20	69.15	38.48	16.07	17.33
Navara	5.43	0.79	1.69	98.48*	27.92	18.52	27.38*
IR 72	9.01*	1.59	1.92*	79.01	14.23	16.38	18.93
ADT 39	6.48	2.60*	0.48	72.54	58.86*	17.41	20.86
ADT 45	7.26	1.99	1.68	67.86	30.50*	15.97	18.67
ASD 16	7.97	2.40*	0.48	61.23	36.51	30.53*	16.86
TPS 4	7.52	1.60	0.47	97.37*	32.33	44.29*	22.94*
ADT 43	8.58*	1.60	0.48	68.23	39.22	47.79*	19.89
Mean	8.39	2.12	1.15	81.03	39.69	24.18	20.74
S.E.D	0.14	0.05	0.02	0.97	0.61	0.53	0.56
CD (P<0.05)	0.30	0.10	0.05	2.02	1.29	1.11	1.17

*Significance at 5% level

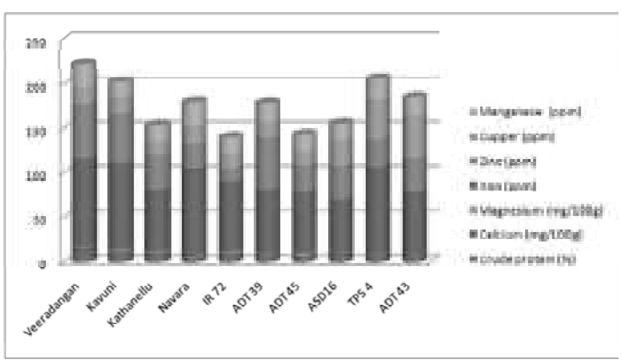

Fig. 3. Mean performance for nutritional quality traits in land races and varieties in rice

characters, while genetic advance will be helpful in calculating suitable selection procedures. Estimates of the amount of variability for different characters and their heritable components available in the population are essential for dynamic and efficient plant breeding.

The values for grain quality genotypic co-efficients of variation ranged from hulling per cent (4.31%) to L/B ratio (19.61 mm) (Table 6) (Fig 2). Moderate GCV was observed for L/B ratio (19.61 mm), L/B ratio after cooking (14.71 mm), volume expansion ratio (12.99), kernel length after cooking (12.89 mm), kernel breadth (11.61 mm), amylose content (11.07%) and gelatinization temperature (10.14). The lowest GCV was recorded for kernel length (9.40 mm), head rice recovery (9.30%), kernel breadth after cooking (8.22 mm), linear elongation ratio (8.12 mm), milling percent (6.04%) and hulling per cent (4.31%). The values for nutritional quality genotypic co-efficients of variation ranged from manganese (17.89 ppm) to magnesium (52.66 mg/100g) (Fig 4). The high GCV was observed for magnesium (52.66 mg/100g), calcium (52.48 mg/ 100g), copper (50.92 ppm), zinc (38.36 ppm) and crude protein (21.05%). The moderate GCV was observed for iron (18.89 ppm) and manganese (17.89 ppm).

The values for grain quality PCV ranged from hulling per cent (4.58%) to L/B ratio (19.73 mm). Moderate PCV was observed for L/B ratio (19.73 mm), gelatinization temperature (17.64), L/B ratio after cooking (14.87 mm), kernel length after cooking (13.26

Table 3. Estimates of genetic variability for grain quality traits in land races and varieties in rice

Characters	Range	Mean	PV	GV	PCV %	GCV %	h^2 (Broad sense)	GA as per cent of mean
Hulling per cent (H %)	89.11-78.30	83.59	14.61	13.00	4.58	4.31	0.89	8.39
Milling per cent (M %)	77.83-64.90	71.56	19.98	18.98	6.24	6.04	0.93	12.07
Head rice recovery (HRR %)	68.13-51.38	58.63	31.14	29.76	9.51	9.30	0.95	18.73
Kernel length (KL-mm)	6.82-4.96	5.50	0.29	0.27	9.84	9.40	0.91	18.51
Kernel breadth (KB- mm)	2.81-2.01	2.34	0.079	0.074	11.94	11.61	0.94	23.28
L/B ratio (L/B)	3.39-1.83	2.38	0.22	0.21	19.73	19.61	0.98	40.16
Kernel length after cooking (KLAC-mm)	8.53-6.20	7.05	0.87	0.82	13.26	12.89	0.94	25.78
Kernel breadth after cooking (KBAC-mm)	3.00-2.30	2.71	0.054	0.050	8.60	8.22	0.91	16.21
L/B ratio after cooking (L/B AC-mm)	3.38-2.06	2.61	0.15	0.14	14.87	14.71	0.97	29.95
Linear elongation ratio (LER-mm)	1.72-1.34	1.51	0.016	0.015	8.36	8.12	0.94	16.28
Volume expansion ratio (VER)	5.39-3.40	4.54	0.36	0.34	13.23	12.99	0.96	26.25
Gelatinization temperature (GT)	4.66-3.33	3.93	0.48	0.15	17.64	10.14	0.33	12.02
Amylose content (AC %)	27.19-20.11	22.29	6.56	6.08	11.49	11.07	0.92	21.95

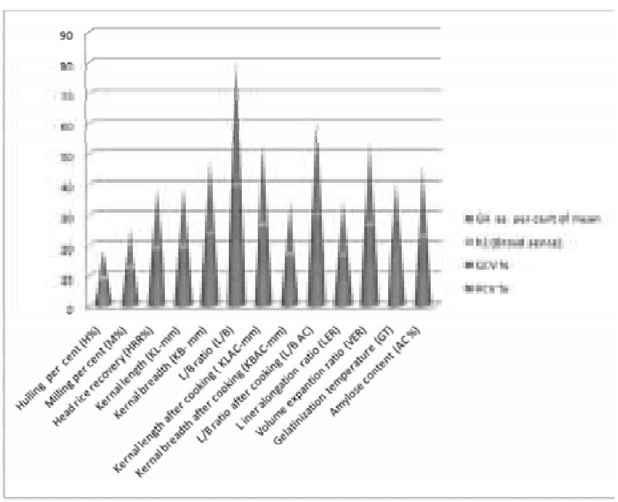

Fig. 2. Estimates of genetic variability for grain quality traits in land races and varieties in rice

mm), volume expansion ratio (13.23) kernel breadth (11.94 mm) and amylose content (11.49 %). The lowest PCV was recorded for kernel length (9.84 mm), head rice recovery (9.51%), kernel breadth after cooking (8.60 mm), linear elongation ratio (8.36), milling percent (6.24%) and hulling per cent (4.58 %). The values for nutritional quality PCV of variation ranged from manganese (18.19 ppm) to magnesium (52.72 mg/ 100g). The high GCV was observed for magnesium (52.72 mg/100g), calcium (52.57 mg/100g), copper (50.99 ppm), zinc (38.41 ppm) and crude protein (22.15 %). The moderate GCV was observed for iron (18.95 ppm) and manganese (18.19 ppm).

High heritability coupled with low genetic advance, low heritability with high genetic advance or low heritability and low genetic advance offer less scope for selection, as they were more influenced by environment and accounted for non-additive gene effects. High heritability coupled with high genetic advance is indicative of greater proportion of additive genetic variance and consequently a high genetic gain is expected from selection (Singh and Rai 1981). The characters having high heritability with low genetic advance as per cent of mean appeared to be controlled by non-additive gene action and selection for such characters may not be effective (Singh and Singh 2007). The genotypes for grain quality recorded high heritability values except moderate heritability observed by gelatinization temperature (33%). For, nutritive traits all the characters under study showed highest heritability. The presence of high heritability indicates that those characters are least influenced by environment.

As heritability in broad sense includes both additive and epistatic gene effects, it will be reliable only if accompanied by high genetic advance. The genotypes for grain quality recorded genetic advance as per cent of mean ranged from hulling per cent (8.39%) to L/B ratio (40.16 mm). L/B ratio (40.16 mm), L/B ratio after cooking (29.95 mm), volume expansion ratio (26.25 mm), kernel breadth (23.28 mm) and amylose content (21.95%) recorded the highest genetic advance. Genetic advance was recorded by kernel

Table 6. Estimates of genetic variability for nutritional quality traits in land races and varieties in rice

Characters	Range	Mean	PV	GV	PCV %	GCV %	h^2 (Broad sense)	GA as per cent of mean
Crude Protein (%)	11.46-5.43	8.39	3.46	3.43	22.15	21.05	0.99	45.21
Calcium (mg/100g)	4.79-0.79	2.12	1.24	1.23	52.57	52.48	0.99	107.94
Magnesium (mg/100g)	1.92-0.47	1.15	0.37	0.36	52.72	52.66	0.99	108.33
Iron (ppm)	99.61-61.23	81.03	235.85	234.45	18.95	18.89	0.99	38.80
Zinc (ppm)	61.15-14.23	39.69	232.35	231.78	38.41	38.36	0.99	78.93
Copper (ppm)	47.79-15.97	24.18	152.01	151.59	50.99	50.92	0.99	104.75
Manganese (ppm)	26.56-16.86	20.74	14.24	13.77	18.19	17.89	0.96	36.25

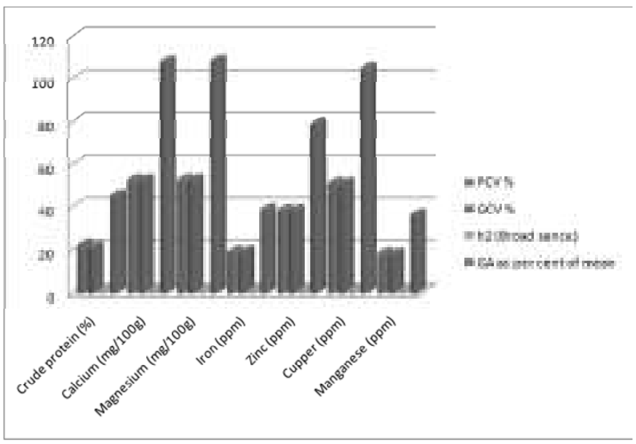

Fig. 4. Estimates of genetic variability for nutritional quality traits in land races and varieties in rice

length (18.51 mm), linear elongation ratio (16.28 mm), kernel breadth after cooking (16.21 mm), milling per cent (12.07%) and gelatinization temperature (12.02). The lowest genetic advance was recorded by hulling per cent (8.39%). The genotypes recorded high genetic advance for nutritive traits for all the characters under study.

The grain quality and nutritional traits of different rice varieties varied among the rice varieties. The difference in these parameters can be exploited by the rice breeders in their hybridization programme. The better quality rice is also delighted by the consumers (Samina asghar *et al.* 2012). From the forgoing discussion, it can be concluded that the cultivar IR 72 and Navara might be the best parent in the breeding programme for further improvement of grain quality characters. Present investigation medicinal landraces had been double the amount of Calcium, Magnesium, Iron, Zinc Copper, Manganese along with good grain quality best mean performance compared to improved cultivars. Veeradangan and Kavuni are the best donors for improving nutritional characters. Above characters possessing high heritability and genetic advance could be effectively used in selection.

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