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Research Note

Genetic analysis and character association studies of physical and cooking quality traits in Rice (*Oryza sativa* L.)

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Abstract
Studies on grain quality characters of 31 pre-released cultures and high yielding varieties of rice revealed that the quality traits viz., kernel breadth, kernel length/ breadth ratio, test weight and water uptake registered high variability estimates both at genotypic and phenotypic level. The lowest genotypic coefficient of variation was observed in volume expansion ratio, kernel length after cooking and amylose content. Hence and amylase content may be considered as important selection indices to bring improvement in physical and chemical traits in rice.

Key words:
Rice, quality characters, correlation

Rice (*Oryza sativa* L.) is one of the commonly consumed cereals and food staples for more than half of the world's population. Rice provides 20 percent of the world's dietary energy supply. It is also a good source of thiamine, riboflavin, niacin and dietary fibre. Unmilled rice contains more nutrients than milled or polished white rice. In Asia, where 95% of the world's rice is produced and consumed, it contributes 40-80% of the calories of Asian diet. In the year 2010, average global area under rice cultivation was 159.96 million hectares with average production of 685.013 million tonnes and average productivity of 4368 kg/ha (FAOSTAT, 2012).

Rice has potential wide range of food categories. Besides having nutritional and medicinal benefits, the by - products of rice are equally important and beneficial. Rice is marketed according to three grain size and shape classes (long, medium and short). Kernel dimensions are primary quality factors in breeding and in most phases of processing, drying, handling equipment, breeding and grading. Grain size and shape are the first quality characteristics considered in developing new varieties (Owens, 2001). The marketing values of rice as an agricultural product depend on its physical qualities after the processing. The percentage of whole grain is the most important parameter for the rice processing industry.

Rice is the only cereal crop cooked and consumed mainly as whole grains, and quality considerations are much more important than for any other food crop (Hossain *et al.*, 2009). Although production, harvesting and postharvest operations affect overall quality of milled rice, variety remains the most important determinant of market and end-use qualities. Quality desired in rice vary from one geographical region to another and consumer demand certain varieties and favors specific quality traits of milled rice for home cooking (Juliano *et al.*, 1964; Azeez and Shafi, 1966).For instance, in japonica rice eating countries, low amylose, short grain is preferred since after cooking it becomes soft and sticky. However, in indica rice consuming countries, long grain with intermediate amylose and gelatinization temperature is preferred since it become soft and fluffy after cooking (Hossain *et al.*, 2009).

In Gujarat, rice grain with medium slender grain type, intermediate amylose content, intermediate gelatinization temperature, medium gel consistency are preferred by consumers. Hence varieties with these qualities fetch high price in the market. In a rice breeding programme for evolving good quality rice, selection of parents with best grain quality characteristics is important. Knowledge about variability, character association among different quality traits helps the breeder in choosing suitable parents for hybridization. Grain quality characters are interrelated among themselves which in turn decides the final cooking and eating characteristics. Little or no information is available on the cooking and eating characteristics of varieties cultivated in rice producing areas of Gujarat state. Therefore, the present investigation was undertaken to study the different genetic parameters and their association among different quality attributing characteristics in selected high yielding pre-released cultures and varieties.

The experimental material consisted of 31 diverse released genotypes of rice possessing various quality traits namely GR-3, GR-4,GR-6, GR-7, GR-11, GR-12, GAR-13, GAR-1, GAR-2, GR-11, GR-12, GR-101, GR-102, GR-103, GR-104, Gurjari, Pankhali 203, Krishna Kamod, Jaya, Dandi, Narmada, Masuri, IR-28, IR-64, NAUR-1, SK-20, GNR-3, Ashoka 200F, AAUDR-1, GR-9, GR-5, Mahi sughandha and pre released culture NWGR-7011.The experiment was conducted at Main Rice Research Station, Anand Agricultural University, Nawagam, Gujarat, India, in a randomized block design with three replications, during kharif 2011. Twenty five days old seedlings were transplanted at a spacing of 20 x 15 cm and recommended package of practices were followed. After harvest seed samples were collected with 14% moisture and physical traits were analyzed for test weight (TW), grain length (GL), grain Breadth (GB), grain length/breadth ratio, kernel length (KL), kernel breadth (KB), length/breadth (L/B) ratio were analyzed by dial guage using SATAKE at quality laboratory. Cooking traits were analyzed for kernel elongation ratio (KER), amylose content (AC), volume expansion ratio (VER), water uptake (WUT) and kernel length after cooking (KLAC). These quality characters were estimated by standard procedures as suggested by Hussain *et al.* (1987). Amylose content and alkali spreading value were estimated following the methods of Juliano (1971). Analysis of variance, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (h2) in broad sense and genetic advance (GA) as percentage of mean were calculated following the method of Singh and Choudary (1985). The genotypic and phenotypic correlations were determined as per the method suggested by Johnson *et al.* (1955). Path coefficient analysis was done as suggested by Dewey and Lu (1959).

The analysis of variance revealed significant differences among the 31 genotypes for all the quality characters indicating sufficient scope for further improvement. Moreover, for hybridization programme, where selection of genetically diverse parents is important to generate the wide array of recombinants, the knowledge of genetic diversity among the accessions is necessary.

In general, the values of phenotypic coefficient of variation were high, when compared to genotypic coefficients of variation, but the differences were low suggesting the less environmental influence on these traits. Among the quality traits viz., test weight registered high variability estimates both at genotypic and phenotypic level (Table 1). Other traits viz., kernel breadth and KER had moderate variability. Chauhan *et al.* (1992) noted that amylose content exhibited least variation, which is in accordance with the present result. High heritability was observed in all the traits except kernel length after cooking, volume expansion ratio and water uptake. Heritability gives information on the nature of inheritance of characters and when the character is highly heritable it indicates that the phenotype strongly reflects the genotype. Chauhan (1998) and Krishnaveni *et al.* (2006) reported high estimates of heritability for kernel length, kernel breadth while high heritability for kernel length/breadth ratio was observed by Chauhan *et al.* (1992) and Lalitha and Sreedhar (1999). Pathak and Sharma (1996) and Krishnaveni *et al.* (2006) reported high heritability estimates for kernel length, kernel breadth, kernel length/breadth ratio, kernel elongation ratio and alkali spreading value which were in agreement with the present results. In the present study, amylose content also showed high heritability estimates, confirming the findings of Lalitha and Sreedhar (1999) and Krishnaveni *et al.* (2006). Characters viz., test weight, kernel breadth and grain L/B ratio recorded high genetic advance as percentage of mean while grain length, grain breadth and kernel length/breadth ratio exhibited moderate genetic advance. Krishnaveni *et al. (*2006) observed high genetic advance as percentage over mean for amylose content. The estimates of heritability and genetic advance in combination are more important than of heritability alone (Panse, 1957). High heritability with high genetic advance as percentage of mean was observed for test weight, grain breadth and grain L/B ratio and amylose content, which indicated the prevalence of additive gene action for gene expression. High heritability with moderate genetic advance as percentage of mean was recorded for grain breadth, kernel expansion ratio and kernel length/breadth ratio which indicated both additive as well as dominant gene action might be involved in controlling these traits.

Knowledge on association of traits will help in selection of characters during breeding programme. Test weight registered positive and highly significant correlation with grain length, grain breadth, grain length/breadth ratio and significantly correlated with kernel bread that both, genotypic and phenotypic levels and with kernel length after cooking only at genotypic level (Table 2).The results for the trait 1000 grain weight are in unison with Gopinath *et al.* (1984) and Yogameenakshi *et al.* (2004). Grain length exhibited positive and significant correlation with grain length/breadth ratio, kernel breadth and kernel length/breadth ratio while negative and significant association with kernel elongation ratio. Grain breadth exhibited positive and significant association with grain length/breadth ratio and kernel length after cooking while negative and significant association with kernel length/breadth ratio. Significant correlation had been established between length/width ratio with grain elongation during cooking by Sarkar *et al.* (2007).

Grain length/ breadth ratio exhibited positive and significant correlation with kernel breadth and kernel length after cooking while negative and significant association with kernel elongation ratio at genotypic level (Table 2). Sarkar *et al.* (2007) reported that direct positive effect imparted on kernel elongation index was highest by cooked kernel length, followed by brown kernel breadth and cooked kernel L/B ratio, contrary to that observed by Rajeswari *et al.* (2010) and Danbana *et al.* (2011). Highly significant negative correlation was observed between kernel breadth at the both the levels. Kernel length was positively and significantly correlated with volume expansion ratio only at the genotypic level and positively and significantly correlated with amylose content at the both the levels while positive and significant association of kernel breadth was observed with kernel length-breadth ratio at phenotypic level (Table 2). Significant correlation had been established between length/width ratio with grain elongation during cooking by Sarkar *et al*. (2007).
Kernel length showed negative significant correlation with the kernel elongation ratio at the genotypic and phenotypic levels. Kernel length/ breadth ratio exhibited negative and significant correlation with kernel length after cooking while positive and significant association with kernel elongation ratio at phenotypic level. Positive correlation existing between amylose and kernel length can be exploited, if these two quality traits can be selected in conjunction. Christopher et al. (2000) observed high direct effect of cooked kernel length and cooked L/B ratio along with positive association with kernel elongation index and highlighted the importance of these traits for quality improvement in rice. Sarkar *et al.* (2007) reported that direct positive effect imparted on kernel elongation index was highest by cooked kernel length followed by brown kernel breadth and cooked kernel L/B ratio. Correlation studies between the physicochemical characteristics and cooking qualities revealed positive correlation between AC and WU which indicate that at high amylose level, rice varieties will absorb more water (Table 3). This positive correlation between amylose content with WU was also reported by Hossain *et al.* (1987), but Vanaja and Babu (2003) found a negative association between these two quality traits.Volume expansion ratio did not show significant correlation with the water uptake and amylose content. Contrasting results were obtained by Ravi *et al.* (2012) and Rajeswari *et al*. (2010).
The 31 genotypes could be good sources for improvement of grain length and coocking quality. Based on narrow-sense heritability estimates, selection for grain length could be effective in early generations because of its high heritability, while selection for grain length and 1000-grain weight would be effective in advanced generations. Critical analysis of results obtained from character association indicated that kernel length/breadth ratio possessed both positive association and high positive direct effects with grain length. Information on association of characters contributed by each character towards grain length will be an added advantage in aiding the selection process. Correlation establishes the extent of association between grain length and its components bring out relative importance, thus giving an obvious understanding of their association with cooking quality. Ultimately, this kind of analysis could help the breeder to design his selection strategies to improve grain length along with cooking quality.

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Table 1 Estimate of genetic components for physical and chemical quality characters of ice.

Tratis	Mean	Heritability ($h^{2)}$	GA	GCV	PCV	GA % over mean
TW	20.14	0.971	9.35	22.86	23.20	46.43
GL	9.45	0.772	1.59	9.32	10.61	16.83
GB	2.44	0.849	0.42	9.04	9.81	17.21
GL/B Ratio	3.92	0.834	1.04	9.12	9.98	26.53
KL	6.08	0.650	0.21	7.91	9.81	3.45
KB	1.63	0.744	0.76	11.41	13.23	46.63
KL/B Ratio	3.73	0.653	0.66	10.10	12.50	17.69
KLAC	9.26	0.401	0.50	4.12	6.50	5.40
KER	1.55	0.804	0.22	7.75	8.64	14.19
VER	4.41	0.076	0.05	2.03	7.36	1.13
WUT	315.59	0.454	41.96	9.58	14.21	13.30
Amylose %	26.62	0.790	2.90	5.95	6.69	10.89

TW –Test weight, GL –Grain length, GB-Grain breadth, GB ratio-Grain length breadth ratio, KL -Kernel length, KB -Kernel Breadth, KLB Ratio- Kernel length breadth ratio, KLAC- Kernel length after cooking, KE Ratio-Kernel elongation ratio, VE Ratio- Volume expansion ratio, WUT-Water uptake.

GA- Genetic advance values, GCV- Genetic coefficient of variation, PCV-Phenotypic coefficient of variation

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Table 2. Genotypic (rg) and Phenotypic (rp) Correlation between Physical and cooking quality traits

Traits		*G L*	*G B*	*GLB Ratio*	*K L*	*K B*	*KL/BRatio*	*K L A C*	*K E R*	*V E R*	*W U T*	*Amylose*
T W	rg	0.564**	0.808**	0.741**	0.253	0.389*	-0.134	0.448*	-0.226	-0.324	0.042	0.279
	rp	0.484**	0.726**	0.676**	0.215	0.324*	-0.1	0.288	-0.196	-0.072	-0.015	0.254
G L	rg		0.259	0.673**	0.18	0.481**	0.623**	0.196	-0.427*	0.241	-0.118	0.281
	rp		0.158	0.572**	0.093	0.418**	0.675**	0.115	-0.308*	-0.072	0.015	0.2
G B	rg		1	0.469**	0.226	0.187	-0.578**	0.668**	-0.095	0.004	0.078	0.166
	rp			0.403**	0.208	0.128	-0.593**	0.354*	-0.091	0.001	0.03	0.067
GB Ratio	rg			1	0.191	0.636**	0.278	0.613**	-0.351*	0.037	0.217	0.118
	rp				0.194	0.589**	0.23	0.353**	-0.266	0.01	0.04	0.102
K L	rg				1	-0.607**	-0.001	0.259	0.203	0.399*	0.12	0.427**
	rp					-0.646**	-0.061	-0.025	0.103	0.068	-0.027	0.295*
K B	rg					1	0.267	0.257	-0.462**	-0.214	0.026	-0.263
	rp						0.258*	0.251	-0.303*	-0.018	0.024	-0.195
k L/B Ratio	rg						1	-0.379**	-0.319	0.093	-0.085	0.112
	rp							-0.117	-0.167	-0.055	0.022	0.133
K L A L	rg							1	0.256	0.17	-0.131	0.058
	rp								0.259*	0.151	0.016	0.093
K E Ratio	rg								1	-0.232	-0.196	0.23
	rp									0.086	-0.122	0.199
V E Ratio	rg									1	0.318	0.167
	rp										-0.206	0.199
W U T	rg										1	-0.084
	rp											-0.106

TW –Test weight, GL –Grain length, GB-Grain breadth, GB ratio-Grain length breadth ratio, KL -Kernel length, KB -Kernel Breadth, KLB Ratio- Kernel length breadth ratio, KLAC- Kernel length after cooking, KE Ratio- Kernel elongation ratio, VE Ratio- Volume expansion ratio, WUT-Water uptake.
*,** significance at 5 and 1 per cent respectively