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QUALITY CHARACTERISTICS OF RICE MUTANTS GENERATED THROUGH GAMMA RADIATION IN WHITE PONNI

RAMCHANDER S.[1*], USHAKUMARI R.[2] AND PILLAI ARUMUGAM M.[3]

[1]Department of Rice (CPBG), Tamil Nadu Agricultural University, Coimbatore, India.
[2]Department of Plant Breeding and Genetics, Agricultural College and Research Institute, Madurai (TNAU), Tamil Nadu, India.
[3]Department of Plant Breeding and Genetics, Agricultural College and Research Institute, Killikulkam (TNAU), Tamil Nadu, India.
*Corresponding E-mail: rubulochander_009@yahoo.co.in

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Abstract-The present investigation was carried out to study the quality attributes of rice grains in semi-dwarf and early mutants of White Ponni generated using gamma radiation. The results obtained from the study revealed that, identified mutants recorded high kernel length before and after cooking, L/B ratio before and after cooking and linear elongation ratio compared to wild type. Desirable semi-dwarf and early mutants exhibited intermediate amylose content and high gel consistency which showed rice grains remains softer when cooling. Most of the quality parameters exhibited higher variability, low to high heritability and low to high genetic advance as percent of mean where simple phenotypic selection is required to improvement of the these traits in rice. The trait kernel length after cooking exhibited positive correlation with L/B ratio before and after cooking and also showed significant positive correlation with linear elongation ratio in White Ponni mutants. The trait L/B ratio after cooking was positively correlated with linear elongation ratio and negatively correlated with breadth wise expansion ratio. Hence, selection based on these above parameters may reward in future quality-breeding programme in rice.

Keywords- Rice, White Ponni, Semi-dwarf, Amylose and Heritability

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Introduction

As a world's major cereal food crop, rice (*Oryza sativa* L.) is crucial to food security for at least half of the world population. Most of the world's rice is cultivated and consumed in Asia, which constitutes more than half of the global population. Since last three decades, the rice production has been doubled mainly due to the adoption of improved technology such as development of high yielding varieties and improved crop management techniques. New varieties with high yield potential, good quality and high resistance to biotic and abiotic stresses are needed in order to meet the demand for more food arising from the rapid human population growth and concurrent decrease in arable land. Improvement of rice quality has now become a foremost consideration for rice buyers and breeding programs. Rice is consumed mainly as milled, white grains or as brown grains (unpolished), and also as ingredients in food products. The cooking and sensory properties of a variety are key components that affect its acceptability to consumers.

Grain quality of rice is the totality of features and characteristics of rice or rice product that meets the demand of end-user. The concept of grain quality covers many features ranging from physical to biochemical properties and includes milling efficiency, grain shape and appearance, cooking easiness, eating palatability and nutrition. Thus, rice grain quality generally includes four classes, i.e. milling quality, appearance quality, cooking and eating quality, and nutritional quality. Grain quality and its assessment are not only important to consumers, end-users, processors, but also to rice breeders who are engaged in creating rice varieties haboring new features such as high quality, high yield potential, highly resistant to abiotic or biotic stresses. It is necessary for rice breeders to understand how the quality traits are inherited from their parents. Genetic studies have revealed many genes and quantitative trait loci (QTL) for grain quality, though the grain quality traits are complex. In any plant-breeding programme, creation of variation is the pre-requisite for any crop improvement. Among various breeding methodologies, mutation breeding is one of the favorite methods of breeder as it is a useful technique to enhance the genetic variability in plant populations. The foremost objective of the present investigation carried out to assess the quality parameters of semi-dwarf and early mutants of White Ponni rice generated through gamma radiation.

Materials and Methods

Biological material

A set of thirty desirable mutants (includes 12 early semi-dwarf mutants, 17 early mutants with tall plant type and one semi-dwarf mutant with same duration as wild type) of White Ponni in M_3 generation developed by gamma irradiation were subjected to quality analysis at Agricultural College and Research Institute (TNAU), Killikulam during 2013. The following traits were observed in mutants and wild type in two replications. Quality traits *viz*., Kernel length before cooking (KLBC), Kernel breadth before cooking (KBBC), L/B ratio before cooking (LBBC), Kernel length after cooking (KLAC), Kernel breadth after cooking (KBAC), L/B ratio after cooking (LBAC), Linear elongation ratio (LER), Breadth wise expansion ratio (BER), Amylose content (AC) and gel consistency (GC) were observed and classified as per [1]. The amylose content of desirable mutants and wild type White Ponni were estimated by the method proposed by [2]. Single plant yield was also estimated in all desirable mutants under investigation.

Data analysis

The phenotypic (PV) and genotypic variances (GV) were estimated according to the formula [3]. Phenotypic and genotypic coefficient of variance (PCV and GCV) for each character was computed based on the methods given by [4]. Heritability (h^2) in the broad sense was calculated according to the formula [3]. Genetic advance and genetic advance as percent of mean was derived according to the method [5]. The genotypic correlation between various quality parameters were worked out as per the method suggested by [5].

Results and Discussion

The *per* se performance [Table-1] of all the desirable mutants were observed for the quality traits in two replications revealed that, the mutants namely WP 59-1, WP 1-1, WP 1-12, WP E-3, WP 1-9, WP 50-4, WP 51-4 and WP E-2 exhibited significant higher kernel length before cooking [Fig-1] when compared to wild type White Ponni. The mutant's *viz.*, WP 48-2 (3.07) and WP 16-6 (3.10) recorded maximum L/B ratio before cooking when compared to wild type (3.02). Evaluation on kernel size, appearance and cooking quality parameters determines the grain quality improvement in rice. Linear elongation of kernel on cooking is one of the major characteristics of fine rice [6]. Generally, rice with more linear elongation and less breadth wise expansion is preferred. During cooking, rice kernels absorb water and increase in volume through increase in length or breadth [7]. Breadth wise increase is not desirable, whereas length wise increase without increase in girth is desirable characteristics in high quality premium rice [8,9,10]. In this study, the mutants WP 7-2, WP 59-1, WP 1-1, WP 48-2, WP 1-12, WP 50-11, WP E-3, WP 31-4 and WP 11-2 recorded significant higher linear elongation ratio with minimum breadth wise expansion ratio. Hence, this evidently expressed that the mutant with medium slender grains, high L/B ratio and linear elongation ratio are selected as preferable genotypes for quality improvement in rice. Amylose content is regarded as the most important indicator in classifying rice varieties because it influences texture and retrogradation potential of cooked grains [11, 12]. The trait amylose content exhibited the mean value of 16.26 with the range of 10.40 to 21.26 in White Ponni mutants with intermediate amylose content. Intermediate amylose rice cooks fluffy and remains soft on cooling and is the most preferred one [13].

Table-1 *Mean performance of semi-dwarf and early mutants of White Ponni*

Mutant No.		KLBC (mm)	KBBC (mm)	L/B ratio (BC)	KLAC (mm)	KBAC (mm)	L/B ratio (AC)	LER	BER	AC (%)	GC (mm)	SPY
White Ponni	(Wildtype)	5.90**	1.95	3.02	7.10**	3.00	2.37	1.20	1.50	18.49**	64.75	31.52
WP 11-1	Early	4.87	1.88	2.64	6.45	3.05	2.13	1.20	1.62**	18.37**	61.75	33.98
WP 7-2	Early	5.37	2.07	2.67	6.60	2.95	2.24	1.34**	1.43	18.49**	72.00**	44.93**
WP 43-1	SDE	4.92	1.93	2.64	6.55	2.85	2.36	1.28	1.48	10.40	60.25	46.46**
WP 47-2	SDE	5.13	2.02	2.49	6.70	2.85	2.31	1.08	1.41	15.80	61.00	39.84
WP 59-1	SDE	6.20**	2.10	3.00	7.05	3.15**	2.19	1.31**	1.50	13.82	76.75**	34.90
WP 48-3	SDE	5.37	1.87	2.96	6.80	3.00	2.27	1.17	1.61**	21.26**	80.50**	26.30
WP 1-1	SDE	5.82**	2.03	2.82	7.70**	3.05	2.52**	1.36**	1.50	12.66	66.50	29.15
WP 48-2	Early	5.67	1.83	3.07**	6.55	3.10**	2.06	1.30**	1.69**	15.39	81.25**	35.11
WP 7-1	SDE	5.05	1.83	2.73	6.15	3.05	2.00	1.22	1.66**	18.30**	79.00**	39.98
WP 48-4	SDE	5.03	1.88	2.66	6.60	2.75	2.36	1.09	1.46	18.51**	66.00	36.39
WP 1-12	SDE	6.07**	2.18**	2.66	7.15**	2.95	2.40	1.44**	1.35	15.52	69.75	37.06
WP 50-11	SDE	4.97	1.97	2.55	7.20**	2.90	2.48	1.40**	1.48	13.80	67.50	44.48**
WP 33-2	SDE	5.13	1.97	2.49	6.05	3.10**	1.94	1.17	1.58	13.67	58.75	33.57
WP D-1	SDE	5.18	1.92	2.67	5.60	2.55	2.20	0.99	1.33	13.68	61.75	30.91
WP 18-1	Early	5.68	2.05	2.83	7.35**	2.85	2.55	1.27	1.39	13.81	60.75	44.66**
WP E-3	Early	5.77**	1.98	2.97	7.65**	2.85	2.75	1.51**	1.44	13.58	70.75	32.29
WP E-4	Early	5.08	1.98	2.63	6.55	2.80	2.32	1.16	1.41	12.35	71.00	30.04
WP 1-3	SDE	5.63	2.07	2.79	7.30**	3.00	2.47	1.18	1.45	13.78	64.25	32.87
WP 1-9	Early	6.20**	2.20	3.00	6.95	3.35**	2.00	1.21	1.53	15.42	76.25**	43.07**
WP 31-4	Early	5.73	1.87	2.93	7.55**	2.85	2.62**	1.33**	1.53	17.61**	70.25	36.40
WP 31-2	Early	5.67	1.90	3.02	6.55	2.95	2.17	1.08	1.55	18.47**	80.25**	35.57
WP 50-4	Early	6.05**	1.87	3.10**	7.55**	2.90	2.53**	1.32	1.55	18.17**	61.50	25.75
WP 16-5	Early	5.73	2.08	2.79	6.75	2.85	2.43	1.09	1.37	18.44**	56.25	26.53
WP 51-4	Early	6.17**	2.07	3.02	7.20**	2.65	2.81**	1.14	1.28	20.57**	57.75	41.71**
WP E-2	Early	6.30**	2.17**	2.95	7.30**	3.05	2.35	1.23	1.41	21.15**	79.25**	38.28
WP 16-6	Early	5.93	1.87	3.09**	7.00	2.90	2.33	1.21	1.55	18.31**	57.10	31.70
WP 11-2	SD	5.80	2.00	2.90	7.35**	2.80	2.55	1.40**	1.40	18.43**	66.55	29.47
WP E-4-1	Early	5.25	1.85	2.79	6.65	2.85	2.39	1.21	1.54	13.68	71.00	28.61
WP E-4-2	Early	5.50	2.05	2.80	6.85	2.85	2.38	1.20	1.39	15.61	67.00	32.52
WP E-4-3	Early	5.70	2.00	2.90	6.95	2.90	2.41	1.22	1.45	16.65	65.50	34.47
Mean		5.58	1.98	2.82	6.90	2.93	2.35	1.24	1.48	16.26	67.84	35.11
SE		0.079	0.064	0.113	0.078	0.080	0.066	0.021	0.057	0.337	1.797	2.778
CD (1%)		0.162	0.130	0.230	0.159	0.164	0.134	0.043	0.116	0.689	3.674	5.682

The coefficient of variation indicates only the extent of variability existing for a particular character, but does not give any information regarding heritable component of it [5] suggested that heritability in combination with genetic advance was more effective and reliable in predicting the resultant effect of selection than heritability alone. However, it is not necessary that a character showing high heritability will also exhibit high genetic advance. The analysis of variance for the various component traits were estimated in selected mutants of White Ponni [Table-1]. The mean performances of the traits and their genetic parameters such as the phenotypic variance (PV), genotypic variance (GV), phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), broad sense heritability (h^2) and genetic advance as percent of mean were computed and presented in [Table-2].

In the present study, most of the quality traits *viz.*, kernel length before and after cooking, linear elongation ratio, amylose content and gel consistency exhibited higher heritability estimates [Fig-2]. Similar results were recorded by [14] for the traits linear elongation ratio, gel consistency and amylose content. These results indicated the existence of greater scope for improvement of these characters through direct phenotypic selection by fixing additive gene effects. While considering genetic advance as percent of mean the trait amylose content-recorded high genetic advance. The results were accorded with the findings of [15,16,17]. This clearly revealed that, the selection is effective while considering these genetic parameters of these traits.

Table-2. *Estimation of genetic parameters for quality parameters in Semi-dwarf and early mutants of White Ponni*

Traits	White Ponni (Mean)	Mean of mutants	Range	V_p	V_g	PCV	GCV	h^2	GA % Mean
Kernal length before cooking (mm)	5.90	5.58	4.87 – 6.30	0.19	0.18	7.78	7.65	96.96	15.50
Kernal breadth before cooking (mm)	2.00	1.98	1.83 – 2.20	0.01	0.01	5.83	4.87	69.83	8.39
L/B ratio before cooking	2.95	2.82	2.53 – 3.25	0.04	0.03	7.41	6.24	70.79	10.81
Kernal length after cooking (mm)	7.10	6.90	5.60 – 7.70	0.25	0.24	7.19	7.10	97.53	14.45
Kernal breadth after cooking (mm)	3.00	2.93	2.55 – 3.35	0.03	0.02	5.63	4.92	76.22	8.85
L/B ratio after cooking	2.37	2.35	1.95 – 2.72	0.041	0.037	8.57	8.11	89.54	15.82
Linear elongation ratio	1.20	1.24	0.99 – 1.51	0.01	0.01	9.68	9.52	96.86	19.32
Breadth wise expansion ratio	1.50	1.48	1.28 – 1.69	0.011	0.008	7.22	6.13	72.00	10.72
Amylose content (%)	18.49	16.26	10.40 – 21.26	7.87	7.76	17.33	17.21	98.56	35.19
Gel consistency (mm)	64.75	67.84	56.25 – 81.25	59.65	56.42	11.37	11.05	94.59	22.15
Single plant yield (gms)	31.52	35.11	25.75 – 46.46	38.39	30.67	17.59	15.71	79.89	28.94

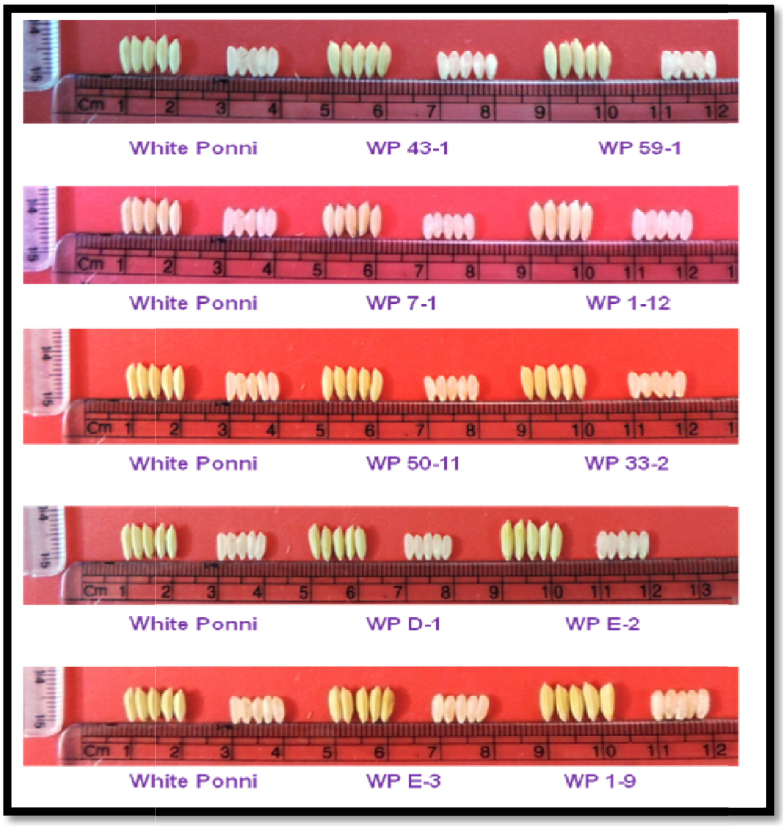

Fig 1. Variation in kernel length and kernel breadth before cooking of semi-dwarf and early mutants of White Ponni

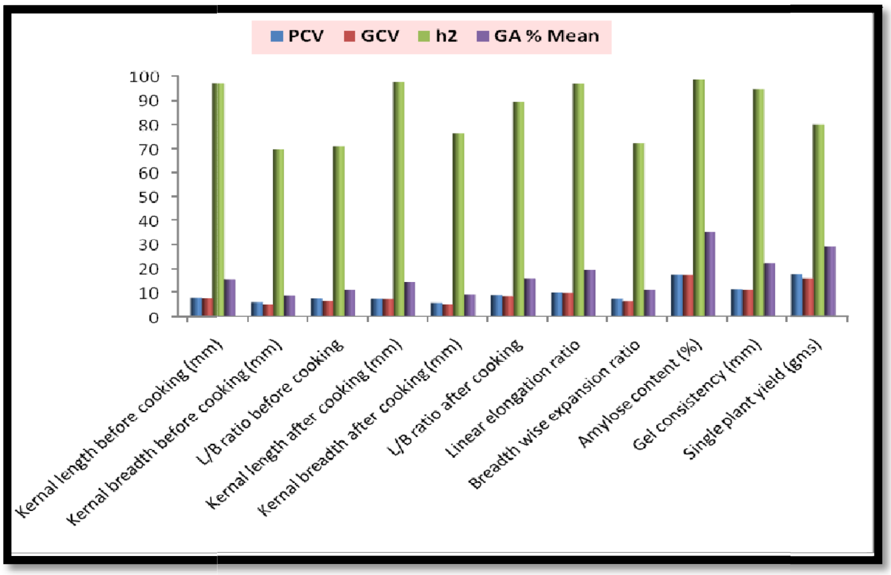

Fig-2. Variability estimates of grain quality parameters in semi-dwarf and early mutants of White Ponni rice

Table-3. *Genotypic correlation coefficient among different quality traits in Semi-dwarf and early mutants of White Ponni*

	KLBC	KBBC	L/B BC	KLAC	KBAC	L/B AC	LER	BER	AC	GC	SPY
KLBC	1.000	0.614**	0.757**	0.633**	0.271	0.407*	0.298	-0.265	0.288	0.155	-0.119
KBBC		1.000	-0.051	0.365*	0.258	0.182	0.192	-0.600**	-0.092	-0.016	0.353
L/B BC			1.000	0.501**	0.144	0.358	0.226	0.172	0.426*	0.203	-0.441*
KLAC				1.000	0.094	0.820**	0.650**	-0.216	0.074	-0.008	-0.046
KBAC					1.000	-0.491	0.260	0.617**	-0.017	0.512**	0.109
L/B AC						1.000	0.412*	-0.550**	0.086	-0.310	-0.090
LER							1.000	0.063	-0.191	0.203	0.138
BER								1.000	0.085	0.442*	-0.190
AC									1.000	0.177	-0.116
GC										1.000	0.039
SPY											1.000

The trait length/ breadth ratio was estimated based on kernel length and breadth before cooking and this trait plays major role in selection of genotype for improving their grain quality for consumer preference.

The extent of relationship among the yield components should be known to aid the breeder in the simultaneous improvement of different traits along with grain yield. The present study focused to determine the inter-correlation between different quality parameters in White Ponni rice mutants. The genoptypic correlation coefficient was estimated for various quality traits in White Ponni mutants and the results were presented in [Table-3]. The trait kernel length before cooking showed positive correlation with kernel breadth before cooking, L/B ratio before cooking, kernel length after cooking and L/B ratio after cooking in White Ponni mutants as reported as well [18,16]. L/B ratio before cooking showed negative and significant correlation with single plant yield [19] and positively correlated with kernel length after cooking. The trait kernel length after cooking exhibited positive correlation with L/B ratio before and after cooking in White Ponni mutants and this was similar with the findings of [18]. The trait L/B ratio after cooking was positively correlated with linear elongation ratio [17] and negatively correlated with breadth wise expansion ratio in mutants of White Ponni. These results were in accordance with the findings of [20].

Conclusion

An understanding of the genetics behind these quality indicators can aid screening early in breeding programs. From the above point of view, it can be concluded that improvement of grain quality attributes by devising appropriate breeding strategies including selection or hybridization with other lines with similar characteristics. Also, due emphasis should be laid upon the improvement in their yield level keeping their physico-chemical properties intact.

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