IJPS INTERNATIONAL JOURNAL OF PLANT SCIENCES
e ISSN-0976-593X Volume **11** | Issue 2 | July, 2016 | 207-212

DOI: 10.15740/HAS/IJPS/11.2/207-212
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RESEARCH ARTICLE

Grain quality characteristics of two line hybrids in rice (*Oryza sativa* L.)

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SUMMARY

Quality of rice is not always easy to define as it depends on the consumer and the intended and use for the grain. The best performing hybrids based on mean performance for grain yield, along with its parents were analyzed for physical and cooking quality characters. The hybrids *viz.*, TNAU 27S × Improved white ponni, TNAU 27S × KDML 105, TS09 24× CO(R) 49, TS09 24 × BPT 5204, TS09 26 × ADT 38 had the highest values of hulling, milling and head rice recovery percentage. In the present study, the hybrids *viz.*, TNAU 27S × KDML 105, TNAU 27S × BPT 5204 categorized under the long slender type and medium slender, respectively. Among the hybrids, TNAU 27S × KDML105 exhibited good milling out turn, head rice recovery, long slender, volume expansion, low gelatinization temperature, soft gel consistency with intermediate amylose content.

Key Words : Rice, Quality, Head rice recovery, Gel consistency, Amylose content

How to cite this article : Karpagam, V., Vinoth, R. and Kalaiyarasi, R. (2016). Grain quality characteristics of two line hybrids in rice (*Oryza sativa* L.). *Internat. J. Plant Sci.*, **11** (2): 207-212, **DOI: 10.15740/HAS/IJPS/11.2/207-212**.

Article chronicle : Received : 25.02.2016; **Revised :** 11.04.2016; **Accepted :** 25.05.2016

Rice (*Oryza* spp.) is one of the most important food crops in the world, being planted on almost 11 per cent of the Earth's cultivated land area over a wide number of ecosystems (Khush, 2005 and Maclean *et al.*, 2002). Of the annual world production of 596.49 million tonnes from 155.13 million hectares, Asia produces 540.62 million tonnes from 138.56 million hectares. Per capita consumption of rice in Asia ranges from 132 to 45grams per day (Swaminathan and Appa Rao, 2009). Consumer preferences shift from low-quality to high-quality rice with increased income and market liberalisation and improvements in post-harvest technologies have also contributed to this shift in consumer preference by decreasing the price difference between low and high-quality rice (Dawe and Slayton, 2004). Traditionally, plant breeders concentrated on breeding for high yields and pest resistance. Recently the trend has changed to incorporate preferred quality characteristics that increase the total economic value of rice.

Rice varieties with the improved quality traits should satisfy the traders and millers besides consumers in rice. The quality traits do mean the chemical properties alone, but comprises the physical milling, cooking and eating

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nutritional qualities etc. Rice unlike other cereals is consumed as a whole grain, therefore, physical properties such as size, shape, uniformity and general appearance are important. Further, because most of the rices are milled, the important physical properties are determined primarily by the milled grains. Hence, it is possible to develop rice hybrids of acceptable grain quality (Manonmani *et al.*, 2010).

Rice grain quality is mainly determined by the combination of many physical as well as chemical characters. Physical quality characters include kernel size, shape, hulling, milling percentage and head rice recovery. Chemical quality is mainly determined by amylose content, gelatinization temperature, gel consistency. High volume expansion and greater length wise expansion of kernel during cooking decide the consumer preference. (Mahalingam *et al*., 2012). Rice with soft to medium gel consistency, intermediate amylose content and gelatinization temperature is a preferred level for the consumer which determines the eating and cooking quality of rice grains (Bao *et al.,* 2002).

The present study was, therefore, aimed to identify high yielding cross combinations with acceptable grain yield and cooking quality parameters. The best performing hybrids based on mean performance for grain yield, along with its parents were analyzed for physical and cooking quality characters.

MATERIAL AND METHODS

The materials for the present study were rice grains of two line hybrids with respect to the grain per plant (Table A) and their parents were analysed for quality characters. The physico chemical and cooking properties in rice were analyzed in Rice quality laboratory at Department of Rice, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore. The best performing twelve hybrids with respect to the grain per plant (Table A) and their parents were analyzed for quality characters as described below in Table A.

Table A : List of hybrids selected for analysis of quality parameters

Sr. No.	Hybrids
1.	TNAU 27S × Improved white ponni
2.	TNAU27S × BPT 5204
3.	TNAU 27S × KDML 105
4.	TNAU 27S × WGL 14
5.	TS09 24 × CO (R) 49
6.	TS09 24 × BPT5204
7.	TS09 26 × G 14
8.	TS09 26 × Improved white ponni
9.	TS09 26 × ADT 38
10.	TS09 26 × KDML105
11.	TS 29 × KDML105
12.	TS 29 × T360

Kernel length :

Length of 10 unbroken brown rice, in three sets was measured and the mean was expressed in mm and the grains were categorized as follows.

Size category	Length (mm)
Extra long	> 7.50
Long	6.61-7.50
Medium	5.51-6.60
Short	< 5.50

Kernel breadth (SES-IRRI, 1996) :

Breadth of 10 unbroken brown rice was measured using vernier caliper in three sets and the mean was expressed in mm.

Kernel length/breadth ratio (L/B) :

The ratio of kernel length and kernel breadth was based on the ratio, the following categories were made for grain shape.

Shape category	L/B ratio
Slender	>3.0
Medium	2.1-3.0
Bold	1.1-2.0
Round	<1.0

Milling traits :

Milling recovery of rough rice is an estimation of the quantity of head rice and total milled rice that can be produced from a unit of rough rice. It is generally expressed as percentage (Khush *et al.*, 1979).

$$\text{Hulling percentage} = \frac{\text{Total hulled rice}}{\text{Total rough rice}} \times 100$$

$$\text{Milling percentage} = \frac{\text{Total milled rice}}{\text{Total rough rice}} \times 100$$

$$\text{Head rice recovery} = \frac{\text{Total head rice}}{\text{Total rought rice}} \times 100$$

Kernel length and breadth after cooking (KLAC and KBAC) :

Kernel length and breadth after cooking were measured by following the method of Azenz and Shafi (1966). Twenty five whole milled kernels were soaked in 20ml of distilled water for 30 min. The samples were placed in a water bath and the temperature was maintained at 98°C for 10 min. The cooked rice was transferred to a Petridish lined with filter paper. The length and breadth of the cooked whole grains were measured and expressed in mm.

Linear elongation ratio (LER) :

The ratio of average length of cooked rice grains to the average length of polished rice grains was computed as linear elongation ratio (Juliano and Perez, 1984).

Breadth wise expansion ratio (BER) :

The ratio of average breadth of cooked rice grains to the average breadth of polished rice grains was computed as breadth wise expansion ratio (Juliano and Perez, 1984).

Gelatinization temperature (GT) :

Gelatinization temperature was obtained by reassuring the alkali spreading value (ASV) of the milled grains. The method suggested by Little *et al.* (1958) was used to score the ASV. Thirty whole milled grains were placed in two Petriplates containing 10 ml of 1.7 per cent KOH solution. The kernels were arranged in such a way to provide space between kernels for spreading. The plates were covered and incubated at room temperature for 23 hours. Grain appearance and disintegration were visually rated after incubation and expressed in numerical scale as described below.

Description	**Score**
Grain not affected	1
Grain swollen	2
Grain swollen, collar incomplete or narrow	3
Grain swollen, collar complete and wide	4
Grain split or segmented, collar complete and wide	5
Grain dispersed, merging with collar	6
Grain completely dispersed and intermingled	7

All rating of 5.5 – 7.0 was classified as low gelatinization temperature (55 – 69°C); 3.5 – 5.4 intermediate (69 -74°C); 2.6 – 3.4 intermediate to high and 1 – 2 high (>74°C) in this study.

Gel consistency (GC) :

Gel consistency was analysed based on the method described by Cagampang *et al.* (1973). Milled rice flour (100 mg) was weighed in duplicate, into the test tubes. To this, 0.2 ml of 95 per cent ethyl alcohol containing 0.025 per cent thymol blue and 2.0 ml of 0.2N KOH were added. The contents were mixed using a vortex genie mixer. The test tubes were covered with glass marbles. Then, the samples were cooked in a vigorously boiling water bath for 8 min. making sure that the contents of the tube reached 2/3[rd] height of the tube. The test tubes were left at room temperature for 5 minutes. Then the tubes were cooled in ice for 20 minutes and laid horizontally on a table lined with graph paper. The total length of the gel was measured in mm from the bottom of the tube to the gel front. The gel consistency was classified as soft (61 – 100 mm), medium (41 – 60 mm) and hard (< 40 mm).

Amylose content :

Test samples were weighed about 100 mg ± 0.5 mg three times for each sample and these samples were placed into 100 ml volumetric flasks. To this, 1 ml of ethanol was added by using pipette to wash down any of the flour adhering to the side of the flask. These contents were shaked well in order to wet the entire sample. To this, 9.0 ml of NaOH solution (1M) was added and mixed it well until the starch was completely dissolved by standing overnight. The test solutions were allowed to cool at room temperature and made up the volume with the distilled water. The blank solution was prepared without the sample in the 1000 ml volumetric flask, from the prepared test solutions, 0.5 ml aliquot was pipetted out into two test tubes. To this, 5.0ml of water, 0.1 ml of acetic acid and 0.20 ml of iodine were added, to make up the volume to 10.0 ml. These contents were mixed well by using vortex mixer. The test chemicals were measured the absorbance at 720 nm against the blank solution using the spectrophotometer. Based on the amylose content the rice was categorized as waxy (< 2%), very low (2 – 8%), low (9- 16%), intermediate (17 - 22%), and high (>23%) as suggested by Juliano (1971).

Volume expansion :

Volume of the milled rice was measured in a graduated measuring cylinder. Then the milled rice was cooked in boiling water bath in cloth bag upto its cooking time. The cooked rice was blotted free of water and final volume was measured. The ratio of the volume of cooked rice to the volume of milled rice was expressed as volume expansion.

RESULTS AND DISCUSSION

Quality is a complex phenomenon governed by physio-chemical properties of starch. In pure lines, all the individual kernels are more or less uniform with respect to different grain quality characteristics. In hybrids, seed borne on F_1 plants represent the F_2 seeds which are intermediate to the parents and uniform in shape but different in cooking quality characteristics. This affects the quality of cooked rice.

The present study was, therefore, aimed to identify high yielding cross combinations with acceptable grain and cooking quality parameters. The best performing twelve hybrids based on mean performance for grain yield, along with its parents were analyzed for physical and cooking quality characters. The physical characters like kernel length, breadth and L/B ratio contribute to appearance of brown and cooked rice. These are important traits determining the market value and consumer preference. Amylose content, gelatinization temperature and gel consistency are very important in determining the cooking and eating quality of rice (Khush *et al.*, 1979).

Virmani and Zaman (1998) have suggested that parental lines with desirable grain quality could give hybrids with improved quality. In the present investigation, there were hybrids which showed better

Table 1 : Mean performance of selected hybrids and their parents for different quality characters

Parents/hybrids	Hulling per cent	Milling per cent	Head rice recovery per cent	Kernel Length (mm)	Kernel Breadth (mm)	L/B ratio	KLAC (mm)	KBAC (mm)	LER	BER	VER	GT	GC	AC (%)
TNAU27S × IWP	68.50	63.25	51.69	5.7	2.00	2.85	7.00	3.00	1.23	1.50	4.60	1.25	51.00	24.40
TNAU27S × BPT5204	75.00	58.33	45.33	6.05	1.90	3.18	7.60	2.56	1.26	1.35	3.70	5.50	58.00	21.50
TNAU27S × KDML105	77.20	66.74	56.00	6.70	2.00	3.35	10.80	4.00	1.61	2.00	4.00	2.25	80.00	21.20
TNAU27S × WGL14	77.80	60.00	52.34	5.40	1.70	3.18	7.00	2.80	1.30	1.65	4.80	3.50	90.00	22.60
TS09 24 × CO(R) 49	77.97	66.58	58.17	5.00	2.10	2.38	8.00	2.60	1.60	1.24	4.80	1.50	57.00	30.10
TS0924 × BPT5204	70.42	63.10	52.34	4.60	1.90	2.42	8.80	3.00	1.91	1.58	4.70	1.25	120.00	26.40
TS0926 × G14	70.77	41.54	36.43	5.50	2.10	2.62	9.20	4.00	1.67	1.90	4.20	2.25	111.00	25.90
TS0926 × IWP	69.79	57.81	42.50	5.40	2.00	2.70	7.60	2.80	1.41	1.40	4.20	1.75	110.00	25.50
TS0926 × ADT 38	70.27	65.54	59.71	5.40	2.1	2.57	8.00	3.00	1.48	1.43	4.00	3.50	68.00	25.00
TS0926 × KDML105	70.90	63.49	53.86	5.6	2.00	2.80	8.20	3.00	1.46	1.50	4.00	3.00	95.00	19.90
TS 29 × KDML 105	75.52	63.92	51.92	5.7	2.10	2.71	9.40	3.00	1.65	1.43	4.40	5.25	111.00	26.40
TS 29 × T 360	69.94	64.16	47.17	6.00	2.10	2.86	9.60	3.20	1.60	1.52	4.60	2.75	82.00	30.50
TNAU27S	77.58	56.42	31.13	6.20	1.70	3.65	8.40	2.80	1.35	1.65	5.20	1.50	56.00	19.70
TS09 24	76.21	68.10	58.60	4.6	1.7	2.71	7.00	2.60	1.52	1.53	4.80	1.75	97.00	21.80
TS09 26	66.31	58.85	46.15	4.5	2.20	2.05	8.00	3.00	1.78	1.36	4.20	2.50	110.00	23.50
TS 29	72.20	65.25	37.49	5.00	2.20	2.27	8.40	3.40	1.68	1.55	5.00	6.00	37.00	24.50
CO(R) 49	75.76	72.22	65.72	4.70	1.80	2.61	8.00	3.00	1.70	1.67	5.40	7.00	61.00	30.30
IWP	66.67	61.97	56.49	5.00	1.60	3.13	7.20	2.80	1.44	1.75	5.00	1.50	112.00	26.60
BPT 5204	79.15	71.00	56.95	5.00	1.7	2.94	8.80	3.00	1.76	1.76	4.60	2.75	80.00	28.30
KDML105	76.15	66.92	43.31	7.10	2.00	3.55	9.40	3.00	1.32	1.50	3.40	6.00	88.00	15.40
ADT 38	59.82	54.02	33.48	5.70	1.80	3.17	8.20	3.40	1.44	1.89	3.80	2.50	44.00	26.70
G14	64.47	61.93	46.35	6.80	2.00	3.40	9.80	3.60	1.44	1.80	4.00	2.50	128.00	26.10
WGL14	68.61	59.49	44.17	5.10	1.80	2.83	7.40	3.00	1.45	1.67	4.80	1.75	59.00	18.90
T360	71.00	65.67	12.11	5.10	2.30	2.22	8.80	3.00	1.73	1.30	3.60	2.25	129.00	24.40

performance over their parents with desirable kernel length and shape (Table 1). RTGW (1997) recommended ≥ 75 per cent hulling per cent, ≥ 65.1 per cent for milled rice and 48 per cent for head rice recovery.

Milling recovery is one of the important criteria of rice quality especially from the stand point of marketing. The hybrid TS09 24 × CO(R) 49 had the highest hulling per cent than the parents. Milling recovery depends on grain shape and appearance, which has direct effect on the percentage of hulling, milling and head rice recovery. The hybrids namely TNAU 27S × Improved white ponni, TNAU 27S × KDML 105, TS09 24 × CO(R) 49, TS09 24 × BPT 5204, TS09 26 × ADT 38 had the highest values of hulling, milling and head rice recovery percentage (Table 1).

The appearance of milled rice is important to the consumer, which in turn makes it important to the producer and the miller. Thus, grain size and shape are the first criteria for rice quality the breeders consider in developing new varieties for releases of commercial production (Adair *et al.*, 1966). In general, medium to long grains are preferred in the Indian subcontinent while the country is also replete with hundreds of short grain domestic types and long grain basmati types the latter commanding highest premium in both domestic and international markets. In the present study, the hybrids *viz.*, TNAU 27S × KDML 105, TNAU 27S × BPT 5204 categorized under the long slender type and medium slender, respectively (Table 1).

Cooking quality parameters like kernel length and breadth after cooking, linear elongation ratio and breadth wise expansion ratio are important regarding consumer preference. Rice with more expansion and less breadth wise ratio is preferred. Kernel length after cooking was higher than parents in TNAU 27S × KDML 105 and TS 29 × T360 (Table 1).

Rice with high gelatinization temperature requires more water and time to cook than rice with low or intermediate gelatinization temperature. There seems to be distinct preference for rice with intermediate gelatinization temperature. (Khush *et al.*, 1979). In the present study, two hybrids namely TNAU 27S × BPT 5204, TS 29 × KDML 105 had the intermediate gelatinization temperature. Among the parents, TS 29, CO (R) 49 and KDML 105 were categorized under the low gelatinization temperature (Table 1).

Gel consistency determines the softness or hardness of the cooked rice. The varieties having the same amylose content can be differentiated for their tenderness of cooked rice by the gel consistency test (Cagampang *et al*., 1973). In the present study, most of the hybrids expressed as soft gel consistency except TNAU 27S × Improved white ponni, TNAU 27S × BPT 5204 and TS09 24 × CO(R) 49 which expressed medium consistency. A similar result of soft gel consistency was reported for varieties and hybrids in rice (Asish *et al.*, 2006) (Table 1).

High amylose varieties cook dry, flaky, fluffy and have volume expansion but become hard after cooking intermediate amylase rice cook fluffy and remain soft on cooking whereas, low amylose varieties cook sticky. Hence, the varieties with intermediate amylose content are mostly preferred. The hybrids TNAU 27S × KDML 105, TNAU 27S × BPT 5204, TNAU 27S × WGL 14 and TNAU 27S × Improved white ponni had intermediate amylose content (Table 1). This is in accordance with findings of Hossain *et al*. (2009) and Danbaba *et al*. (2011).

Among the hybrids, TNAU 27S × KDML105 exhibited good milling out turn, head rice recovery, long slender, volume expansion, low gelatinization temperature, soft gel consistency with intermediate amylose content.

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