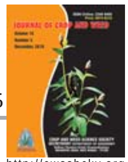
Journal of Crop and Weed, 16(2): 01-07 (2020)

ISSN- O : 2349 9400 ; P : 0974 6315



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Estimation of physical and cooking grain quality traits in two line hybrids of rice (*Oryza sativa* L.)

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Received : 02.08.2019 ; Revised : 09.08.2020 ; Accepted : 12.08.2020

DOI: https://doi.org/10.22271/09746315.2020.v16.i2.1308

ABSTRACT

In this study, a total of 40 hybrids developed from five female (TGMS) lines and eight testers raised in L x T fashion and examined for fourteen quality traits. The hybrid TNAU 95S X AC38479 recorded highest hulling, milling and head rice recovery. Out of 40 hybrids, sixteen were categorized as medium slender while TNAU 60S X Palawan and TNAU 18S X Palawan were categorized under the long slender type. Linear elongation ratio was significantly higher in five hybrids and seven hybrids expressed intermediate gelatinization temperature. Twenty-six hybrids expressed soft gel consistency and twenty-two hybrids had intermediate amylose content. This study revealed that considering both physical and cooking quality traits, the two-line hybrids namely TNAU 45S X AC38479, TNAU 45S X CB 15121, TNAU 45S X Khao do ngoi and TNAU 45S X CB 15117 had acceptable grain quality traits and these hybrids could be promoted commercially.

Keywords: Two line hybrids, cooking quality, miller traits, physical grain quality and rice

Rice is the stable and most favourite food for more than half of the world's population. It is provides nearly 20 per cent of dietary fiber for the World. Coming to rice consumption, there is diversity from one country to other (Juliano *et al*., 1964; Azeez and Shafi, 1966). In *japonica* rice-eating countries, low amylose and short-grain is preferred while in *indica* rice consuming countries, long grain with intermediate amylose and alkali spreading value, soft gel consistency and high volume expansion of cooked rice is preferred (Hossain *et al*., 2009). Rice varieties with improved quality traits should satisfy the traders and millers besides consumers in rice. Maintaining rice grain quality to meet the diverse interest groups in the sector currently represents major challenges of rice development in many rice-producing areas of the world. The economic value of rice depends on its cooking and processing quality, which can be measured in terms of different physical grain parameters and cooking traits (Oko *et al.,* 2012). Besides grain length and breadth, length-wise expansion without an increase in girth is considered a highly desirable trait of high-quality rice. Amylose content and gelatinization temperature are important cooking quality factors in rice.

Traditionally, farmers are rice producers growing many varieties and inclined to accepting any new varieties with seemingly better grain yield without considering other qualities. Immense efforts of rice breeders made during the last ten years have enabled the country to become the second-largest in the world to develop and commercialize hybrid and its technology. It enhances heterotic potential which in turn increases yield by 20-30 per cent over cultivated varieties (Virmani, 1994). Two-line hybrid production is one of the new vistas of hybrid production in rice and having the ability to overcome problems associated with a three-line hybrid system.

Though 93 rice three-line hybrids have been released or notified all over India, their spread is not commensurate with expectations (IIRR, 2017-18). Along with other reasons, lack of consumer acceptance also added the cause for slow spread. Since rice hybrids have entered the country recently, there is a need to look into the quality aspects so that hybrid rice can be developed coupled with improved quality characteristics. Research work on quality rice hybrids is scanty. Keeping this in view, forty two line rice hybrids were used in the present study to find out the grain quality characters along with parents.

MATERIALS AND METHODS

This experiment was carried at rice quality lab, Department of Rice, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu. The material consists of forty hybrids and their thirteen parents (five thermosensitive genic male sterile female parents, four *indica* male parents and four *japonica* male parents) and these are evaluated for fourteen quality traits.

Milling traits: The milling traits for forty hybrids along with parents and checks were analyzed as per SES (2002), IRRI.

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$$\text{Hulling percentage}\left(\%\right)=\frac{\text{Total hulled rice}}{\text{Total rough rice}}\text{X100}$$

$$\text{Milling percentage}\left(\%\right)=\frac{\text{Weight of total milled polished rice}}{\text{Total rough rice}}\text{X100}$$

$$\text{Head Rice Recovery}\left(\%\right)=\frac{\text{Weight of total head rice}}{\text{Weight of total rough rice}}\text{X100}$$

Grain dimensions: The physical grain dimensions for forty hybrids along with parents and checks were recorded as per SES (2002), IRRI.

Kernel length and breadth (mm): Length and breadth of ten unbroken brown rice in three sets were measured using Vernier Caliper and the mean value was expressed in millimeter (mm).

Kernel length/ breadth ratio: The ratio of kernel length and kernel breadth was worked out. The various scales are slender (>3.00), medium (2.10-3.00), bold (1.10-2.00) and round (1.0 or less).

Chalkiness of endosperm: A representative milled sample was in magnification for the degree (extent) of chalkiness that will best describe the sample concerning i. White belly, ii. White center and iii. White back. The scores for chalkiness is based on the percent of kernel area according to SES (2002), IRRI and it is measured as none- 0, small (less than 10%) - 1, medium (11-20%) - 5 and large (more than 20%) - 9.

Cooking quality traits: The cooking quality traits were recorded for 10 kernels for two replications for forty hybrids along with parents. The kernel length after cooking and kernel breadth after cooking was measured using the formula proposed by Azenz and Shafi, 1996. Linear elongation ratio (LER) is a ratio of mean length of cooked rice to mean length of milled rice and estimated based on the recommendation of Juliano and Perez, 1984.

Breadth wise expansion ratio (BER): Breadth wise expansion ratio was computed as the ratio of the mean breadth of cooked rice to mean breadth of milled rice. The scale for breadth wise expansion ratio is classified into three scales viz., 1 (>1.40), 2 (1.30-1.40) and 3 (<1.30).

Gelatinization temperature (GT) proposed by Little *et al.* (1958) was used in this study and its score is based on Alkali Spreading Value (ASV) of milled rice. Gel consistency (GC) was analyzed based on the method described by Cagampang *et al.* (1973). The simplified procedure of Juliano *et al.* (1981) was used for the estimation of amylose content. The amylose content of each genotype was expressed as a percentage of the total quantity of samples taken for analysis. The mean data from fourteen quality traits was calculated from two replications of each sample. The critical difference was calculated for each trait based on the formula proposed by Jones, 2009.

RESULTS AND DISCUSSION

The results of fourteen quality traits of thirteen parents and forty two-line hybrids were represented in the tables 1 and 2.

Miller preference traits

In general, hulling percentage, milling percentage and head rice recovery are considered as miller preference traits. Genotypes had an average of 66.56 hulling percentage while in parents it was ranged from 62.00 per cent (CB 15137) to 75.12 per cent (TNAU 60S). Ten parents and eleven hybrids recorded significantly higher values of hulling percentage than the general mean. Genotypes recorded an average of 59.54 per cent milling ability. Out of eight parents that showed significantly higher values for milling percentage, TNAU 45S (68.20%) among the lines and CB 15121 (67.91%) among testers ranked first. Five best expressing hybrids for milling ability were TNAU 95S/AC38479 (70.22), TNAU 45S/Khao Kap Sang (69.23), TNAU 18S/CB 15121 (68.55), TNAU 95/Khao Kap Sang (68.45) and TNAU 14S/AC38479 (68.44). The line TNAU 60S exhibited the highest head rice recovery (62.33%) followed by TNAU 45S (60.54%), testers Palawan (60.23%) and CB 15121 (60.22%). Ten parents and eight hybrids expressed significantly higher head rice recovery.

Milling recovery is one of the important criteria of rice quality especially from the standpoint of marketing. Milling recovery depends on grain shape and appearance which has a direct effect on the percentage of hulling, milling and head rice recovery. The hybrid TNAU 95S/AC38479 had the highest hulling, milling and head rice recovery with the values 78.60 , 70.22 and 64.21 per cent respectively followed by TNAU 45S/Khao Kap Sang with the values at 78.27, 69.23 and 63.88 per cent respectively. These two hybrids could be useful for a marketing point of view and can promote commercially for millers.

Physical grain appearance traits

All the lines and testers in this study had medium kernel length. Among hybrids, three categories were present- long kernels TNAU 18S/Palawan and TNAU 60S/Palawan showed 7.1 mm and 7.0 mm respectively and two hybrids showed length > 6.6 mm; six hybrids had short kernels of length < 5.5 mm of which TNAU 18S/CB 13212 had the shortest length of 4.8 mm. Among lines, TNAU 45S had the least kernel breadth of 1.7 mm and TNAU 95S with the highest value of 2.3 mm. In testers, AC38479, CB 15117 and CB 15137 exhibited the least value (1.8 mm) while KhaoKap Sang showed the highest value (2.4 mm) for kernel breadth. Among the hybrids, TNAU 18S/AC38479, TNAU 45S/CB 15121, TNAU 45S/CB 15137, TNAU 60S/CB 15137 and TNAU 95S/CB 15137 showed the least value of kernel breadth of 1.8 mm. Five lines and six testers except Khao Kap Sang and Khao do ngoi possessed kernel length/ breadth ratio of >3.0 and falling under the category of slender grain. Among hybrids, 19 possessed slender grains and the rest had medium grains according to kernel length/ breadth ratio. Among all the genotypes, two parents *viz*., Khao Kap Sang and AC38479 and eleven hybrids showed the highest score of nine for chalkiness of endosperm. Twenty-three hybrids and nine parents except TNAU 95S and Palawan had the lowest score of one for chalkiness of endosperm.

Hybrid rice developed in China had a yield advantage of more than 15 per cent over conventional pure-line varieties. However, rice hybrids, when introduced into other countries, were rejected due to their larger grain size, excessive chalkiness and low milling yield (Virmani and Zaman, 1998). The physical characters like kernel length, breadth and L/B ratio contribute to the appearance and high head rice recovery. These are important traits determining market value and consumer preference. In the present investigation, some hybrids showed better performance over their parents with desirable kernel length and shape.

Adair *et al.* (1966) insisted that the grain size and shape are the prime most criteria for developing new quality rice varieties for commercial production. In general, medium to long grains is preferred in the Indian subcontinent though the country has hundreds of short-grain domestic types and long grain basmati types with the later commanding highest premium in both domestic and international markets. In the present study, the sixteen hybrids were categorized as medium slender while hybrids TNAU 60S/Palawan and TNAU 18S/Palawan were categorized under the long slender type. This finding agrees with the fact declared by DRR (2012) which indicated that more than 50 per cent of the second-generation hybrids released so far possess long slender and long bold grains.

Cooking quality traits

Kernel length after cooking: This trait was exhibited significantly on the positive side by four parents *viz.*, Khao Kap Sang (10.1 mm), TNAU 60S (9.8 mm), TNAU 95S (9.7 mm) and TNAU 14S (9.5 mm) and 17 hybrids with significance over the general mean of 9.2 mm.

Linear expansion ratio: Among the lines, TNAU 60S (1.53) and testers Khao Kap Sang (1.58) showed desirable length-wise expansion on the positive side with the highest value. The hybrids with higher LER were TNAU 45S/CB 15117 (1.69), TNAU 18S/CB 15117 (1.67), TNAU 14S/CB 15121 (1.63), TNAU 95S/CB 15121 (1.61) and TNAU 45S/CB 15121 (1.60).

Kernel breadth after cooking: Kernel breadth after cooking showed the least desirable value in TNAU 45S (2.06 mm) and the highest value in TNAU 95S (3.06 mm) in lines. In testers, the least and highest values were possessed by CB 15117 (2.18 mm) and Khao Kap Sang (3.12 mm) respectively. Two hybrids TNAU 18S/CB 15121 and TNAU 45S/CB 15121 (2.2 mm) had the least breadth wise expansion after cooking followed by TNAU 60S/CB 15137 (2.3 mm).

Breadth wise expansion ratio: The least breadth-wise expansion was exhibited by TNAU 14S and TNAU 45S in lines and by CB 15117 (1.21) in testers. Two hybrids TNAU 18S/CB 15121 and TNAU 45S/CB 15121 showed the least breadth-wise expansion ratio of 1.22 and five hybrids with 1.25.

Amylose content: In the parents, the tropical *japonica* lines had higher amylose content ranging from 25.22 (AC38479) to 26.69 (Khao Kap Sang) per cent, while all others had intermediate amylose with mean of 23.41 per cent. Based on amylose classification, 12 hybrids were found to possess high amylose (>25.0%) and the hybrid TNAU 45S/AC 38479 recorded the highest value of 26.78% and five hybrids possessed low amylose of <20.0%.

Gelatinization temperature (GT): Out of 13 parents, five parents namely TNAU 18S, TNAU 95S, CB 13212, CB 15117 and CB 15137 had high gelatinization temperature (2.0) and others possessed intermediate values (3-5). Seventeen hybrids had low GT and three hybrids based on TNAU 95S involving tropical *japonica* parents (KhaoKap Sang, Khao do ngoi and AC38479) had low GT of scores 6 and 7. The rest of the hybrids fell in the desirable category.

Gel consistency: All the parents had intermediate gel consistency with the values falling between 40 – 60mm. In hybrids, 26 combinations possessed soft gel consistency of >60 mm and the longest gel length was recorded by TNAU 14S/KhaoKap Sang (68.0 mm). The

Table 1: Mean performance of rice genotypes for physical grain quality traits

S.No.	Genotypes	H (%)	M (%)	HRR (%)	KL	KB	L/B	C
	Parents							
1	TNAU14S	64.14	59.30	55.24	6.4**	2.1	3.0	1
2	TNAU18S	69.74**	62.74**	59.42**	6.0	1.9	3.2**	1
3	TNAU45S	71.20**	68.20**	60.54**	5.5	1.7	3.2**	1
4	TNAU60S	75.12**	68.12**	62.33**	6.4**	2.0	3.2**	1
5	TNAU95S	68.25	58.25	55.41*	6.3**	2.3**	3.2**	5**
6	Palawan	72.34**	67.34**	60.23**	6.0	2.0	3.0	5**
7	KhaoKap Sang	69.88**	62.88**	57.89**	6.4**	2.4**	2.7	9**
8	Khao do ngoi	73.28**	65.28**	58.66**	6.0	2.1	2.9	1
9	AC 38479	70.80**	65.80**	59.63**	5.8	1.8	3.2**	9**
10	CB 13212	69.68**	61.68	56.56**	6.5**	2.1	3.1**	1
11	CB 15117	68.63*	60.63	54.23	6.0	1.8	3.3**	1
12	CB 15121	72.91**	67.91**	60.22	5.9	2.0	3.0	1
13	CB 15137	62.00	57.00	55.26	5.7	1.8	3.2**	1
	Hybrid combinations							
1	TNAU14SX Palawan	76.73**	67.42**	62.54**	6.5**	2.5**	2.6	1
2	TNAU14SX KhaoKap Sang	62.36	55.96	48.46	6.4**	2.6**	2.5	9**
3	TNAU14SX Khao do ngoi	63.54	55.38	47.93	6.3**	2.1	3.0	9**
4	TNAU14SX AC38479	76.54**	68.44**	63.18**	6.0	2.5**	2.4	9**
5	TNAU14SX CB 13212	61.79	54.68	47.16	6.0	2.0	3.0	1
6	TNAU14SX CB 15117	74.56**	65.21**	60.87**	6.4**	2.0	3.2**	1
7	TNAU14SX CB 15121	69.20**	62.11**	55.81*	5.2	2.0	2.6	1
8	TNAU14SX CB 15137	61.40	53.62	48.73	6.2*	2.0	3.1**	1
9	TNAU18SX Palawan	54.81	48.69	42.08	7.1**	2.2	3.2**	5**
10	TNAU18SX KhaoKap Sang	64.97	58.36	52.61	6.6**	2.0	3.3**	5**
11	TNAU18SX Khao do ngoi	61.61	55.67	46.61	6.0	2.4**	2.5	1
12	TNAU18SX AC38479	65.32	59.94	53.19	5.8	1.8	3.2**	5**
13	TNAU18SX CB 13212	61.85	54.66	47.67	4.8	2.0	2.4	1
14	TNAU18SX CB 15117	63.98	55.41	50.40	5.4	2.0	2.7	1
15	TNAU18SX CB 15121	77.42**	68.55**	63.22**	5.8	1.8	3.2**	1
16	TNAU18SX CB 15137	60.67	52.18	45.94	5.8	2.0	2.9	1
17	TNAU45SX Palawan	61.01	52.69	45.72	6.4**	2.0	3.2**	1
18	TNAU45SX KhaoKap Sang	78.27**	69.23**	63.88**	5.8	2.2	2.6	9**
19	TNAU45SX Khao do ngoi	55.91	48.71	42.14	6.0	2.0	3.0	9**
20	TNAU45SX AC38479	65.83	61.02	54.09	5.8	2.4**	2.4	9**
21	TNAU45SX CB 13212	56.74	50.88	42.64	6.2*	1.9	3.3**	1
22	TNAU45SX CB 15117	67.71	61.18	54.16	5.4	2.2	2.5	1
23	TNAU45SX CB 15121	67.50	61.99	54.18	5.2	1.8	2.9	1
24	TNAU45SX CB 15137	56.16	49.48	42.95	6.4**	1.8	3.6**	1
25	TNAU60SX Palawan	72.89**	64.28**	59.23**	7.0**	2.0	3.5**	5**
26	TNAU60SX KhaoKap Sang	60.35	53.61	46.76	6.0	2.4**	2.5	9**
27	TNAU60SX Khao do ngoi	64.49	57.21	52.76	6.5**	2.4**	2.7	9**
28	TNAU60SX AC38479	62.37	54.63	47.83	5.9	2.5**	2.4	5**
29	TNAU60SX CB 13212	73.87**	65.22**	60.58**	6.2*	2.5**	2.5	1
30	TNAU60SX CB 15117	65.73	61.09	53.84	6.5**	1.9	3.4**	1
31	TNAU60SX CB 15121	69.97**	62.39**	58.22**	6.2*	2.0	3.1**	1
32	TNAU60SX CB 15137	63.89	54.11	49.76	6.0	1.8	3.3**	5**
33	TNAU95SX Palawan	62.18	52.67	48.66	6.1	1.9	3.2**	1
34	TNAU95SX KhaoKap Sang	77.95**	68.45**	63.12**	6.0	2.8**	2.1	9**
35	TNAU95SX Khao do ngoi	65.67	61.11	53.47	6.6**	2.3**	2.9	9**
36	TNAU95SX AC38479	78.60**	70.22**	64.21**	5.8	2.8**	2.1	9**
37	TNAU95SX CB 13212	64.52	57.96	52.84	6.0	1.9	3.2**	1
38	TNAU95SX CB 15117	58.18	51.26	45.19	5.2	2.0	2.6	1
39	TNAU95SX CB 15121	61.46	56.78	46.18	5.6	2.0	2.8	1
40	TNAU95SX CB 15137	51.60	47.86	41.56	6.2*	1.8	3.4**	1
Mean		**66.56**	**59.54**	**53.51**	**6.06**	**2.09**	**2.92**	**3.42**
LSD (0.01)		**2.37**	**2.24**	**2.41**	**0.17**	**0.09**	**0.10**	**1.24**
LSD (0.05)		**1.80**	**1.70**	**1.82**	**0.13**	**0.07**	**0.15**	**0.94**

*Note: * and ** denote significance at 5% and 1% level, respectively. H%: Hulling percentage; M%: Milling percentage; HRR%: Head rice recovery%; KL: Kernel length (mm); KB: Kernel breadth (mm); L/B: Kernel length/Kernel breadth ratio; C: Chalkiness*

Table 2: Mean performance of rice genotypes for cooking quality traits

S.No.	Genotype	KLAC	LER	KBAC	BER	AC (%)	GC	GT
	Parents							
1	TNAU14S	9.5**	1.48	2.54	1.21	22.39	52.0	3
2	TNAU18S	9.1	1.52	2.38	1.25	24.76**	57.0	2
3	TNAU45S	8.0	1.45	2.06	1.21	23.25	51.0	3
4	TNAU60S	9.8**	1.53	2.62	1.31	22.11	45.0	3
5	TNAU95S	9.7**	1.33	3.06	1.33	24.28	51.0	2
6	Palawan	8.3	1.38	2.50	1.25	25.76**	45.0	3
7	KhaoKap Sang	10.1**	1.58**	3.12	1.30	26.69**	44.5	4**
8	Khao do ngoi	9.0	1.50	2.56	1.22	25.44**	55.0	5**
9	AC 38479	8.7	1.50	2.21	1.23	25.22**	51.0	4**
10	CB 13212	9.0	1.38	2.56	1.22	23.28	57.0	2
11	CB 15117	8.9	1.48	2.18	1.21	22.94	45.0	2
12	CB 15121	8.5	1.44	2.52	1.26	22.42	49.5	4**
13	CB 15137	8.1	1.42	2.34	1.30	23.21	50.0	2
	Hybrid Combinations							
1	TNAU14SX Palawan	9.8**	1.51	3.4**	1.36**	21.42	61**	2
2	TNAU14SX KhaoKap Sang	9.6**	1.50	3.5**	1.35**	17.68	68**	5**
3	TNAU14SX Khao do ngoi	9.5**	1.51	3.1**	1.48	23.36	63**	3
4	TNAU14SX AC38479	9.3	1.55**	3.3**	1.32*	17.21	57	3
5	TNAU14SX CB 13212	9.2	1.53	2.6	1.30	23.91	64**	2
6	TNAU14SX CB 15117	9.6**	1.50	2.8	1.40**	23.33	63**	3
7	TNAU14SX CB 15121	8.5	1.63**	2.7	1.35**	26.61**	50	2
8	TNAU14SX CB 15137	9.5**	1.53	2.5	1.25	24.83**	65**	2
9	TNAU18SX Palawan	10.2**	1.44	3.0**	1.36**	23.59	64**	3
10	TNAU18SX KhaoKap Sang	9.9**	1.50	2.7	1.35**	18.31	58	3
11	TNAU18SX Khao do ngoi	9.2	1.53	3.2**	1.33**	22.01	62**	2
12	TNAU18SX AC38479	9.1	1.57**	2.3	1.28	25.66**	66**	3
13	TNAU18SX CB 13212	7.5	1.56**	2.7	1.35**	25.26**	65**	2
14	TNAU18SX CB 15117	9.0	1.67**	2.5	1.25	26.44**	66**	2
15	TNAU18SX CB 15121	9.0	1.55**	2.2	1.22	23.69	53	3
16	TNAU18SX CB 15137	9.1	1.57**	2.6	1.30	25.22**	50	2
17	TNAU45SX Palawan	9.7**	1.52	2.6	1.30	21.44	56	2
18	TNAU45SX KhaoKap Sang	9.0	1.55**	3.0**	1.36**	23.49	63**	3
19	TNAU45SX Khao do ngoi	9.4*	1.57**	2.5	1.25	23.31	63**	5**
20	TNAU45SX AC38479	9.2	1.59**	3.3**	1.38**	26.78**	67**	4**
21	TNAU45SX CB 13212	9.4*	1.52	2.5	1.32*	23.76	64**	2
22	TNAU45SX CB 15117	9.1	1.69**	3.0**	1.36**	17.25	57	2
23	TNAU45SX CB 15121	8.3	1.60**	2.2	1.22	22.75	52	5**
24	TNAU45SX CB 15137	9.7**	1.52	2.5	1.39**	25.77**	66**	2
25	TNAU60SX Palawan	10.1**	1.44	2.8	1.40**	23.85	64**	3
26	TNAU60SX KhaoKap Sang	9.3	1.55**	3.3**	1.38**	17.41	57	3
27	TNAU60SX Khao do ngoi	9.7**	1.49	3.2**	1.33**	22.86	63**	5**
28	TNAU60SX AC38479	9.1	1.54	3.3**	1.32*	18.63	59	5**
29	TNAU60SX CB 13212	9.5**	1.53*	3.4**	1.36**	25.53**	66**	2
30	TNAU60SX CB 15117	9.7**	1.49	2.4	1.26	23.57	64**	2
31	TNAU60SX CB 15121	9.3	1.50	2.5	1.25	25.89**	66**	3
32	TNAU60SX CB 15137	9.3	1.55**	2.3	1.28	24.47*	64**	2
33	TNAU95SX Palawan	9.2	1.51	2.5	1.32*	26.46**	47	3
34	TNAU95SX KhaoKap Sang	9.3	1.55**	3.5**	1.25	23.17	63**	6**
35	TNAU95SX Khao do ngoi	9.8**	1.48	3.2**	1.39**	22.69	50	6**
36	TNAU95SX AC38479	9.1	1.57**	3.6**	1.29	22.81	53	7**
37	TNAU95SX CB 13212	9.2	1.53	2.5	1.32*	22.69	55	3
38	TNAU95SX CB 15117	7.9	1.52	2.8	1.40**	25.71**	66**	4**
39	TNAU95SX CB 15121	9.0	1.61**	2.6	1.30	25.46**	65**	2
40	TNAU95SX CB 15137	9.5**	1.53	2.4	1.33**	24.55*	65**	2
Mean		**9.20**	**1.52**	**2.75**	**1.30**	**23.41**	**58.17**	**3.1**
LSD (0.01)		**0.20**	**0.02**	**0.14**	**0.02**	**0.89**	**2.55**	**0.46**
LSD (0.05)		**0.15**	**0.01**	**0.11**	**0.01**	**0.68**	**1.92**	**0.35**

*Note: * and ** denote significance at 5% and 1% level, respectively. C.D.: Critical difference; KLAC: Kernel length after cooking; KBAC: Kernel breadth after cooking; LER: Linear elongation ratio; BER: Breadth wise expansion ratio; AC: Amylose content%; GC: Gel consistency (mm); GT: Gelatinization temperature* rest of the hybrids had intermediate values all >50.0 mm except TNAU 95S/Palawan (47.0 mm).

In hybrids, seed-borne on F_1 plants represent the F_2 seeds which are intermediate to the parents with uniformity in shape but differing in cooking quality characteristics due to segregation of endosperm genotypes. This might affect the quality of cooked rice unless the parents are chosen wisely. Cooking quality parameters like kernel length and breadth after cooking, linear elongation ratio and breadth wise expansion ratio are important criteria for consumer preference. Rice with more expansion and less breadth wise ratio is preferred. Linear elongation ratio was significantly higher in five hybrids *viz*., TNAU 45 S/CB 15117, TNAU 18 S/CB 15117, TNAU 14S/CB 15121, TNAU 95S/CB 15121 and TNAU 45S/CB 15121 with values of 1.69, 1.67, 1.63, 1.61 and 1.60 respectively.

Rice with high gelatinization temperature requires more water and time to cook than rice with low or intermediate gelatinization temperature. Khush *et al.* (1979) insisted that there seems to be a distinct preference for rice with intermediate gelatinization temperature. In the present study, seven hybrids namely TNAU 14S/KhaoKap Sang, TNAU 45S/Khao do ngoi, TNAU 45S/CB 15121, TNAU 60S/Khao do ngoi, TNAU 60S/AC38479, TNAU 45S/AC38479 and TNAU 95S/CB 15117 expressed intermediate gelatinization temperature.

Rice grain with high amylose and soft gel consistency is desirable as gel consistency determines the softness and 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, twenty-six hybrids expressed soft gel consistency (>60); a similar result of soft gel consistency was reported for hybrid rice by Ashish *et al.* (2006). Chen *et al.* (2008) pointed out that the high amylose varieties with hard gel consistency cook dry, flaky and have volume expansion but became hard after cooking. Intermediate amylose rice cook fluffy and remain soft on cooking, whereas, low amylose varieties cook sticky. Hence the varieties with intermediate amylose content are mostly preferred. In the present study, twenty-two hybrids had intermediate amylose content. However, twelve hybrids with high and other six hybrids had low amylose content were also present in this study.

Careful analysis of the grain quality characters of the newly released hybrids indicates the significant improvement in grain quality traits like high head rice recovery (>60-65%), alkali spreading value of 4-5 and intermediate amylose content (22-24.5) in most of the new generation hybrids released after 2006 (DRR, 2012). Therefore, the present study was also aimed to identify high yielding cross combinations with acceptable grain and cooking quality parameters. Accordingly, forty hybrids along with parents were analyzed for their physical and cooking quality characters. Virmani and Zaman (1998) have insisted that parental lines should have desirable grain quality for producing hybrids with improved quality. This study revealed that considering both physical and cooking quality traits, the two-line hybrids namely TNAU 45S/AC38479, TNAU 45S/CB 15121, TNAU 45S/Khao do ngoi and TNAU 45S/CB 15117 had acceptable grain quality traits and these hybrids can be studied further in different locations and can be promoted commercially.

REFERENCES

Adair, C. R., Bollich, C. N., Bowman, D. H., Jodon, N. E., Johnston, T.H., Webb, B. D. and Atkins, J.G. 1973. Rice breeding and test methods in the United States. *In. Rice in the United States: Varieties and Production*, USDA Handbook 289. U.S. Dept. Agric. Washington, DC., USA, pp. 19 - 64.

Ashish, K.B., Kalaiyarasi, R., Thiyagarajan, K. and Mannonmani, S. 2006. Physicochemical and cooking quality characteristics of promising varieties and hybrids in rice. *Indian J. Genet. Plant Breed.*, **66(2):**107-112.

Azeez, M.A. and Shafi, M. 1966. Quality in rice. Department of Agriculture West Pakistan *Tech. Bull*., **13**: 50.

Cagampang, G. B., Perez, C.M. and Juliano, B.O. 1973. A gel consistency test for eating quality of rice. *J. Sci. Food Agric.*, **24**:1589-1594.

Chen, M.H., Bergman, C., Pinson, S.R.M. and Fjellstrom, R. 2008. Waxy gene haplotypes: Associations with apparent amylose content and the effect by the environment in an international rice germplasm collection. *J. Cereal Sci.*, **47(3)**:536-545.

Hossain, S., Singh, A.K. and Zaman, F.U. 2009. Cooking and eating characteristics of some newly identified inter sub-specific (*indica / japonica*) rice hybrids. *Sci. Asia*, **35(4)**: 320-325.

Jones, G.R.D. 2009. Critical difference calculations revised: inclusion of variation in standard deviation with analyte concentration. *Ann. Clin. Biochem.,* **46**:517-519. DOI: 10.1258/acb.2009.009083

Juliano, B.O. and Perez, C.M. 1984. Results of a collaborative test on the measurement of grain elongation of milled rice during cooking. *J. Cereal Sci.*, **2**(4): 281-292.

Juliano, B.O., Cagampang, G. B., Cruz, L. J. and Santiago, R.G. 1964. Some physicochemical properties of rice in Southeast Asia. *Cereal Chem.*, **41**(4):275-286.

Juliano, B.O., Perez, C. M., Blakeney, A. B., Castillo, T., Kongseree, N., Laignelet, B., Lapis, E.T., Murthy, V.V.S., Paule, C.M. and Webb, B.D. 1981. International cooperative testing on the amylose content of milled rice. *Starch*, **33**(5):157-162.

Khush, G. S., Paule, C. M. and Delacruz, N.M. 1979. Rice grain quality evaluation and improvement of IRRI. *In. Proc. Workshop on Chemical Aspects of Rice Grain Quality*, Los Banos, Philippines, pp. 21–31.

Oko, A., Ubi, B. and Efisue, A. A. 2012. A comparative study on Local and newly introduced rice varieties in Ebonyi state of Nigeria based on selected agronomic characteristics. *Int. J. Agric. For.*, **2**(1):11-17.

Virmani, S.S. 1994. Prospects of hybrid rice in tropics and subtropics. *In. Hybrid Rice Technology, New Developments and Future Prospects* (Ed. Virmani, S.S.), IRRI, P.O. Box 933, Manila, Philippines.

Virmani, S.S. and Zaman, F.U. 1998. Improving grain quality of hybrid rice: challenges, strategies and achievements. *In. Advances in Hybrid Rice Technology* (Eds. Virmani, S.S., Siddiq, E.A. and Muralidharan, K.), Proc. of 3rd Int. Symp. Hybrid Rice, Nov. 14-16, 1996, Hyderabad, India. Manila (Philippines): International Rice Research Institute, pp.177-186.