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# Evaluation of Physical, Chemical and Cooking Characteristics among Parents and F1 Hybrids in a 7 x 7 Diallel in Rice (*Oryza sativa* L.)

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**ABSTRACT:** *The study was carried out to determine the physical, chemical and cooking characteristics among parents used in the crosses and their F1 hybrids derived from the crosses. Parameters assessed include grain lengths of paddy, grain width of paddy, length by width ratio of paddy, length of milled rice, length by width ratio of milled rice, width of milled rice, milling recovery, water absorption rate on cooking, length of cooked rice, rate of elongation and weight of cooked rice, milled rice length dimension, grain textual appearance after cooking and aroma. Results obtained were analysed using Excel Plant Breeding tools (PB tools 1.3, 2013) and Statistical tools for Agricultural Research (STAR 2.0.1, 2013). Result showed significant difference for most of the parameters assessed.*

**KEYWORDS:** physical, chemical, cooking characteristics, parents, F1 hybrids, rice

## INTRODUCTION

Rice (*Oryza sativa* L.) has occupied the position as one of the leading food crops in the universe, providing food for more than half of the world's population as a staple food (Singh *et al.*, 2005; Baroudy *et al*., 2020). It is widely cultivated and consumed since time immemorial throughout the universe and is the second most important cereal crop in terms of cultivation after wheat (Oko *et al.*, 2012). It contributes about 40% to 80% of the calorie when consumed mainly as a whole grain after cooking thereby serving an important role in livelihood and food security (Thomas *et al.*, 2013; Bhat and Riar, 2017).

Rice have varied agro-morphological characters some of which are promising in terms of yield (Sharma *et al.*, 2020). The grain quality of rice is a complex character composed of many components such as nutritional quality, appearance, cooking quality, and eating quality. Recently, there is increasing demand for rice varieties with excellent quality characteristics throughout the universe since cooking and eating quality have the major role in determining economy, market, and consumer acceptability (Asghar *et al.*, 2012).

Therefore, breeding between relevant varieties may be helpful in providing relevant information about the kind of gene action involved in the expression of a trait which can be obtained through diallel analysis (Hassanien *et al*., 2020). In other words, diallel analysis provides genetic information that enables breeders to select the most optimal breeding

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strategies for hybrid variety. In the early stages of breeding techniques, additive and non-additive gene action estimations are critical. Selection would be successful in the early generations when additive gene action is the dominating mode of action. Unless these effects are fixed in the homozygous line, selection will occur in later generations. This study aimed to assess heterosis, combining ability and genetic parameters for earliness and yield traits in rice. Although rice hybrids are known to show a very high level of heterosis for grain yield, they suffer a huge problem in grain quality mainly because of the high degree of grain quality diversity of parental lines (Hossain *et al.*, 2009). With the consumers being more concerned for the quality, emphasis on quality breeding has assumed a greater significance in recent years. A wide variation in the chemical composition of rice provides further scope for improving its nutrition and grain quality through breeding. The study was therefore undertaken to characterize and evaluate the physical, chemical and cooking characteristics among parents and F1 hybrids in a 7 x 7 diallel in rice.

## MATERIALS AND METHODS

A total of 28 samples were used for the study comprising of seven parents and 21 F1 hybrids derived from crossing the parents in the field. For physical measurement of lengths, width, a digital micrometer screw gauge was used to measure the rice length and width both cooked and un-cooked, milled and paddy rice.

For cooking characteristics, a sample of the seven parents and 21 hybrids, 2.0 grams were obtained and put on a test tube (250ml volume capacity) and 10ml of water were added to each test tube, corked and labeled (they were arranged on test tube rack to avoid unnecessary movement. The whole test tubes were immersed in a beaker containing hot boiling water at 100$^o$C and cooking process by conduction method into test tube containing sample were carried out for 30 minutes. Post-cooking parameters were assessed accordingly. An electrical cooking appliance A Toshiba model was used. Post cooking parameters such as grain textural appearance were assessed by pressing each sample of cooked rice between the fingers and classified as sticky, non-sticky and readily separable. Aroma was assessed by smelling the sample from the test tube and classified as scented, non-scented, lightly scented. Milled rice were classified as extra-long, long, medium based on length dimension.

## RESULTS AND DISCUSSION

Mean values for physical, chemical and cooking characteristics were recorded in table 1. The highest mean value recorded for paddy rice grain lengths is 10.79mm and the minimum being 8.35mm. Grain width of paddy shows maximum width of 2.40mm and minimum of 1.72mm, length and with ratio recorded maximum 6.17mm and 3.77mm minimum value. Length of milled rice recorded maximum 7.94mm and 6.14mm minimum value. The length of milled rice values recorded supersedes the lengths (6.10 – 6.43mm) recorded by Mayowa *et al.* (2017), Width of milled rice (1.88 – 1.43mm) and other physical parameters are recorded in table 1. Similarly, all cooking properties, that is, water absorption rate on cooking, length of cooked rice, rate of elongation and weight of cooked rice are summarized in table 1. The length of cooked rice recorded between 7.20mm – 10.56mm which is similar to results obtained by Mayowa *et al.* (2017). Water uptake ratio observed is also similar to the findings of Oko *et al.*

(2012). It was also observed that some varieties increased twice to thrice its original weight on cooking. This is a trait needed by consumers. High water uptake ratio affects palatability of cooked rice (Ohtsubo and Nakamura, 2017; Yu *et al.,* 2017). High rate of cooked rice elongation and water uptake ratio observed in table 1 is a preferred quality (Okpala *et al.*, 2021). The difference in water uptake might be attributed to difference in amylose content of the rice. High amylose content tends to absorb more water on cooking (Frei *et al.*, 2003; Sanusi *et al.*, 2017). Cooking quality of rice mainly depends on amylose content and gelatinization temperature. Amylose contents determines the texture of cooked rice (Lu *et al.*, 2013). Rice varieties with high amylose content absorb more water and have fluffy texture after cooking as seen in P1 x P3, P7, P2 x P7, P1 x P7, P2 x P4, P3 x P7, P4 x P3, P5. From observations, it indicated that parent P7 absorbs more water and also showed that most hybrids derived from it have inherited such traits.

Mean square from analysis of variance indicated highly significant difference for almost all the traits studied (Table 2). Higher variance component on dominance and additive recorded on chalkiness of the endosperm resistance to blast disease and escape to Quilar bird attack is an indication of possibility of gene linkage effect (Singh, 2013). Similarly, higher specific combining ability recorded on same traits is an indication that dominance gene action was in play (Lopes *et al.,* 2015). Higher additive gene effect was recorded on Quilar attack escape, chalkiness of the endosperm, resistance to panicle blast is an indication that progress can be achieved on such traits for hybridization (Yan *et al.,* 2017). Heritability in narrow sense (h2) was also found to be higher in Quilar bird escape, resistance to panicle blast, paddy grain length which indicate that progress in selection for such traits is possible (Su *et al.,* 2012). Higher SCA variance recorded 0.9615 (table 2) on such trait indicating dominance gene effect, therefore improving the trait could be achieved through heterosis breeding since hybrids selected on the basis of their SCA effects would excel in their heterotic effect (Gopikannan and Ganesh, 2013; Bano and Singh, 2019).

Table 3 shows some cooking characteristics of the parents and F1 hybrids. Grain appearance after cooking were classified based on texture as sticky, non-sticky and readily separable. The sticky nature of rice may be attributed to high amylose content of the grain while the non-sticky and readily separable is an indication of lesser amylose content (Futakuchi *et al.,* 2013). The aroma rating were carried out by smelling through the cooked rice from test tubes and were classified as scented, non-scented and lightly scented. The aromatic quality of rice is one of the required qualities by consumers (Diako *et al.,* 2010; Singh, 2013).

Rice dimension were classified as extra long, long and medium in line with standard evaluation system for rice. Long slender rice which are readily separable are mostly preferred quality in terms of dimension (Singh, 2013).

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Table 1: Mean performance of physical, chemical and cooking characteristics among parents and F1 hybrids in Rice (*Oryza sativa* L.)

| ENTRIES | GRAIN LENGHT OF PADDYRICE (mm) | GRAIN WIDTH OF PADDY RICE (mm) | LENGTH by WIDTH RATIO OF PADDY RICE | LENGTH OF MILLED RICE (mm) | LENGTH by WIDTH RATIO OF MILLED RICE | WIDTH OF MILLED RICE (mm) | MILLING RECOVERY (%) | WATER ABSORPTION RATE ON COOKING (ml) | LENGTH OF COOKED RICE (mm) | RATE OF ELONGATION (mm) | WEIGHT OF COOKED RICE (g) | WATER UP TAKE RATIO (g) | CHALKINESS OF THE ENDOSPERM | SUSCEPTIBILITY RESISTANCE TO PANICLE BLAST | QUILABIRD ATTACK |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P1 | 10.38 | 1.93 | 5.38 | 7.94 | 1.88 | 4.22 | 79.00 | 2.95 | 10.30 | 2.36 | 5.75 | 2.88 | 1.00 | 0.00 | 0.00 |
| P1xP2 | 10.61 | 1.81 | 5.86 | 7.86 | 1.55 | 5.07 | 74.00 | 2.95 | 10.09 | 2.14 | 5.58 | 2.79 | 5.00 | 3.00 | 5.00 |
| P1xP3 | 10.48 | 1.85 | 5.66 | 7.45 | 1.54 | 4.33 | 77.00 | 3.95 | 10.56 | 3.11 | 6.18 | 3.09 | 1.00 | 0.00 | 0.00 |
| P1xP4 | 10.04 | 1.81 | 5.55 | 7.34 | 1.58 | 4.80 | 78.00 | 2.95 | 9.50 | 2.16 | 5.77 | 2.89 | 1.00 | 0.00 | 0.00 |
| P1xP5 | 9.92 | 1.77 | 5.60 | 6.59 | 1.44 | 4.58 | 79.00 | 1.95 | 10.00 | 3.41 | 6.20 | 3.10 | 9.00 | 0.00 | 0.00 |
| P1xP6 | 9.81 | 1.96 | 5.01 | 6.68 | 1.64 | 4.07 | 69.00 | 3.00 | 9.00 | 2.32 | 5.72 | 2.86 | 5.00 | 0.00 | 1.00 |
| P1xP7 | 8.65 | 1.82 | 4.75 | 6.22 | 1.46 | 4.26 | 74.00 | 3.00 | 7.20 | 0.98 | 3.90 | 1.95 | 9.00 | 0.00 | 1.00 |
| P2 | 10.61 | 2.06 | 5.15 | 7.72 | 1.80 | 4.28 | 68.00 | 2.96 | 10.18 | 2.46 | 5.78 | 2.89 | 5.00 | 5.00 | 5.00 |
| P2xP3 | 9.21 | 1.82 | 5.06 | 6.99 | 1.61 | 4.34 | 60.00 | 2.95 | 10.10 | 3.11 | 6.04 | 3.02 | 1.00 | 0.00 | 1.00 |
| P2xP4 | 9.13 | 1.93 | 4.73 | 7.40 | 1.64 | 4.51 | 79.00 | 3.00 | 10.40 | 3.00 | 6.10 | 3.05 | 5.00 | 0.00 | 1.00 |
| P2xP5 | 10.21 | 2.32 | 4.40 | 7.04 | 1.71 | 4.12 | 76.00 | 2.95 | 9.65 | 2.65 | 5.76 | 2.88 | 1.00 | 0.00 | 1.00 |
| P2xP6 | 10.40 | 1.78 | 5.84 | 6.68 | 1.64 | 4.07 | 79.00 | 2.00 | 7.84 | 1.16 | 4.10 | 2.05 | 9.00 | 0.00 | 5.00 |
| P2xP7 | 9.75 | 2.40 | 4.06 | 7.16 | 1.88 | 3.81 | 67.00 | 3.95 | 10.40 | 3.24 | 6.88 | 3.44 | 1.00 | 0.00 | 1.00 |
| P3 | 10.22 | 1.79 | 5.71 | 7.01 | 1.58 | 4.44 | 75.00 | 1.95 | 8.20 | 1.19 | 3.95 | 1.98 | 5.00 | 0.00 | 0.00 |
| P3xP4 | 9.50 | 1.76 | 5.40 | 7.52 | 1.43 | 5.26 | 78.00 | 2.95 | 9.88 | 2.36 | 5.74 | 2.87 | 5.00 | 0.00 | 0.00 |
| P3xP5 | 9.50 | 1.73 | 5.49 | 7.27 | 1.59 | 4.57 | 70.00 | 3.00 | 9.50 | 2.23 | 6.14 | 3.07 | 9.00 | 0.00 | 0.00 |
| P3xP6 | 10.38 | 1.73 | 6.00 | 7.37 | 1.44 | 5.12 | 68.00 | 2.70 | 9.04 | 1.67 | 5.98 | 2.99 | 9.00 | 0.00 | 0.00 |
| P3xP7 | 10.65 | 1.79 | 5.95 | 7.47 | 1.64 | 4.55 | 65.00 | 2.95 | 10.08 | 2.61 | 5.80 | 2.90 | 5.00 | 0.00 | 1.00 |
| P4 | 8.71 | 1.73 | 5.03 | 7.03 | 1.59 | 4.42 | 63.00 | 2.95 | 8.25 | 1.22 | 5.74 | 2.87 | 9.00 | 1.00 | 0.00 |
| P4xP5 | 10.14 | 1.77 | 5.73 | 7.33 | 1.56 | 4.70 | 77.00 | 2.95 | 10.00 | 2.67 | 5.79 | 2.90 | 5.00 | 0.00 | 0.00 |
| P4xP6 | 8.35 | 1.94 | 4.30 | 6.14 | 1.65 | 3.72 | 74.00 | 2.95 | 9.16 | 3.02 | 5.76 | 2.88 | 5.00 | 0.00 | 1.00 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P4xP7 | 9.46 | 1.87 | 5.06 | 7.48 | 1.65 | 4.53 | 67.00 | 3.00 | 10.40 | 2.92 | 6.09 | 3.05 | 9.00 | 0.00 | 1.00 |
| P5 | 9.42 | 2.15 | 3.77 | 6.88 | 1.74 | 3.95 | 80.00 | 3.00 | 8.00 | 1.12 | 5.73 | 2.87 | 1.00 | 0.00 | 0.00 |
| P5xP6 | 10.79 | 2.10 | 5.14 | 7.69 | 1.80 | 4.27 | 56.00 | 3.00 | 10.36 | 2.67 | 6.12 | 3.06 | 9.00 | 0.00 | 0.00 |
| P5xP7 | 10.21 | 1.80 | 5.67 | 7.50 | 1.60 | 4.69 | 62.00 | 2.95 | 10.14 | 2.64 | 5.76 | 2.88 | 9.00 | 0.00 | 0.00 |
| P6 | 9.77 | 1.90 | 5.14 | 7.50 | 1.53 | 4.90 | 70.00 | 2.95 | 9.32 | 1.82 | 5.78 | 2.89 | 5.00 | 0.00 | 1.00 |
| P6xP7 | 10.21 | 1.73 | 5.90 | 6.93 | 1.54 | 4.50 | 72.00 | 3.00 | 9.90 | 2.97 | 6.15 | 3.08 | 5.00 | 0.00 | 1.00 |
| P7 | 10.61 | 1.72 | 6.17 | 7.20 | 1.43 | 5.03 | 77.00 | 3.95 | 10.21 | 3.01 | 6.05 | 3.03 | 5.00 | 0.00 | 1.00 |
| Mean | 9.90 | 1.88 | 5.27 | 7.19 | 1.61 | 4.47 | 71.89 | 2.96 | 9.56 | 2.37 | 5.73 | 2.86 | 5.29 | 0.32 | 0.96 |
| Mini | 8.35 | 1.72 | 3.77 | 6.14 | 1.43 | 3.72 | 56.00 | 1.95 | 7.20 | 0.98 | 3.90 | 1.95 | 1.00 | 0.00 | 0.00 |
| Max | 10.79 | 2.40 | 6.17 | 7.94 | 1.88 | 5.26 | 80.00 | 3.95 | 10.56 | 3.41 | 6.88 | 3.44 | 9.00 | 5.00 | 5.00 |

**Key:** P1 = FARO 26, P2 = FARO 64, P3 = FARO 57, P4 = FARO 33, P5 = FARO 66, P6 = FARO 44, P7 = FARO 31,

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Table 2: Analysis of variance of physical and chemical characteristics of rice

| | Mean Square | | | Variance Components | | Genetic Parameters | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | ANOVA | GCA | SCA | GCA | SCA | VA | VD | h2 | H2 | Dominance Ratio |
| Grain length of paddyrice | 1.2915** | 0.5853** | 0.3863** | 0.0221 | 0.3863 | 0.0442 | 0.3863 | 0.1027 | 1 | 4.1795 |
| Grain width of paddy rice | 0.093** | 0.0513** | 0.0252** | 0.0029 | 0.0252 | 0.0058 | 0.0252 | 0.1873 | 1 | 2.9456 |
| Length by width ratio of paddy rice | 1.1214** | 0.4389** | 0.3552** | 0.0093 | 0.3552 | 0.0186 | 0.3552 | 0.0497 | 1 | 6.1825 |
| Length of milled rice | 0.6008** | 0.0563 | 0.2414** | 0.0000 | 0.2414 | 0.0000 | 0.2414 | 0.0000 | 1 | NaN |
| Length by width ratio of milled rice | 0.0469** | 0.0183** | 0.0148** | 0.0004 | 0.0148 | 0.0008 | 0.0148 | 0.0497 | 1 | 6.1817 |
| Width of milled rice | 0.4537** | 0.0931 | 0.1679** | 0.0000 | 0.1679 | 0.0000 | 0.1679 | 0.0000 | 1 | NaN |
| Milling recovery | 130.2976** | 32.3492 | 46.5992** | 0.0000 | 46.5992 | 0.0000 | 46.5992 | 0.0000 | 1 | NaN |
| Water absorption rate on cooking | 0.6648** | 0.2429** | 0.2155** | 0.0030 | 0.2155 | 0.0061 | 0.2155 | 0.0274 | 1 | 8.4276 |
| Length of cooked rice | 2.4711** | 0.3413 | 0.9615** | 0.0000 | 0.9615 | 0.0000 | 0.9615 | 0.0000 | 1 | NaN |
| Rate of elongation | 1.5341** | 0.2278 | 0.5924** | 0.0000 | 0.5924 | 0.0000 | 0.5924 | 0.0000 | 1 | NaN |
| Weight of cooked rice | 1.3316** | 0.1646 | 0.5237** | 0.0000 | 0.5237 | 0.0000 | 0.5237 | 0.0000 | 1 | NaN |
| Water up take ratio | 0.3326** | 0.0414 | 0.1307** | 0.0000 | 0.1307 | 0.0000 | 0.1307 | 0.0000 | 1 | NaN |
| Chalkiness of the endosperm | 28.1905** | 7.0265 | 10.0741** | 0.0000 | 10.0741 | 0.0000 | 10.0741 | 0.0000 | 1 | NaN |
| Susceptibility resistance to panicle blast | 3.5675** | 2.5132* | 0.8108** | 0.1892 | 0.8108 | 0.3783 | 0.8108 | 0.3181 | 1 | 2.0704 |
| Quilabird attack | 6.7738** | 6.8783** | 0.9378** | 0.6601 | 0.9378 | 1.3201 | 0.9378 | 0.5847 | 1 | 1.1920 |

**Key:** * = significant at 0.05 probability, ** = significant at 0.01 probability, GCA = general combining ability, SCA = specific combining ability, VA = additive variance, VD = dominance variance, h2 = narrow sense heritability, H2 = broad sense heritability, P1 = FARO 26, P2 = FARO 64, P3 = FARO 57, P4 = FARO 33, P5 = FARO 66, P6 = FARO 44, P7 = FARO 31,

Table 3: Some cooking characteristics of parents and F1 hybrids

| Variety | Stickiness | Scent | Length (mm) |
|---|---|---|---|
| P1 | NSTK | L.S | XL |
| P1xP2 | STK | S | XL |
| P1xP3 | R.S | S | L |
| P1xP4 | NSTK | N.S | L |
| P1xP5 | R.S | N.S | L |
| P1xP6 | NSTK | N.S | L |
| P1xP7 | STK | S | M |
| P2 | NSTK | S | XL |
| P2xP3 | R.S | S | L |
| P2xP4 | R.S | N.S | L |
| P2xP5 | NSTK | N.S | L |
| P2xP6 | STK | L.S | L |
| P2xP7 | R.S | S | L |
| P3 | STK | S | L |
| P3xP4 | NSTK | N.S | XL |
| P3xP5 | R.S | N.S | L |
| P3xP6 | R.S | S | L |
| P3xP7 | R.S | S | L |
| P4 | NSTK | NS | L |
| P4xP5 | R.S | N.S | L |
| P4xP6 | NSTK | L.S | M |
| P4xP7 | R.S | S | L |
| P5 | NSTK | NS | L |
| P5xP6 | R.S | S | XL |
| P5xP7 | NSTK | S | XL |
| P6 | R.S | L.S | L |
| P6xP7 | R.S | S | L |
| P7 | R.S | S | L |

**KEY**: NSTK – Non-sticky, STK – Sticky, R.S = Readily separable, XL – Extra long (> 7.5mm), L – Long (6.6  7.5mm), M – Medium (5.51 – 6.6mm), S – Scented, L.S – Lightly scented, N.S – Non-scented