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Evaluation of biometric yield parameters and grain quality characteristics of various rice genotypes grown in Nepal

S. DHUNGANA
Institute of Agriculture and Animal Science
Rampur, Chitwan, Nepal
S. K. GHIMIRE
N. R. ADHIKARI
Institute of Agriculture and Animal Science
Rampur, Chitwan, Nepal
S. P. KHATIWADA
Agriculture Botany Department, NARC, Khumaltar

Abstract:

Rice is one of the most important cereal crops in south East Asia which has been used as the major source of stable food. Aromatic rice has been high in demand in global market as well as in Nepalese market. The field trial has been conducted in the randomized augmented design in research block of Agri-Botany Department NARC; Khumaltar from June to November 2013 to evaluate the performance of eleven rice varieties, three type of aroma test has been conducted. Pooled analysis of yield showed that Chiniya Puri has highest yield of 6.8 kg in area of 4.5 m². The amylose content was found highest in Aanga with 27% whereas 9 varieties were found to have mild aroma and two doesn't emit any aroma. Longest panicle length was found in Basmati-370 with 27 cm whereas highest number of grains per panicle was found in Chiniya Puri and Anjana has highest Milled rice recovery percentage of 74%.

Key words: Amylose Content, Milled rice recovery, L/B, Kernel length

1. INTRODUCTION:

Rice (*Oryza sativa* L.) is a cereal crop belonging to family Gramineae. It produces edible grains which provide about 20% dietary energy. It has been cultivated for estimated years of 10000 years (Lui*et al*, 2007) and now is main source of food for more than 1/3 of world population (Singh and singh, 2008). Aromatic varieties are most appreciated by consumers and fetch higher market price then non aromatic rice varieties in world rice market (Singh e*t al*., 2000; Juliano, 2000). The intensity of aroma which is determined by volatile compounds in aromatic rice is affected by the grain maturation and storage (Singh *et al*., 2000; Fitzerald*et al*., 2008 and Gay *et al*., 2010).Aromatic rice consist a special group of rice accessions which are known for their specific aroma and fine grain quality which arises in its cooked condition (Ahuja *et al*., 1995; Khush and Dela Cruz, 1998; Kumar *et al*., 1996; Nene, 1998; Singh *et al.,* 2000 a, b). Aroma in rice grain is due to presence of more than 100 bio-chemical compounds (Petrov*et al*., 1996) out of which the most important chemical determining the aroma in rice is 2-Acetyl-1-Pyrroline (Buttery *et al*., 1982).Quality Characters of rice grains reveled to complex physio-chemical properties. Excellent kernel shape along with length and breadth ratio of kernel plays an important feature of quality rice (Patil*et a*l, 2003). Grain size and shape are the most desirable characters for determining the quality of rice and development of its varieties (Adair *et al*., 1966). Kernel appearance, size, shape, aroma, nutritional value and cooking behavior are important traits for judging the quality and preferences of rice from one group of consumer to the next (Khush*et al*, 1979; Dela Cruz and Khush, 2000 and Sellappan*et al*, 2009). Amylose content in rice is considered as main parameter determining the cooking and eating quality of rice (Juliano, 1972) which is specified by a single major locus with

modification of some minor genes (Bollich and Webb, 1973; MC Kenzie and Ratger, 1983 and Kumar and Khush, 1988). AC determines the hardiness and stickiness of cooked rice.

OBJECTIVE/ PURPOSE OF STUDY

1. Identification of superior genotypes having both quality traits and aroma
2. To assist in breeding program for development of rice varieties with superior grain quality and aroma
3. Collection and conservation of rice landraces along with study of variability among the genotypes

2. MATERIALS AND METHODS

2.1 Planting Materials:

Seeds of various rice cultivars were collected from the Gene Bank of NARC, Khumaltar with the aid of Agri-Botany Department.

2.2 Plot Layout:

The research was conducted in randomized block design consisting of thirteen genotypes including three check varieties. Each plot was 3.75 m in length whereas 1.2m in width with area of $4.5m^{2.}$ Each genotype was planted in six rows consisting of 25 plantlets in each row.

2.3 Sowing and Transplantation

Seedling of Seventeen days were used which were sown on June 11^{th} and transplantation was done on 28^{th} of June 2013.

2.4 Biometric and Yield Characteristics

2.4.1 Days to Maturity

This record was maintained as the day where the 85% of grains in each plot get changed to yellow color (Standard Evaluation System for Rice, IRRI, 2002).

2.4.2 Plant Height

The plant height of plant was taken by measuring from base to the tip of panicle, excluding the awns if present. It is the height of plant including Culm length and panicle length.

2.4.3 Panicle length

The length of panicle was taken as the distance between the bases of panicle to the tip of panicle excluding the awns length

2.4.4 Grain number per panicle

10 panicles from each sample plot were selected on random basis and are hand threshed to record the number of grains per panicle.

2.4.5 Number of fertile grain per panicle

The grains having rice kernel was counted as the fertile grains.

2.4.6 Grain yield/plot

After harvesting the grains they were allowed for sun drying for duration of ten days and then their weight was measured by using electronic balance. Similarly moisture content of rice sample was measured by using Dale 400 moisture meter. Average moisture content in grains was maintained as 14% and then grain yield per plot was determined.

2.4.7 Straw yield

After detaching the grains the straw was allowed to dry in sun for ten days then the weight of straw was taken with the help of electronic balance.

2.5 Grain Quality Parameters

2.5.1 Hulling percentage

125 gram of rice seeds from each sample genotype were de-hulled by using Standard Otake De-husker and the whole grain yield were calculated by using formula.

Hulling (%) = Amount of brown rice ÷ Amount of rough rice (sample rice) ×100

2.5.2 Milled rice recovery

Amount of rice after removing the barn is calculated and is termed as milled rice recovery. Higher the percentage of rice recovery more it's beneficial.

2.5.3 Grain classification

Length and breadth of ten de-husked entire brown rice was measured by using dial micrometer and then classified into four distinct groups on the basis of their L/B ratios and kernel length.

2.5.4 L/B ratio

Sample of rice kernels are measured on both length and breadth and classified into four distinct groups as Slender, Medium, Bold and Round on basis of their L/B ratio.

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

(Standard Evaluation System for Rice, IRRI, 2002)

2.5.6 Kernel Length

Length of 10 milled rice kernels from each variety was measured by using dial micrometer and the varieties were classified into 4 distinct classes on the basis of their length as Extra-long, Long, Medium and Short ranging length of kernel.

Size	Extra Long	Long	Medium	Short
Length of Kernel(mm)	>7.5	6.6-7.5	5.51-6.6	<5.5

(Standard Evaluation System for Rice, IRRI, 2002)

2.5.7 Kernel Breadth

Length of 10 milled rice kernels from each variety was measured by using dial micrometer

2.6 Chemical traits

2.6.1 Alkali spreading value and clearing test

Six de-husked brown rice from each sample was taken in a Petri-dish to check alkali spreading value and clearing test. 10 ml of 1.7% KOH solution is placed in Petri-dish where the sample of rice was placed with plenty of space and then covered by the lid and placed in a cardboard box maintaining 30°C temperature and left for 23 hours. Then reading was taken on

seven different categories as shown in table 2 (Standard Evaluation System for Rice, IRRI, November 2002).

2.6.2 Amylose content

100 mg of rice flour sample from each variety was taken and 1 ml of 95 % ethanol along with 9 ml of 1.0 N NaOH was added in the solution. The mixture was allowed to heat by keeping in heated water-bath for 10 minutes. The samples were then allowed to cool and then diluted to 100 ml by adding distilled water in it. From the suspension thus prepared 5 ml of sample solution was taken where 1 ml acetic solution was added to acidify the solution and later on 1.5 ml Iodine solution containing 0.2 % iodine and 2% potassium iodide was added and volume made to 100 ml with addition of distilled water. Samples were then kept at room temperature for 20 minutes. The reading of absorbance was taken with the help of spectrometer at 620 nm. NaOH solution was used as the control. AC of rice sampled varieties was calculated by comparing with standard graph (Perez and Juliano, 1978).

2.6.3 Gelatinisation temperature

It was determined by using the relationship with alkali spreading value. The value rated for alkali spreading value based on the response shown by six rice kernels on 1.7% KOH kept at room temperature of 30°C for 23 hours. Alkali digestion value was used to find out the GT value.

2.6.4 Grain elongation ratio

10 grains of each sample was taken and length was measured with the help of graph. Then the sample was placed in a test tube containing 15 ml tap water and left for 20 minutes. Then the test tubes containing samples were placed in water bath containing hot water and left for 20 minutes maintaining 80 $^{\circ}$C temperatures. Then the test tubes were taken out from water bath and allowed to cool and the grains were transferred to filter paper and left for some time then elongation is measured by using micrometer.

2.7 Aroma test

2.7.1 Leaf aroma test (LAT)

0.2 gm sample from each rice variety was weighed and cut down into small pieces which were placed in cleaned Petri-plates. 1.7% KOH solution was prepared by adding 19.54 gm. (85% purity) of KOH pellets in 1000 ml of distilled water.10 ml of freshly prepared KOH solution was added over to the Petri--plates containing the leaf samples. Then the samples were covered and kept in room temperature for 10 minutes. After 10 minutes the lids of Petri--plates were removed and the content was smelt one by one and scored on scale of 1-3 as 1, 2 and 3 corresponding to absence of aroma, slight or mild aroma and strong or high aroma respectively (Standard Evaluation System for Rice, IRRI, November 2002)

A panel of five members consisting of two scientist and staff from NARC Agri-Botany Department and two students from IAAS were invited to score the aroma of each genotype.

2.7.2 Grain aroma test (GAT)

40 grains from each variety was selected and put in Petri--dish in order to know the aroma of grains.1.7% KOH solution was prepared by adding 19.54 gm (85% purity) of KOH pellets in1000 ml of distilled water. 10 ml of sample solution prepared was added in each Petri--dish containing the sample and then the samples were left for one hour at room temperature with the lid covered. After an hour the lids of sample were removed one by one and was smelt to find out the aroma content and scored on scale of 1-3 as 1, 2 and 3 corresponding to absence of aroma, slight or mild aroma and strong aroma (Standard Evaluation System for Rice, IRRI, 2002). Same panel of members were used for the process.

2.7.3 Aroma of cooked rice (CAT)

5 gm. of sample from each variety was added to a test tube containing 15 ml of tap water and allowed to soak for 15 minutes. Then it is transferred to water-bath and cooked for 20

minutes at 80°C. Then the sample was allowed to cool with and kept in refrigerator for 20 minutes with its mouth sealed. Then aroma of rice was taken and noted into three distinct classes as 1, 2 and 3 on the basis of Absence of aroma, Slight aroma and Strong aroma (Standard Evaluation System for Rice, IRRI, 2002). Same panel of members were used for the process.

3. RESULTS AND DISCUSSIONS

3.1 Physical Parameters

There have been significant differences among the mean of days to maturity whereas the average days to maturity was 133 and earliest maturity was found in Jhinuwa with 115 days whereas Pokhreli Masino was late maturing variety with 143 days. Jhinuwa genotypes would be further explored in the process of developing early maturing varieties by hybridization program. There was significant difference among the plant height of rice genotypes while significant variation among the plant height of rice genotypes was observed. The height of plant was found highest in Pokhreli Masino of 155 cm whereas average height was 123cm. Slight significant differences among the genotypes for panicle length were observed but there was moderate variation among the genotypes on basis of their panicle length. The mean of panicle length was observed as 24 cm whereas seven varieties have longer panicle length than that of average and longest length was found in Basmati-370 with 27 cm. highly significant result was observed among the genotypes for grain filling period where average period was 34 while Jhinuwa has the lowest grain filling days of 29.83 and longest in Hansa Raj. The variation among panicle length may be due to influence of variety as they are assessed by different genetic background (Idris and Matin, 19; Anonymous, 1993; Nahida*et al*, 2013).The result of present study was also supported by Kole and Hasib, 2006 while study done on genetic variability for

various traits showed that panicle length was under genetic control (Ifftikhar*et al*, 2009). They can be used in selection process for same desirable traits.

There was significant difference in number of effective tillers among the rice genotypes .The mean of number of effective tillers was 11 whereas lowest was 8 and highest was found in Anjana with 16 effective tillers per hill. There was significant difference among the genotypes for mean thousand grain weight which may be due to their genetic background and heredity. The average weight was 25 gm whereas highest of 3o gm was observed in Aanga and Anjana varieties. Among the eleven varieties it was found that the highest number of grain per panicle was found in Chiniya Puri variety with 276 whereas average was only 203. It has also been found the highest grain yield has been observed in same variety Chiniya Puri with 6.68 kg in 4.5m^2 whereas it also have highest straw yield, which shows that its best variety for both straw and grains.

3.2 Quality Parameters

Significant differences in result were observed among the eleven varieties. Hulling percentage on normal lies from 63-83 % while hulling percentage of 80 % and more is desirable as with the increase in hulling percentage amount of rice recovery increases (Swaragi et al., 2008).All genotypes have higher hulling percentage higher than the lowest level while three genotypes were better than the higher level of 80%. Highest hulling percentage was found in Jhinuwa with 83% whereas lowest was found in 75.98%. A significant difference was observed among the means of Milled rice recovery of varieties.There was variation among the genotypes based on milled rice recovery amount which depends on the varietal character as well as the drying condition of grains (Witte, 1972; Adair et al, 1973). It indicated that genotypes having higher rate of milled rice recovery and hulling percentage is good for

breeder to develop new rice genotypes. Highest Milled rice recovery was found in Anjana with 74 % while lowest was found in Basmati-370 with 67%.

Significant results were observed among the means of kernel length among the eleven varieties. The average kernel length was found to be 5.70 mm whereas maximum was 6.87 of Basmati-370 whereas shortest length was found in 3.99 mm. The results thus obtained were better than the result of 3.6 mm to 6.5 mm (S.S Dipti, 2007) and in some points nearer to findings 4.30 mm to 7.80 mm (Meena et al, 1999) and 3.33 mm to 8.02 mm (Srivastava, 2013).

There has been a significant result among the means of kernel breadth, the average breadth was found as 2.28 mm whereas maximum was 2.97 mm in Hansa raj and minimum was found in Pokhreli Masino with 1.89 mm. The result thus we obtained on basis of width of kernel in Nepalese grains were on average and somehow better than the previous. The results were found superior then the results observed on aromatic rice as 1.7 mm to 3.77 mm (S. S. Dipti, 2002).

The average kernel length was found as 5.70 mm whereas the longest was 6.88mm in Basmati-360 and shortest was observed in Gudgudo with 3.94 mm similarly the average L/B ratio was observed as 2.58 whereas the maximum as found in Basmati-370 with 3.87 and minimum was found in Gudgudo. Based on the classification to L/B ratio and Kernel length it was found that three out of eleven were Slender whereas three have bold grain types, similarly one has long grain size whereas four have short grain size and remaining six have medium size of grain.

3.3 Chemical Parameters

Among the twelve rice varieties it was found that ten variety emitted aroma in all three tests while two didn't emit any aroma during the test out of which Khumal-4 was not aroma

emitting check variety. Similarly it was found that three varieties have intermediate level of Gelatization temperature (70-75°C) whereas remaining have low of (55-69°C) Gelatization temperature. Although not any significant result has been observed among the varieties in Amylose content but highest was observed in Aanga with 27.78% while lowest was observed in Hansa Raj with only 7.03%.AC determines the hardiness and stickiness of cooked rice. AC higher than 25 % gives non sticky soft or hard cooked rice. Rice having AC 20-25 % gives soft and relatively sticky cooked rice (Anonymous, 1997).Amylose content of rice is considered as the main parameter that determine cooking and eating quality of rice (Juliano, 1972) so the content of aroma plays an important role in finding consumers demand and price. The average alkali spreading value of the twelve varieties were found to be five whereas three varieties were found to have value of 7. Not any significant differences were found among the means of grain elongation ratio of eleven rice varieties.

4. CONCLUSIONS

Aroma is one of the most important traits determining the consumer's preferences on purchase of rice. Aromatic rice cultivate throughout the country in a small scale only for home consumption although it is highly demanded and fetch higher price than non-aromatic rice. From the research conducted we can draw some conclusions that Nepalese Aromatic and Non Aromatic landraces possesses special quality which can be further utilized in plant breeding program. These genotypes are better than the present cultivated modern varieties and they can compete with imported rice grains in term of grain quality. It was found that the local landraces like Aanga, Anjana and Chiniya Puri along with Gudgudo has huge genetic as well as agronomic traits which are beneficial for further breeding

process so these so be preserved. Chiniya Puri yields more than the commercially grown aromatic varieties similarly Anjana have good amylose content so they may be grown and used to reduce food security prevailing in the country.

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Table 1. Biometric and yield characteristics of rice varieties

S.	Genotypes	DM	PH	PL	GFP	NGPP	NET	1000 GW	GY	SY
1	Aanga	121.3^{cd}	124.4^{a-s}	22.11^{ab}	32.83^{cd}	255.7^{ab}	11.39^{abc}	30.57^{b-f}	4.377^{abc}	6.913^{ab}
2	Anjana	128.3^{abc}	120.4^{b-s}	24.11^{ab}	30.83^{d}	134.7^{cdef}	16.39^{a}	30.87^{b-f}	4.622^{ab}	6.793^{ab}
3	Basmati 370	134.9^{abc}	119.8^{b-s}	27.78^{ab}	32.5^{d}	186.4^{bcd}	10.06^{abc}	20.61^{h-o}	4.764^{ab}	6.62^{ab}
4	Chiniya Puri	127.9^{abc}	141.8^{a-p}	24.78^{ab}	34.5^{abcd}	276.4^{ab}	14.06^{ab}	25.12^{d-j}	6.681^{a}	8.87^{a}
5	CNTRL 85033	141.3^{abc}	84.44^{e-s}	22.11^{ab}	35.17^{abcd}	177.7^{bcd}	13.39^{ab}	29.58^{b-g}	3.575^{abc}	5.147^{abc}
6	Gudgudo	157.3^{a}	151.4^{a-j}	24.11^{ab}	37.83^{abcd}	165.7^{cdef}	8.389^{abc}	17.34^{j-o}	1.176^{cde}	5.053^{abc}
7	Hansa Raj	134.3^{abc}	131.4^{a-s}	23.11^{ab}	40.17^{abcd}	177.7^{bcd}	11.39^{abc}	28.15^{b-g}	4.236^{abc}	6.123^{abc}
8	IR 67017	132.3^{abc}	85.44^{e-s}	25.11^{ab}	33.83^{bcd}	175.7^{cdef}	10.39^{abc}	29.48^{b-g}	4.173^{abc}	6.193^{ab}
9	Jhinuwa	115.3^{d}	103.4^{e-s}	22.11^{ab}	29.83^{d}	177.7^{cdef}	11.39^{abc}	24.36^{e-k}	3.253^{abc}	5.233^{abc}
10	Khumal-4	135.2^{abc}	143^{a-p}	27^{ab}	32.67^{d}	245.2^{ab}	11.17^{abc}	19.04^{j-o}	5.72^{ab}	7.717^{ab}
11	Pokhreli Masino	143^{ab}	155.2^{a-g}	26^{ab}	34.33^{bcd}	271^{ab}	10.17^{abc}	21.6^{h-n}	5.112^{ab}	7.225^{ab}

Superscript letters (a-e) indicate significant differences (p<0.5) among varieties whereas mean with same letter with the column varieties are not significantly different (p<0.5).

Table 2 Quality Characteristics of Aromatic Varieties

S.N	Genotypes	Hulling %	MRR	KL	KB	L/B
1	Aanga	79.92^{abc}	72.2^{ab}	5.83^{abcde}	2.55^{a}	2.25^{ab}
2	Anjana	80.49^{ab}	74.26^{ab}	5.59^{bcde}	2.62^{a}	2.09^{ab}
3	Basmati 370	79.04^{abc}	67.68^{abc}	6.88^{abc}	1.94^{ab}	3.57^{ab}
4	Chiniya Puri	79.24^{abc}	70.57^{abc}	5.44^{bcde}	2.48^{a}	2.24^{ab}
5	CNTRL 85033	75.98^{bcd}	71.64^{ab}	6.29^{abcde}	2.17^{a}	2.91^{ab}
6	Gudgudo	80.27^{ab}	69.12^{abc}	3.94^{e}	2.37^{a}	1.61^{b}
7	Hansa Raj	78.39^{abc}	75.05^{ab}	5.03^{bcde}	2.97^{a}	1.72^{b}
8	IR 67017	79.45^{abc}	72.04^{ab}	6.55^{abcd}	1.88^{ab}	3.51^{ab}
9	Jhinuwa	83.24^{a}	67.75^{abc}	5.49^{bcde}	2.20^{a}	2.47^{ab}
10	Khumal-4	76.26^{abc}	69.43^{abc}	5.62^{bcde}	1.99^{ab}	2.82^{ab}
11	Pokhreli Masino	78.86^{abc}	68.71^{abc}	6.05^{abcde}	1.9^{ab}	3.22^{ab}

Superscript letters (a-e) indicate significant differences (p<0.5) among varieties whereas mean with same letter with the column varieties are not significantly different (p<0.5).

Table 3 Classification of Grain Size and Shape

SN	Genotype	L/B	G.S	K.L.	Grain Size
1	Aanga	2.25	Medium	5.83	Medium
2	Anjana	2.09	Bold	5.60	Medium
3	Basmati 370	3.57	Slender	6.88	Long
4	Chiniya Puri	2.24	Medium	5.44	Short
5	CNTRL 85033	2.92	Medium	6.29	Medium
6	Gudgudo	1.61	Bold	3.94	Short
7	Hansa Raj	1.72	Bold	5.03	Short
8	IR 67017	3.51	Slender	6.55	Medium

9	Jhinuwa	2.47	Medium	5.49	Short
10	Khumal-4	2.82	Medium	5.62	Medium
11	Pokhreli Masino	3.23	Slender	6.05	Medium

Table 4 Chemical traits of rice varieties

S.N	Name of Varieties	ASV	CV	A.C	G.T	GER	LAT	GAT	CAT
1	Aanga	6	4,5	27.78^{ab}	low	1.30^{a}	Mild	Mild	Mild
2	Basmati-370	4	2,3	25.77^{ab}	low	1.44^{a}	Mild	Mild	Mild
3	Anjana	7	5,6	26.85^{ab}	low	1.35^{a}	Mild	Mild	Mild
4	Chiniya Puri	6	4,5	26.62^{ab}	low	1.35^{a}	Mild	Mild	Mild
5	CNTRL 85033	6	4,5	21.55^{ab}	low	1.25^{a}	Mild	Mild	Mild
6	Gudgudo	7	5,6	25.87^{ab}	intermediate	1.41^{a}	Mild	Mild	Mild
7	Hansa Raj	5	4,5	7.03^{ab}	intermediate	1.28^{a}	Mild	Absence	Mild
8	IR 67017	7	5,6	23.25^{ab}	low	1.46^{a}	Mild	High	Mild
9	Jhinuwa	6	5,6	26.62^{ab}	low	1.31^{a}	Absence	Absence	Absence
10	Pokhreli Masino	6	4,5	22.78^{ab}	low	1.38^{a}	Mild	Mild	Mild
11	Khumal -4	4	2,3	20.96^{ab}	intermediate	1.28^{a}	Absence	Absence	Absence

Superscript letters (a-e) indicate significant differences ($p<0.5$) among varieties whereas mean with same letter with the column varieties are not significantly different ($p<0.5$).