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Evaluation of Agronomic Traits for Yield and Yield Components in Advance Breeding Lines of Rice

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Abstract: In present work fifteen advanced lines of rice (Line-59, Line-25, Line-NPT-1, Line-161-S, Line-188, Line-186, Line-9, Line-93, Line-99, Line-184, Line-103, Line-77, Line-5, Line-18 and Line-188-S) were evaluated in the background of Bas-385 for their yield and yield attributing traits. Mean values for quantitative traits were compared according to least significant difference (LSD) statistical test. The observations were recorded in accordance with IRRI technical bulletin on morphology and varietals characteristics. Data on agronomic parameters was collected from productive tillers of three plants of each entry at appropriate stage of growth to examine variation. Among the entire yield attributing traits plant height, panicle length, primary branches, secondary branches, filled spikelets, unfilled spikelets, tillers per plant, thousand grains weight and yield per plant showed significant variability. Line-18, Line-186, Line-59, Line-103 and Line-77 proved to be best in grain yield/plant. Correlation analysis represent that yield was positively correlated with filled spikelet (0.645^{**} P=0.01) and 1000 grains weight with primary branches (0.654^{*} P=0.01). Range of genetic distance observed among the tested lines was (GD = 0-60%) based on SDS PAGE. The dendrogram showed that sixteen genotypes were grouped in five categories (A–E) comprising 5, 6, 2, 2 and 1 genotypes, respectively. Line-103 and Line-59 were most distantly related to each other and could be used for breeding to improve rice cultivars. To exploit their genetic potential, these genotypes can beneficially be used in the breeding programs.

Key words: Agronomic · Yield · Rice · Spikelet

INTRODUCTION

Rice (*Oryza sativa* L.) belongs to family Poaceae of tribe *Oryzeae*. The genus *Oryza* consists of two cultivated species *Oryza sativa (*Asian species*)* and *Oryza glaberrima (*African species*)* and about 20 wild species [1]. Among Oryza species, *indica* rice are genetically very diverse for non-sticky that grow throughout low land tropical and temperate Asia. In contrast, the *Japonica* is sticky rice grown in upland areas of temperate East and South East Asia and higher elevations in South Asia and are not genetically as diverse as *indica* [2].

Rice is an economically important crop and accounts for more than 50% of their daily calorie intake. Rice provides 27% of dietary energy supply and 20% of dietary protein intake. Most of rice consumed directly by humans. Apart from providing a significant proportion of the daily calorie and protein intake for half the world population, *Oryza sativa* is also a livestock feed that has an array of industrial and non-industrial uses [3].

Though production of rice has increased markedly from about 200 million tons of paddy rice in 1960 to over 678 million tons in 2009, still it falls short of growing demand due to population increase which is rising at a rate of 2% annually. To feed this increasing population, 35% more rice will be required than the present level of rice production worldwide. Increase in human populations and adverse environmental conditions deteriorated yield making it a great threats for rice production today [4]. Apart from the environmental factors major causes of low production are (i) non accessibility of varieties well suited for a specific zone (ii) superior spikelet and (iii) lack of appropriate cultural practices. Among the major yield limiting factors, superior spikelet is the most important factor responsible for reduction of rice yield. Generally earlier flowering superior spikelets of rice usually located

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on apical primary branches, fill fast and produce large and heavier grains. While, later flowering inferior spikelets usually located on proximal secondary branches, or either sterile or fill slowly and poorly to produce grains unsuitable for human consumption [5].

There are two possible strategies which can improve the yield and quality of rice (i) exploitation of heterosis (ii) Modification of plant. Fortunately several lines of rice have been developed by the scientist of Genetics Department of Hazara University, based on modification of plant type. The evaluation of these lines for their physiological parameters attributing to yield is imperative. Keeping in view present attempt has been made to evaluate agronomic traits contributing to yield and yield components of advance breeding lines of rice to evaluate the performance of advance rice lines by characterizing yield and yield attributing to select the most suitable and high yielding genotype/rice line.

MATERIALS AND METHODS

Plant Material: During present study fifteen advance lines (Line-59, Bas-385, Line-25, Line-NPT-1, Line-161-S, Line-188, Line-186, Line-9, Line-93, Line-99, Line-184, Line-103, Line-77, Line-5, Line-18 and Line-188-S) of rice have developed in the background of Bas-385 by modifying present plant architecture by the Department of Genetics Hazara University at National Tea Research Institute, Shinkiari, Mansehra, KP during the time period 2012-2013 and used for study (Table 1).

Morphological Characterization of Advance Lines of Rice: Data on various morphological parameters was collected from different genotypes at appropriate stage of development to assay variation in different traits.

Matured Stem Length: Stem length of the plant was measured in centimeter (cm) from the base of plant to the panicle tip.

Stem Thickness: It was taken in millimeters from outer diameter of tillers.

Productive Tillers/Plant: The tillers which bear the panicle were separately recorded as productive tillers.

Leaf Length: Leaf length was measured in centimeter (cm).

Leaf Width: widest portion of leaf just below the flag leaf was measured in centimeter.

Flag Leaf Length: Flag leaf length was measured in centimeter (cm).

Flag Leaf Width: Flag leaf width was measured in centimeter (cm).

Panicle Length: Panicle length was measured in centimeter (cm) from base of panicle to the tip of the panicle.

Branches /Panicle: Panicle bears the number of branches which consists both primary and secondary branches. These branches were counted separately.

$$\text{Yield/Plant (g)};\quad \frac{\text{Yield/Plant} = \text{Weight of 1000 grains} \times \text{Total number of spikelets}}{1000}$$

Sterility %: Sterility % was calculated as

$$S\,(\%) = \frac{\text{Number of sterile spikelets} \times 100}{\text{Total number of spikelets}}$$

1000 Grains Weight: The actual measurement was taken from 1000 healthy and well developed grain with 13% moisture content.

Grain Chalkiness: Grain chalkiness was measured carefully with the help of digital vernier caliper.

Physical grain quality analysis (Grain size, shape and appearance); Physical grain quality measuring grain size and shape were determined. Grain length and width was measured in mm as standard scale.

Physical Grain Quality Analysis: physical grain quality that measured by grain size and shape. Grain length (from base to tip), width (widest portion) and was measured in mm with the help of digital vernier caliper and seeds were classified into short, medium, long and extra-long by using IRRI descriptor.

Chemical Characters: There is a wide array of rice cultivars with broadly different combinations of chemical properties, such parameters under observation were:

Gelatinization Temperature (GT): GT is considered as the time required for cooking. Gelatinization temperature was assessed by the degree of alkali spreading and clearing of powdered rice soaked in 1.7% potassium hydroxide just for 23 hours at room temperature. Rice with low gelatinization temperature degraded completely, while rice with intermediate gelatinization temperature showed only partial degradation. Rice with high gelatinization temperature remained mostly unaffected in the solution.

Gel consistency (GC): The GC is responsible for softness of cooked rice. In present study GC was evaluated by the technique of Bhattacharya [6]. For GC seeds from each variety of rice was crushed very well by using mortar and pestle and sieved with 1 mm sieve. Then 100 mg of rice grains powder was taken in long test tube (2×19.5 cm) and added 0.2 ml of ethanol containing 0.25 percent of thymol blue and 2.0 ml of 2.8g of potassium hydroxide (KOH) in 250 ml distilled water was added and mixed well using vortex mixture, kept in boiling water bath for 8 min, cooled for 5 min, mixed and kept in ice bath for 20 min. Later tubes were removed, laid horizontally for 1 hour and measurements were made using graph paper. The degree of disintegration and the transparency of paste dissolved out of the kernels were evaluated and classified as: Soft (61-100 mm), Medium (41-60 mm), Hard (<40mm).

Assessment of Aroma in Elite Rice Lines: The seeds from each rice lines were dehulled and ground. Rice flour of each rice grain was kept in an individual plastic box of 5x5 cm. Five hundred ml of diluted alkali (1.7%) was added to each box and covered tightly. Then at room temperature the treated samples were placed for 30 minutes. One by one opened the boxes and noted aroma noted by smelling each box.

Proteins Estimation and Expressions: for total soluble protein extraction/separation Sambrook *et al.* [7] method was used.

Statistical Analysis: each band was considered as a single locus/allele. Alleles/loci (bands) were scored as present (1) or absent (0). Genetic diversity was estimated using following formula Nei and Li, [8].

$$GD = 1 - d_{xy}/d_x + d_y - d_{xy}$$

Where, GD = Genetic distance between two genotypes, d_{xy}=number of common bands in 2 genotypes, d_x=total number of bands in genotype 1 and d_y=total number of bands in genotype 2. The bi-variant 1-0 data matrix was also used to construct a dendrogram using computer program "Popgene" and for the analysis of other quantitative data statistix 9 trial version software was used.

RESULTS

Data on morphological parameters was collected from different genotypes at appropriate stage of growth to evaluate the different traits for improving the potential yield. The materials showed considerable variability for morphological (both qualitative and quantitative) traits.

Tillers/plant: Tillers/plant is one of the yields contributing character. It ranged from 7.333 to 24.67. The maximum tillers/plant was recorded for Line-18 (24.67) followed by Bas-385, Line-186, Line-25, Line-161-S, Line-59, Line-77, Line-103, Line-NPT-1, Line-93, Line-188, Line-5, Line-9, Line-188-S and Line-99. The minimum tillers/plant was recorded for Line-184 (7.333), (Table1).

Stem Length: It ranged from to 97.77 to 145.7. The maximum stem length was recorded for Line-93 (145.7) followed by Line-59, Line-184, Line-NPT-1, Line-188-S, Line-5, Line-186, Line-103, Line-161-S, Bas-385, Line-188, Line-18, Line-99, Line-77, Line- 9. The minimum stem length was record for Line-25 (97.77), (Table 1).

Stem Thickness: It ranged from 1.4000 to 2.267. The maximum stem thickness was recorded for Line-99 (2.267) followed by Line-188-S, Line-9, Line-5, Line-188, Bas-385, Line-25, Line-161-S, Line-93, Line-103, Line-184, Line-59, Line-18, Line-186 and Line-NPT-1. The minimum stem thickness was recorded for Line-77 (1.4000), (Table 1).

Ligule Length: It ranged from 1.400 to 3.333. The maximum ligule length was recorded for Line-161-S (3.333) followed by Bas-385,Line- 99, Line-25, Line-188, Line-5, Line-18, Line-77, Line-NPT-1, Line-186, Line-103, Line-59, Line-93, Line-184 and Line-9. The minimum ligule length was recorded for Line-188-S (1.400), (Table 1).

Yield/Plant (g): It ranged from 30.20 to 128.7. The maximum yield/plant was recorded for Line-18 (128.7g) followed by Line-186, Line-59, Line-103, Line-77, Line-NPT-1, Line-9, Line-188, Line-161-S, Line-188-S, Line-93, Line-5, Line-25, Bas-385 and Line-184. While, the minimum yield/plant was recorded for Line-99 (30.20g), (Table 1).

Table 1: Means for stem length, tillers/plant, stem thickness, ligule length and yield/plant of advance lines of rice

Variety	Stem length (cm)	Tillers/plant(no)	Stem thickness (cm)	Ligule Length(mm)	Yield/plant (g)
Line-59	137.7 ab	14.67 bc	1.633 ab	1.833 bc	109.7 c
Bas-385	117.9 bcd	18.00 ab	1.800 ab	2.667 ab	40.40 m
Line-25	97.77 d	16.67 ab	1.767 ab	2.600 abc	43.40 l
Line-NPT-1	135.1 ab	13.67 bc	1.467 ab	1.900 bc	102.1 f
Line-161-S	120.0 abcd	15.00 bc	1.767 ab	3.333 a	89.40 h
Line-188	114.1 bcd	11.33 bc	1.900 ab	2.533 abc	89.80 h
Line-186	125.1 abc	17.67 ab	1.500 ab	1.900 bc	112.1 b
Line-9	107.5 cd	10.67 bc	2.067 ab	1.600 bc	93.00 g
Line-93	145.7 a	12.00 bc	1.767 ab	1.800 bc	73.20 j
Line-99	113.5 bcd	9.667 bc	2.267 a	2.667 ab	30.20 o
Line-184	137.1 ab	7.333 c	1.733 ab	1.800 bc	39.20 n
Line-103	122.9 abcd	14.00 bc	1.733 ab	1.900 bc	104.8 d
Line-77	111.3 bcd	14.33 bc	1.400 b	1.933 bc	102.6 e
Line-5	128.7 abc	11.33 bc	1.967 ab	2.433 abc	52.50 k
Line-18	113.9 bcd	24.67 a	1.533 ab	2.367 abc	128.7 a
Line-188-S	133.7 abc	10.33 bc	2.267 a	1.400 c	78.10 i
CV%	13.10	37.77	27.86	34.46	0.31

Mean sharing same letters in a column are not significantly different at 5% probability level using LSD test

Table 2: Means for leaf length, leaf length of blade, leaf width, flag leaf length, flag leaf width of advance lines of rice

Variety	Leaf Length (cm)	Leaf Length of Blade(cm)	Leaf Width (cm)	Flag Leaf Length (cm)	Flag Leaf Width(cm)
Line-59	62.00 bc	37.33 c	1.267 abcd	55.20 d	1.633 ab
Bas-385	68.33 abc	43.87 abc	1.433 a	58.27 cd	1.600 ab
Line-25	85.03 a	58.10 ab	1.300 abcd	62.83 bcd	1.500 ab
Line-NPT1	81.93 ab	58.20 ab	0.967 bcd	69.43 abcd	1.333 b
Line-161-S	82.37 ab	59.63 a	1.067 abcd	69.80 abcd	1.533 ab
Line-188	80.10 ab	49.80 abc	1.100 abcd	73.63 abc	1.567 ab
Line-186	76.10 abc	48.57 abc	1.233 abcd	72.73 abc	1.233 b
Line-9	68.87 abc	39.57 bc	1.033 abcd	76.63 ab	2.033 a
Line-93	67.97 abc	43.63 abc	0.867 d	75.33 ab	1.400 ab
Line-99	73.27 abc	44.77 abc	0.900 cd	83.17 a	1.333 b
Line-184	72.10 abc	47.93abc	0.967 bcd	78.17 ab	1.367 b
Line-103	64.67 abc	39.57 bc	1.033 abcd	75.03 abc	1.300 b
Line-77	65.60 abc	46.87 abc	1.233 abcd	69.90 abcd	1.400 ab
Line-5	64.37 abc	43.10 abc	1.400 ab	71.37 abcd	1.467 ab
Line-18	68.40 abc	44.63 abc	1.333 abc	65.67 bcd	1.667 ab
Line-188-S	56.20 c	35.43 c	1.300 abcd	61.47 bcd	1.633 ab
CV%	17.47	25.29	23.73	14.48	25.47

Mean sharing same letters in a column are not significantly different at 5% probability level using LSD test

Leaf Length: It is one of the important yield attributing traits. In recent investigation leaf length ranged from 56.20 to 85.03. The maximum leaf length was recorded for Line-25(85.03) followed by Line-161-S, Line-NPT-1, Line-186, Line-99, Line-184, Line-9, Line-18, Bas-385, Line-93, Line-77, Line-103, Line-5 and Line-59. The minimum leaf length was recorded for Line-188-S (56.20), (Table 2).

Leaf Length of Blade: It ranged from 35.43 to 59.63. The maximum leaf length of blade was recorded for Line-161-S (59.63) followed by Line-NPT-1, Line-25, Line-188, Line-186, Line-184, Line-77, Line-99, Line-18, Bas-385, Line-93, Line-5, Line-9, Line-103 and Line-59. The minimum leaf value was recorded for Line-188-S (35.43), (Table 2).

Table 3: Means for panicle length, primary branches, secondary branches, filled spikelet, unfilled spikelet of advance lines of rice

Variety	Panicle Length(cm)	Primary branches(no)	Secondary branches(no)	Filled spikelet(no)	Unfilled spikelet(no)
Line-59	29.55 bcde	16.66 bcde	44.89 cdef	187.8 de	41.55 bcdef
Bas-385	29.85 abcde	10.44 g	26.33 g	129.8 fg	20.00 ef
Line-25	21.40 g	9.883 g	27.10 g	120.5 g	16.22 f
Line-NPT-1	31.38 abc	13.44 defg	36.99 efg	180.7 de	56.33 b
Line-161-S	25.80 f	13.11 efg	50.99 bcde	194.8 cde	36.88 bcdef
Line-188	28.47 cdef	13.55 defg	50.33 bcde	198.4 bcde	46.55 bcd
Line-186	31.64 abc	17.77 abc	56.89 abcd	269.2 a	51.33 bc
Line-9	27.83 def	20.55 a	65.89 ab	245.1 ab	57.89 b
Line-93	32.46 ab	15.00 cdef	61.22 abc	237.2 abc	55.33 bc
Line-99	29.59 bcde	12.10 fg	30.77 fg	123.7 g	29.22 cdef
Line-184	26.56 ef	16.99 abcd	29.55 fg	176.0 ef	17.00 ef
Line-103	32.79 ab	17.88 abc	47.11 cdef	211.7 bcde	54.55 bc
Line-77	33.22 ab	20.44 a	46.77 cdef	227.7 abcd	42.89 bcde
Line-5	30.16 abcd	15.22 cdef	40.44 defg	203.1 bcde	22.89 def
Line-18	27.79 def	13.55 defg	38.55 efg	190.9 cde	21.55 def
Line-188-S	30.78 abcd	19.33 ab	71.89 a	211.0 bcde	179.8 a
CV%	7.09	14.62	23.39	15.19	33.42

Mean sharing same letters in a column are not significantly different at 5% probability level using LSD test

Leaf Width: It ranged from 0.867 to 1.433. The maximum leaf width was recorded for Bas-385 (1.433) followed by Line-5, Line-18, Line-25, Line-188-S, Line-59, Line-186, Line-77, Line-188, Line-161-S, Line-9, Line-103, Line-NPT-1, Line-184 and Line-99. The minimum leaf width was recorded for Line-93 (0.867) (Table 2).

Flag Leaf Length: It ranged from 55.20 to 83.17. The maximum flag leaf length was recorded for Line-99 (83.17) followed by Line-184, Line-9, Line-93, Line-103, Line-188, Line-186, Line-5, Line-77, Line-161-S, Line-NPT-1, Line-18, Line-25, Line-188-S and Bas-385. The minimum flag leaf length was recorded for Line- 59 (55.20) (Table 2).

Flag Leaf Width: It ranged from 1.233 to 2.033. The maximum flag leaf width was recorded for Line-9 (2.033) followed by Line-18, Line-59, Line-188-S, Bas-385, Line-188, Line-161-S, Line-25, Line-5, Line-93, Line-77, Line-184, Line-NPT-1, Line-99 and Line-103. The minimum flag leaf width was recorded for Line-186 (1.233) (Table 2).

Panicle Length: It is one of the yield attributing traits. It ranged from 21.40 to 33.22. The maximum panicle length was recorded for Line-77 (33.22) followed byLine-103, Line-93, Line-186, Line-NPT-1, Line-188-S, Line-5, Bas-385, Line-99, Line-59, Line-188, Line-9, Line-18, Line-184, Line-161-S. The minimum panicle length was recorded for Line-29(21.40) (Table 3).

Primary Branches: It is one of the yield attributing traits. It ranged from 9.883 to 20.55. The maximum primary branches was recorded forLine-9 (20.55) followed by Line-77, Line-188-S, Line-103, Line-186, Line-184, Line-59, Line-5, Line-93, Line-188, Line-18, Line-NPT-1, Line-161-S, Line-99, Bas-385. The minimum primary branches was recorded forLine-25 (9.883) (Table 3).

Secondary Branches: It is one of the yield attributing traits. It ranged from 26.33 to 71.89. The maximum secondary branches was recorded for 188-S (71.89) followed by 9, 93, 186, 161-S, 188, 103, 77, 59, 5, 18, NPT-1, 99, 184, 25. The minimum secondary branches was recorded for Bas-385 (26.33) (Table 3).

Filled Spikelets: It is the important quantitative and yield attributing trait. It ranged from 120.5 to 269.2 to. The maximum filled spikelets was recorded for Line-186 (269.2) followed by Line-9, Line-93, Line-77, Line-103, Line-188-S, Line-5, Line-188, Line-161-S, Line-18, Line-59, Line-NPT-1, Line-184, Bas-385, Line-99. The minimum filled spikelet was recorded for Line-25 (120.5) (Table 3).

Unfilled Spikelets: It is one of the important quantitative and yield attributing trait. It ranged from 16.22 to 179.8. The maximum unfilled spikelets was recorded for Line-188-S (179.8) followed by Line-9, Line-NPT-1, Line-93, Line-103, Line-186, Line-188, Line-77, Line-59, Line-161-S,

Table 4: Evaluation of advance lines of rice for qualitative traits

Variety	Size	Shape	GT Temperature	Aroma	GC
Line-59	Long	Slender	High	MS	Soft
Bas-385	Long	Slender	High	MS	Soft
Line-25	Short	Medium	Intermediate	NS	Soft
Line-NPT-1	Long	Slender	Low	NS	Soft
Line-161-S	Long	Slender	Low	NS	Soft
Line-188	Short	Medium	Intermediate	SS	Soft
Line-186	Medium	Slender	Intermediate	NS	Hard
Line-9	Long	Slender	Intermediate	MS	Soft
Line-93	Long	Slender	High	MS	Medium
Line-99	Long	Slender	Intermediate	NS	Soft
Line-184	Long	Slender	Intermediate	NS	Soft
Line-103	Long	Slender	Intermediate	MS	Hard
Line-77	Long	Slender	Low	NS	M-hard
Line-5	Short	Slender	Intermediate	NS	Hard
Line-18	Long	Slender	Intermediate	NS	Hard
Line-188-S	Short	Medium	Low	NS	Medium

Line-99, Line-5, Line-18, Bas-385, Line-184. The minimum unfilled spikelets was recorded for Line-25 (16.22) (Table 3).

Physio-Chemical Properties of Advanced Lines of Rice: Grain size: It is one of the important characters related to the cosumer preference. Bas-385 and all advanced lines have long size except Line-25, Line-188, Line-5 and Line-188-S that have short size while Line-186 has medium grain size (Table 4).

Grain Shape: Bas-385 and all advance lines have slender shape except Line-25, Line-188 and Line-188-S have medium shape grain (Table 4).

Gelatinization Temperature: Bas-385, Line-59 and Line-93 have high gelatinization temperature and Line-NPT-1, Line-161-S, Line-77 and Line-188-S have low gelatinization temperature, while all other advance lines have intermediate gelatinization temperature (Table 4).

Aroma: Bas-385, Line-59,Line-9, Line-93 and Line-103 have mild scented while all other advance lines have no aroma except Line-188 have strongly scented (Table 4).

Gel Consistency: Bas-385, Line-59, Line-25, Line-NPT-1, Line-161-S, Line-188, Line-9, Line-99 and Line-184 have soft gel while Line-93, Line-188-S and Line-77 have medium and medium hard gel consistency, respectively (Table 4).

Grain Length: Grain length is one of the important characters in rice grain quality. Grain length ranged from 5.077 to 6.803. The maximum grain length was recorded for Line-9 (6.803) followed by Line-161-S, Line-93, Line-18, Line-77, Line-103, Bas-385, Line-NPT-1, Line-59, Line-99, Line-184, Line-186, Line-5, Line-188, Line-188-S. The minimum grain length was recorded for Line-25 (5.077),(Table 5).

Grain Width: Grain width ranged from 1.673 to 1.763. The maximum grain width was recorded for Line-25 (1.763) followed by Line-188-S, Line-188, Line-59, Line-103, Line-99, Line-9, Line-18, Line-161-S, Line-186, Line-184, Line-93, Line-5, Bas-385, Line-77. The minimum grain width was recorded for Line-NPT-1 (1.673), (Table 5).

Length/Breadth (L/B ratio): L/B ratio ranged from 2.877 to 4.010. The maximum L/B ratio was recorded for Line-NPT-1 (4.010) followed by Line-77, Line-9, Bas-385, Line-93, Line-161-S, Line-184, Line-18, Line-99, Line-103, Line-59, Line-186, Line-5, Line-188, Line-188-S. The minimum L/B ratio was recorded for Line-25 (2.877) (Table 5).

Kernel Chalkiness: Kernel chalkiness is the key factor in determining quality and price. Kernal chalkiness ranged from 17.26 to 55.55. The maximum kernel chalkiness was recorded for Line-188 (55.55) followed by Line-25, Line-59, Line-188-S, Line-18. The minimum kernel chalkiness was recorded for Line-161-S (17.26) (Table 5).

Table 5: Means for grain length, grain width, L/B ratio and kernel chalkiness % of advance lines of rice

Variety	Grain length (mm)	Grain width (mm)	L/B ratio	Kernal chalkiness%
Line-59	6.717 a	1.747 b	3.843 a	33.33 b
Bas-385	6.720 a	1.687 efg	3.977 a	0.000 e
Line-25	5.077 c	1.763 a	2.877 c	40.00 b
Line-NPT-1	6.720 a	1.673 g	4.010 a	0.000 e
Line-161-S	6.743 a	1.700 de	3.963 a	17.26 d
Line-188	5.100 c	1.757 ab	2.897 c	55.55 a
Line-186	5.627 b	1.697 de	3.313 b	0.000 e
Line-9	6.803 a	1.703 d	3.993 a	0.000 e
Line-93	6.730 a	1.693 def	3.966 a	0.000 e
Line-99	6.710 a	1.707 d	3.923 a	0.000 e
Line-184	6.700 a	1.693 def	3.950 a	0.000 e
Line-103	6.723 a	1.723 c	3.900 a	0.000 e
Line-77	6.723 a	1.680 fg	3.997 a	0.000 e
Line-5	5.130 c	1.693 def	3.023 c	0.000 e
Line-18	6.730 a	1.703 d	3.943 a	17.85 cd
Line-188-S	5.093 c	1.760 ab	2.887 c	24.44 c
CV%	3.38	0.56	3.45	34.53

Mean sharing same letters in a column are not significantly different at 5% probability level using LSD test

Table 6: Evaluation of advance lines of rice for quantitative traits

Variety	No. nodes /stem	Sterility%	1000grain wt(g)	GC, mm
Line-59	3	18.88	28.8	90
Bas-385	2	9.59	21.2	84
Line-25	1	12.27	23.6	95
Line-NPT-1	3	25.55	22.8	100
Line-161-S	3	14.99	22.4	100
Line-188	3	18.76	32	70
Line-186	3	15.55	26.4	30
Line-9	2	21.40	28.4	68
Line-93	3	19.19	23.2	47
Line-99	3	18.37	24.4	75
Line-184	3	8.10	25.2	64
Line-103	3	20.27	29.6	31
Line-77	3	12.55	31.2	37
Line-5	3	9.39	30.4	33
Line-18	4	11.15	26	31
Line-188-S	4	46.49	30.4	54

Table 7a: Banding pattern of total crude proteins of rice lines (1-9)

Band	Bas-385	59	25	NPT-1	161-S	188	186	9	93
1	1	0	0	0	1	1	0	1	1
2	1	1	0	1	1	1	1	1	1
3	1	1	1	1	1	0	1	1	1
4	1	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1	1

The symbol ‘’1’’ represent presence and ‘’0’’ indicates absence of the band

Table 7b: Banding pattern of total crude proteins of rice lines (10-16)

Band	Bas-385	99	184	103	77	5	18	188-S
1	1	0	0	0	0	1	1	1
2	1	0	1	0	1	1	1	1
3	1	1	1	0	1	1	1	1
4	1	1	1	1	1	1	1	1
5	1	1	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1

The symbol ''1'' represent presence and ''0'' indicates absence of the band

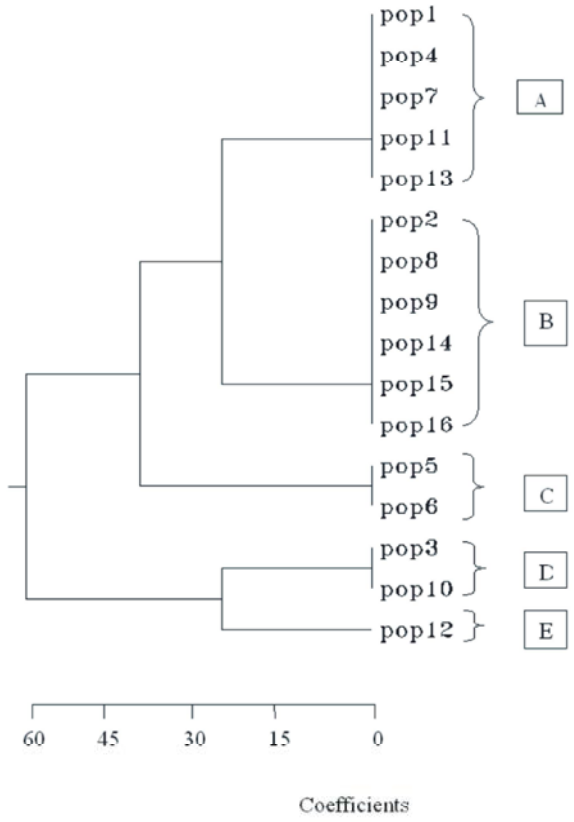

Fig. 1: Dendrogram constructed for sixteen rice genotypes using protein profiles obtained by SDS-PAGE

Sterility: The maximum sterility percentage was recorded for Line-188-S (46.49), while The minimum sterility was recorded for Line-184 (8.10) (Table 6).

1000 Grains Weight: It is an important component of yield. The maximum 1000 grains weight was recorded for Line-188 (32 g), while the minimum weight was recorded for Bas-385 (21.2g) (Table 6).

Gel Consistency: The maximum gel consistency was recorded for Line-NPT-1 and Line-161-S (100), while the minimum value was recorded for Line-186 (30) (Table 6).

Correlation analysis represent that yield was positively correlated with filled spikelets (.645** P=0.01) and 1000 grains weight with primary branches (0.654* P=0.01).

Genetic Diversity: Genetic diversity was estimated on the bases of seed storage proteins separated using SDS-PAGE. A total of 6 bands were scored in the sixteen germplasm. Loci were scored as present (1) or absent (0). Locus (Bands) numbers 4, 5 and 6 were present in all the sixteen genotypes (Table 7a and 7b). Range of genetic distance observed among the germplasm was 0–60%. The minimum genetic distances (0%) were observed among 32 comparisons, while the maximum genetic distance (GD=60%) was observed for only one comparison. Genetic distances of 10, 20, 30, 40 and 50 % were observed for 0, 52, 21, 6 and 9 comparisons, respectively.

The dendrogram of 16 genotypes based on SDS-PAGE is presented in Fig 1. Sixteen rice genotypes were clustered in 5 groups ''A'', ''B'', ''C'', ''D'' and ''E''. Group "B" was largest group comprised of 6 genotypes. Groups "A'', ''C'', ''D'' and "E" comprised 5, 2, 2 and 1 genotypes, respectively. Genotypes 1 (Line-59) and 12 (Line-103) were found most distantly related to each other.

DISCUSSION

Fifteen advanced breeding lines of rice and check variety (Bas-385) were studied for different morphological and yield attributing traits to assess the genetic variability. Tillers/plant among rice genotypes ranged from 24.67 to 7.333. The minimum tillers/plant of 7.333 was produced by Line-184. Line-18 produced maximum number of tillers 24.67 per plant. This observation was supported by Zahid *et al.,* [9], who studied 12 genotypes of coarse rice to check their yield performance in Kallar tract and reported highly significant variation for different traits including the number of productive tillers/plant, an important yield component in rice. Advance lines of rice showed significant difference with respect to plant height.

The highest plant height (145.7) was found in Line-93 while lowest plant height (97.77) was found in Line-25. Zahid *et al.,* [9] also studied fourteen genotypes of basmati rice and observe high heritability couple with high genetic advancement for plant height and 1000-grain weight.

Panicle length is an important yield attributing trait. In present study it ranged from minimum 21.40 for Line-29 to maximum 33.22 for Line-77. Similar results were reported by Tahir *et al*., [10], who studied the genetic variability for different characters in ten rice genotypes for various traits and found that these traits are under the genetic control and could be used in the selection of desirable traits. Similarly branches per panicle also play a key role in increasing yield. In our case primary and secondary branches/panicle showed great variability. Primary branches/panicle ranged from 9.833 to 20.55. The minimum primary branches/ panicle were recorded in Line-25 and the maximum were recorded in Line-9. On the other hand maximum secondary branches were found in Line-188-S and minimum secondary branches were found in Bas-385. These results are in agreement with the findings of Tahir *et al*., [10], who also observed great variations in primary and secondary branches/ panicle in different rice genotypes.

Other quantitative traits that contribute towards yields are filled and unfilled spikelets. In present study both showed considerable variability. The maximum (269.2) number of filled spikelets was found in Line-186 and minimum (120.5) in Line-25. While, the maximum unfilled spikelets (179.8) was recorded for Line-188-S and the minimum (16.22) number of unfilled spikelets was found in Line-25. These characters are directly related to yield of plant, more the number of filled spikelets the plant will be higher in yield. Our results showed that number of secondary branches and number of filled spikelets have positive significant correlation. These results are in accordance with the findings of Tahir *et al*., [10].

The results of present study for physical parameters indicated that the highest grain length (6.803mm) was found in Line-9 and the lowest grain length (5.077 mm) was found in Line-25. Line-25 showed the highest grain width (1.763 mm) and the lowest grain width was found in Line-NPT-1 (1.673 mm). Rice Quality Workshop [11], reported that marketing of rice mostly depends on the grain size, shape, physical dimensions and weight which are of prime importance. The highest L/B ratio (4.010) was recorded for Line-NPT-1 and lowest L/B ratio (2.877) was found in Line-25. These results are contradictory with the findings of Kaul, [12], who reported that length/width (L/B) ratio for rice grain ranges between 2.5-3.0. In present investigation, medium length and the highest 1000-grain weight (32 g) was recorded in Line-188, while the lowest grain weight (21.2g) was recorded by the Bas-385 that was noted as long grain. These results are in conformity with IRRI, [13], who reported that longer grains are lighter in weight than medium or bold grains.

Among the rice varieties, the chalkiness was absent in varieties B-385, Line-NPT-1, Line-186, Line-9, Line-93, Line-99, Line-184, Line-103, Line-77, Line-5 and kernel chalkiness below 20% was recorded in Line-161-S and Line-18. These results showed conformity with Cheng *et al*., [14], who reported that chalky grains reduce the palatability of cooked food, hence the presence of more than 20% chalkiness in rice kernels is not acceptable in world markets. Aromatic rice is important and has high demand in the global market. Mild aroma was detected in varieties like B-385, Line-59, Line-9, Line-93 and Line-103. Similar results showed by Cruz and Khush, [15], who reported that long grain aromatic rice is highly popular and are the most expensive in the rice international markets.

In present study Line-25, Line-188, Line-186, Line-9, Line-99, Line-184, Line-103, Line-5 and Line-18 have the medium disintegration while Line-NPT-1, Line-161-S, Line-77 and Line-188-S have partial disintegration similar results was showed by Kang *et al*., [16], who reported that consumers preferred the rice having Intermediate to low GT varieties because its take less time to cook than high GT varieties. In our results most of the rice lines such as Line-59, Bas-385, Line-25, Line-NPT-1, Line-161-S, Line-188, Line-9, Line-99 and Line-184 have soft gel. These results are in conformity with Tang *et al*., [17], who concluded that rice grains with soft gel cook more gently and remain soft after cooling.

SDS-PAGE analysis based on total seed storage protein profile revealed considerable level of genetic variation among the rice genotypes. Sixteen rice lines were grouped into 5 clusters (clusters A-E) based on the dissimilarity matrix using cluster analysis. Cluster "B" was found as largest cluster comprising 6 genotypes while clusters "C" and "D" were smallest comprising 2 genotypes for each. It is also evident from cluster analysis that genotype 1 (Line-59) and genotype 12 (Line-103) both the advance lines were most distantly related to each other. These results confirm the findings of Asghar *et al*., [18] who analyzed 20 accessions of *Oryza sativa* for total seed storage protein through SDS-PAGE and found considerable variation in protein banding pattern of rice genotypes. Statistical analysis showed that grain

yield/plant among rice lines ranged from 30.20 to 128.7. The minimum yield/plant of 30.20 g was produced by Line-99 and the maximum yield (128.7g) per plant was recorded in Line-18. These results support the findings of Zahid *et al*., [9], who studied 12 genotypes of coarse rice to check their yield performance in Kallar tract and reported highly significant variation for different traits including the yield/plant, as an important yield component in rice.

Among all the agronomic traits contributing to yield panicle length, primary branches, secondary branches, tillers/plant, node/stem, fertile spikelet and thousand grain weight were positively correlated with each other while fertile spikelet played highly significant positive correlation with grain yield/plant. Stem thickness showed negative significant correlation (-.551* P=0.01) with grain yield/plant. Our findings showed that Line-18, Line-186, Line-59, Line-103 and Line 77 showed best performance towards 1000 grains weight (g), primary branches, secondary branches, filled spikelet and yield/plant. Line-188 have strong aroma.

While, Line-188 proved to be better in yield, aroma and 1000 grain weight (g) and Line-103 and Line-59 were most distantly related and may be used for future rice cultivars improvement. While, Line-59, Line-9, Line-93, Line-103 and Bas-385 are recommended for future breeding programs to produce long grains aromatic rice.

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