UDC 575.630
https://doi.org/10.2298/GENSR2203005K
Original scientific article

AGRO-MORPHOLOGICAL AND BIOCHEMICAL CHARACTERIZATION AND PRINCIPAL COMPONENT ANALYSIS FOR YIELD AND QUALITY CHARACTERS IN FINE-SCENTED RICE GENOTYPES

Ravi Kiran Reddy KONDI[1]*, Sonali KAR[2] and Soumya SURAKANTI[3]

[1]Division of Genetics and Plant breeding at S.G.C.A.R.S, Kumhrawand, Jagdalpur, Bastar (C.G.), Indira Gandhi Krishi Vishwavidyalaya, Raipur.
[2]Department of Genetics and Plant Breeding, S.G.C.A.R.S, Kumhrawand, Jagdalpur, Bastar (C.G.), Indira Gandhi Krishi Vishwavidyalaya, Raipur.
[3]Postgraduate, Division of Genetics and Plant breeding at B. A College of Agriculture, Anand Agricultural University, Anand, Gujarat.

Kondi R. K. R., S. Kar, S. Surakanti (2022). *Agro-morphological and biochemical characterization and principal component analysis for yield and quality characters in fine-scented rice genotypes* - Genetika, Vol 54, No.3, 1005-1021.

Forty-one fine-scented rice genotypes were evaluated for 18 agro-morphological and quality characters for characterization, and 21 quantitative characters were evaluated for principal component analysis in R-studio software. Characterization of agro-morphological traits viz., plant height, days to 50% flowering, panicle length, number of effective tillers per plant, test weight, grain length, grain breadth, grain L: B ratio, kernel length, kernel breadth, kernel dimensions, awns, colour of awns, distribution of awns, and quality traits viz., alkali spreading value, gel consistency, grain aroma, and amylose content showed huge diversity among the genotypes. PCA revealed that PC1 showed the highest amount of variance (32.0%) followed by PC2 (15.7%), PC3 (9.0%), PC4 (8.1%), PC5 (7.8%), PC6 (5.4%) for quantitative characters. Out of 21 principal components, only 6 showed an eigenvalue greater than 1 and contributes about 78.1% total variance.

Corresponding author: Ravi Kiran Reddy Kondi, Division of Genetics and Plant breeding at S.G.C.A.R.S, Kumhrawand, Jagdalpur, Bastar (C.G.), Indira Gandhi Krishi Vishwavidyalaya, Raipur, ravikiranreddy1819@gmail.com

Genotypes in PC1 showed higher values for grain L: B ratio and kernel L: B ratio. Similarly, PC2 showed higher variable values for characters like test weight, kernel length, grain length, grain breadth, alkali spreading value, grain yield per plot and amylose content. PC3 for harvest index, panicle length, gel consistency, no. of effective tillers per plant and head rice recovery. PC4 for characters like plant height, kernel breadth and days to 50% flowering. PC5 for characters like kernel elongation ratio, and filled grains per panicle. PC6 for characters like no. of tillers in a square meter and no. of panicles in a square meter. This pre-breeding characterization study may be useful in finding potential genotypes which are having both yield and quality characters which may be useful in breeding for high-yielding varieties with good-quality characters.

Keywords: Characterization, Fine-scented rice, Principal component analysis, RCBD

Abbreviations: DUS = Distinct, Uniform, Stability, PCA= principal component analysis, RCBD= Randomized complete block design, PC= principal component, PH=Plant height; PL=Panicle length; NETP=Number of effective tillers per plant; TNFGP=Number of filled grains per panicles; NTSM=Number of tillers per square meter; NPSM=Number of panicles per square meter; DTF=Days to 50% flowering; HI=Harvest index; TW=Test weight; HR=Head rice recovery; GL=Grain length; GB=Grain breadth; GLB=Grain length breadth ratio; KL=kernel length; KB=kernel breadth; KLB=Kernel length breadth ratio; ASV=Alkali spreading value; GC=Gel consistency; AC=Amylose content; KER=Kernel elongation ratio; GY=Grain yield per plot; ARA=aroma; AWS= awns; COA=colour of awns; DOA=distribution of awns

INTRODUCTION

Rice is the second most-grown crop worldwide following maize, and this is a dietary staple for approximately 50 percent of the population (KONDI *et al*., 2022). For around 21% of the global population, it is a major source of calories. As a result, it is capable of combating poverty and starvation in heavily populated and underdeveloped countries. This is why it's recognized as the "grain of life." When contrasted with global rice consumption and production, Asia accounts for roughly 90% of global rice consumption and production. In 2019-20, China is the major producer of rice, followed by India (AL *et al*., 2021). By 2050, the population of the world is expected to grow from 7.6 billion to 9.8 billion people (KOR *et al*., 2017), so by increased population may increase the demand for rice production. To satisfy the potential demands of a growing population and ensure food security, we will have to boost output by many folds over whatever we are currently generating. The green revolution increased production by many magnitudes and was primarily concerned with yield. Quality, however, is just as critical as quantity. According to a report, quality is the second most important breeding target in 11 of the world's top rice-producing countries (JULIANO and VILLAREAL, 1993). The increase in living standards and lifestyles of the people living in the developing countries made people to choose particular grain qualities like slenderness, elongation lengthwise, less sticky, moderate amylose content, and fragrance in rice, for which they are willing to pay a higher price (LOUIS *et al*., 2005). Rice's greatest valuable feature is the presence of aroma (CRUZ and KHUSH, 2000). Aromatic forms, on the other hand, have some drawbacks (BERNER and HOFF, 1986). As a result, breeders concentrated their efforts on adding quality characteristics such as best grains, fine cooking value, lengthwise elongation, and nice fragrance, which command a maximum value in both domestic and foreign markets (BHATTA CHARJEE *et al*., 2002). Rice grain quality is a multifactorial characteristic that is determined by climate, crop handling, and crop interactions. Grain size, form, and L: B ratio all have an effect on grain quality (RITA and SARAWGI, 2008). As a result, grain size and form are given special consideration when producing new elite varieties. Consumers prefer rice with a mild to moderate gel consistency and a moderate amylose content and gelatinization temperature (ROBIN *et al*., 2019). Among various types of rice, there is a lot of difference in quality and grain yield. However, there are very few studies on the genetic factors controlling rice quality traits (RANI *et al*., 2008). Studies from all over the globe were intrigued by the diversity of quality properties and decided to learn more about them in order to produce new elite crops with higher yields and higher quality. The objective of this project is to evaluate the genetics of fine-scented rice genotypes for quality and yield traits, as well as to determine better-performing lines, characterization and genotype divergence that can be used for further crop modification.

MATERIALS AND METHODS

During Kharif 2020, the Genetics and Plant breeding department at S.G.C.A.R.S, Jagdalpur, Bastar (C.G.) aimed to study the genetics of 21 yield and quality characteristics in 41 fine-scented genotypes of rice using four checks. With an overall plot size of 7.68 m2, the research was performed in RCBD having 3 replications and a spacing of 20 cm between rows and 15 cm between plants. Some of the trait's conclusions were based on plots, while others were based on random plants per plot. On a plot basis, traits such as panicles per meter square, days to 50% flowering, tillers per square meter, harvest index, grains yield per plot, and test weight was measured. Number of effective tillers, plant height, filled grains per panicle, and panicle length, were estimated by randomly selecting five plants from each plot. Kernel length, grain length, kernel width, and grain width were determined with venire callipers by sampling 10 fully formed grains from each replication and calculating the mean, while grain L: B ratio and kernel L: B ratio were calculated using SHOBA *et al.* (2006) Distinct, Uniform, Stability (DUS) descriptors. POKHREL *et al.* (1983) and CRUZ and KHUSH (2000) procedure was used to calculate the elongation ratio. Head rice recovery was determined by milling ten fully formed grains in a hand-held dehuller and calculating the number of whole kernels produced after milling. SULTANA *et al*. (2022) approach was used to determine the gel consistency. GRAHAM (2002) procedure was used to calculate the alkali spreading value. On the basis of the SULTANA *et al*. (2022) technique, the amylose level was calculated in every rice sample. The scent of the grain was assessed by SHOBA *et al*. (2006) Distinct, Uniform, and Stability (DUS) descriptors. BANFIELD (1978) recommended protocol was used to measure the PCA. The statistical analysis was done by using R-studio software. The 41 fine-scented genotypes were presented in (Table 1).

Table 1. 41 fine-scented rice genotypes with four checks used under study

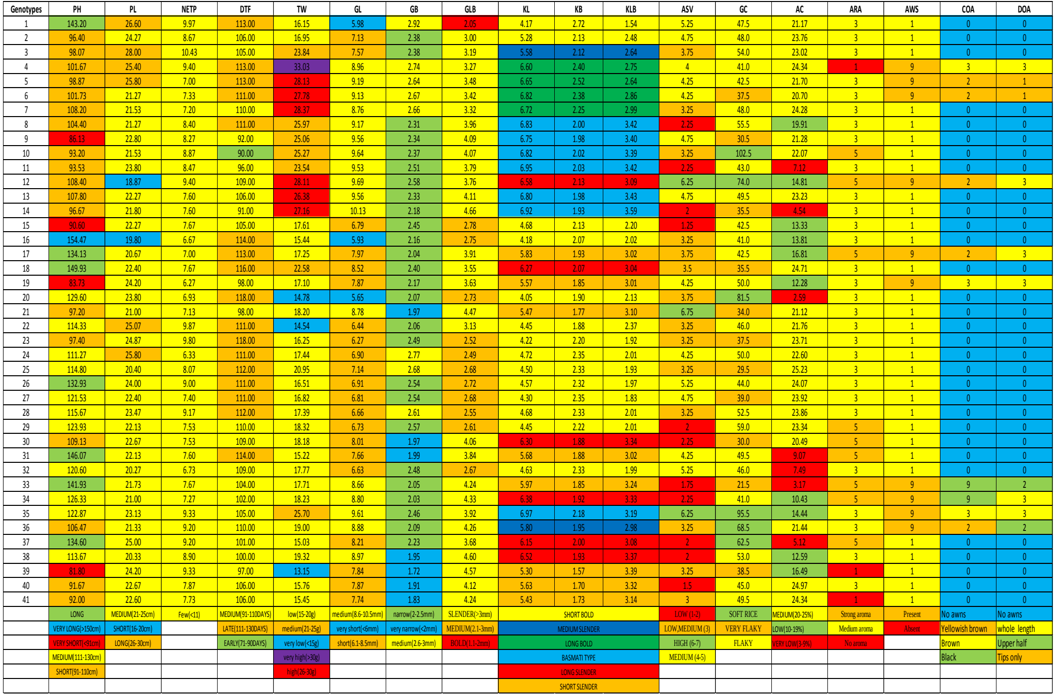
S.no	Genotypes
1	R 1656-2151-1-412-1
2	R 1919-537-1-160-1
3	R 2054-685-1-205-1
4	R1624-61-1-59-1
5	R1624-61-2-60-1
6	R1624-61-3-61-1
7	R1896-82-1-60-1
8	R1915-115-1-88-1
9	R2054-147-1-103-1
10	R2054-147-2-104-1
11	R2054-147-3-105-1
12	R2281-308-1-185-1
13	R2282-552-1-309-1
14	R2032-87-1-23-1
15	CG Sugandhit Bhog (c)
16	CG Devbhog (c)
17	Indira Sugandhit Dhan-1 (c)
18	Dubraj (c)
19	Nagri Dubraj Mutant-1
20	Samundrachini 5-50
21	Jhilli Mutant 13-5
22	Jeeraphool Mutant 5
23	Vishnubhog Mutant V-74-6
24	R2369-481-1-258-1
25	R2369-475-2-252-1
26	R2369-483-1-259-1
27	R2369-478-1-255-1
28	R2369-475-1-251-1
29	R2369-479-1-256-1
30	R2400-562-1-339-1
31	Ker ghul
32	R2369-480-1-257-1
33	Banspatri
34	Maharaji
35	Kasturi
36	R 2400-562-2-340-1
37	RL 910 (LAYCHA)
38	RM 504 (Mahraji)
39	JDP-2520-2-4-1
40	R-FS-2019-1
41	R-FS-2019-2

RESULTS AND DISCUSSION

Agro-morphological and quality traits characterization

A particular variety may be differentiated from other varieties by its morphological and quality traits. So, these stable characters serve as markers for the identification of varieties from each other. Such stable characters should have less environmental influence and can be passed from one generation to another generation. The 41 rice genotypes with four checks were differentiated based on agro-morphological and quality characters. The result for 41 genotypes characterization was presented in (Table 2).

Table 2. 41 genotypes characterization based on morphological and quality characters according to DUS descriptors



Genotypes	PH	PL	NETP	DTF	TW	GL	GB	GLB	KL	KB	KLB	ASV	GC	AC	ARA	AWS	COA	DOA
1	143.20	26.60	9.97	113.00	16.15	5.98	2.92	2.05	4.17	2.72	1.54	5.25	47.5	21.17	3	1	0	0
2	96.40	24.27	8.67	106.00	16.95	7.13	2.38	3.00	5.28	2.13	2.48	4.75	48.0	23.76	3	1	0	0
3	98.07	28.00	10.43	105.00	23.84	7.57	2.38	3.19	5.58	2.12	2.64	3.75	54.0	23.02	3	1	0	0
4	101.67	25.40	9.40	113.00	33.03	8.96	2.74	3.27	6.60	2.40	2.75	4	41.0	24.34	1	9	3	3
5	98.87	25.80	7.00	113.00	28.13	9.19	2.64	3.48	6.65	2.52	2.64	4.25	42.5	21.70	3	9	2	1
6	101.73	21.27	7.33	111.00	27.78	9.13	2.67	3.42	6.82	2.38	2.86	4.25	37.5	20.70	3	9	2	1
7	108.20	21.53	7.20	110.00	28.37	8.76	2.66	3.32	6.72	2.25	2.99	3.25	48.0	24.28	3	1	0	0
8	104.40	21.27	8.40	111.00	25.97	9.17	2.31	3.96	6.83	2.00	3.42	2.25	55.5	19.91	3	1	0	0
9	86.13	22.80	8.27	92.00	25.06	9.56	2.34	4.09	6.75	1.98	3.40	4.75	30.5	21.28	3	1	0	0
10	93.20	21.53	8.87	90.00	25.27	9.64	2.37	4.07	6.82	2.02	3.39	3.25	102.5	22.07	5	1	0	0
11	93.53	23.80	8.47	96.00	23.54	9.53	2.51	3.79	6.95	2.03	3.42	2.25	43.0	7.12	3	1	0	0
12	108.40	18.87	9.40	109.00	28.11	9.69	2.58	3.76	6.58	2.13	3.09	6.25	74.0	14.81	5	9	2	3
13	107.80	22.27	7.60	106.00	26.38	9.56	2.33	4.11	6.80	1.98	3.43	4.75	49.5	23.23	3	1	0	0
14	96.67	21.80	7.60	91.00	27.16	10.13	2.18	4.66	6.92	1.93	3.59	2	35.5	4.54	3	1	0	0
15	90.60	22.27	7.67	105.00	17.61	6.79	2.45	2.78	4.68	2.13	2.20	1.25	42.5	13.33	3	1	0	0
16	154.47	19.80	6.67	114.00	15.44	5.93	2.16	2.75	4.18	2.07	2.02	3.25	41.0	13.81	3	1	0	0
17	134.13	20.67	7.00	113.00	17.25	7.97	2.04	3.91	5.83	1.93	3.02	3.75	42.5	16.81	5	9	2	3
18	149.93	22.40	7.67	116.00	22.58	8.52	2.40	3.55	6.27	2.07	3.04	3.5	35.5	24.71	3	1	0	0
19	83.73	24.20	6.27	98.00	17.10	7.87	2.17	3.63	5.57	1.85	3.01	4.25	50.0	12.28	3	9	3	3
20	129.60	23.80	6.93	118.00	14.78	5.65	2.07	2.73	4.05	1.90	2.13	3.75	81.5	2.59	3	1	0	0
21	97.20	21.00	7.13	98.00	18.20	8.78	1.97	4.47	5.47	1.77	3.10	6.75	34.0	21.12	3	1	0	0
22	114.33	25.07	9.87	111.00	14.54	6.44	2.06	3.13	4.45	1.88	2.37	3.25	46.0	21.76	3	1	0	0
23	97.40	24.87	9.80	118.00	16.25	6.27	2.49	2.52	4.22	2.20	1.92	3.25	37.5	23.71	3	1	0	0
24	111.27	25.80	6.33	111.00	17.44	6.90	2.77	2.49	4.72	2.35	2.01	4.25	50.0	22.60	3	1	0	0
25	114.80	20.40	8.07	112.00	20.95	7.14	2.68	2.68	4.50	2.33	1.93	3.25	29.5	25.23	3	1	0	0
26	132.93	24.00	9.00	111.00	16.51	6.91	2.54	2.72	4.57	2.32	1.97	5.25	44.0	24.07	3	1	0	0
27	121.53	22.40	7.40	111.00	16.82	6.81	2.54	2.68	4.30	2.35	1.83	4.75	39.0	23.92	3	1	0	0
28	115.67	23.47	9.17	112.00	17.39	6.66	2.61	2.55	4.68	2.33	2.01	3.25	52.5	23.86	3	1	0	0
29	123.93	22.13	7.53	110.00	18.32	6.73	2.57	2.61	4.45	2.22	2.01	2	59.0	23.34	5	1	0	0
30	109.13	22.67	7.53	109.00	18.18	8.01	1.97	4.06	6.30	1.88	3.34	2.25	30.0	20.49	5	1	0	0
31	146.07	22.13	7.60	114.00	15.22	7.66	1.99	3.84	5.68	1.88	3.02	4.25	49.5	9.07	5	1	0	0
32	120.60	20.27	6.73	109.00	17.77	6.63	2.48	2.67	4.63	2.33	1.99	5.25	46.0	7.49	3	1	0	0
33	141.93	21.73	7.67	104.00	17.71	8.66	2.05	4.24	5.97	1.85	3.24	1.75	21.5	3.17	5	9	9	2
34	126.33	21.00	7.27	102.00	18.23	8.80	2.03	4.33	6.38	1.92	3.33	2.25	41.0	10.43	5	9	9	3
35	122.87	23.13	9.33	105.00	25.70	9.61	2.46	3.92	6.97	2.18	3.19	6.25	95.5	14.44	3	9	3	3
36	106.47	21.33	9.20	110.00	19.00	8.88	2.09	4.26	5.80	1.95	2.98	3.25	68.5	21.44	3	9	2	2
37	134.60	25.00	9.20	101.00	15.03	8.21	2.23	3.68	6.15	2.00	3.08	2	62.5	5.12	5	1	0	0
38	113.67	20.33	8.90	100.00	19.32	8.97	1.95	4.60	6.52	1.93	3.37	2	53.0	12.59	3	1	0	0
39	81.80	24.20	9.33	97.00	13.15	7.84	1.72	4.57	5.30	1.57	3.39	3.25	38.5	16.49	1	1	0	0
40	91.67	22.67	7.87	106.00	15.76	7.87	1.91	4.12	5.63	1.70	3.32	1.5	45.0	24.97	3	1	0	0
41	92.00	22.60	7.73	106.00	15.45	7.74	1.83	4.24	5.43	1.73	3.14	3	49.5	24.34	1	1	0	0
	LONG	MEDIUM(21-25cm)	Few(<11)	MEDIUM(91-110DAYS)	low(15-20g)	medium(8.6-10.5mm)	narrow(2-2.5mm)	SLENDER(>3mm)	SHORT BOLD			LOW (1-2)	SOFT RICE	MEDIUM(20-25%)	Strong aroma	Present	No awns	No awns
	VERY LONG(>150cm)	SHORT(16-20cm)		LATE(111-130DAYS)	medium(21-25g)	very short(<6mm)	very narrow(<2mm)	MEDIUM(2.1-3mm)	MEDIUM SLENDER			LOW,MEDIUM (3)	VERY FLAKY	LOW(10-19%)	Medium aroma	Absent	Yellowish brown	whole length
	VERY SHORT(<91cm)	LONG(26-30cm)		EARLY(71-90DAYS)	very low(<15g)	short(6.1-8.5mm)	medium(2.6-3mm)	BOLD(1.1-2mm)	LONG BOLD			HIGH (6-7)	FLAKY	VERY LOW(3-9%)	No aroma		Brown	Upper half
	MEDIUM(111-130cm)				very high(>30g)				BASMATI TYPE			MEDIUM (4-5)					Black	Tips only
	SHORT(91-110cm)				high(26-30g)				LONG SLENDER									
									SHORT SLENDER									

Plant height

In 41 genotypes 18 genotypes were short (91-110cm), 11 genotypes with medium height (111-130cm), 7 genotypes with long height (131-150cm), 4 have a very short height (<91cm) and 1 genotype found to be very long (>150cm). Plant height distribution was shown in (Table 2).

Panicle length

Among 41 genotypes 33 were having medium panicle length (21-25cm), 2 were having short panicle length (16-20cm) and 6 were found to have long panicle length (26-30cm). Panicle length distribution was shown in (Table 2).

Number of effective tillers per plant (Panicles)

All genotypes reported a few number of panicles per plant. The panicle number per plant was shown in (Table 2).

Days to 50% flowering

Out of 41 genotypes, 23 had medium (91-110days) days to 50% flowering, 17 were found to have late days to 50% flowering (111-130days) and 1 was found to be early (71-90days). Days to 50% flowering distribution was shown in (Table 2).

Test weight

In 41 genotypes, 24 showed low test weight (15-20g), 7 were having medium (21-25g), 6 had high (26-30g), 3 are having very low (<15g), and 1 had very high (>30g) test weight. Test weight distribution was shown in (Table 2).

Grain length

Out of 41 genotypes 21 were found to have short grain length (6.1-8.5mm), 17 were having medium (8.6-10.5mm), and 3 are having very short (<6mm) grain length. Grain's physical appearance was shown in (Figure1). The grain length distribution was shown in (Table 2).

Grain breadth

In 41 genotypes, 26 genotypes were having narrow grain breadth (2.1-2.5mm),8 were having medium grain breadth (2.6-3mm), and 7 are found to be a very narrow grain breadth (<2mm). Grain breadth distribution was shown in (Figure 1). The physical appearance of the paddy was presented below in (Table 2).

Grain L: B ratio

Out of 41 rice genotypes, 29 were found to be slender type (>3), 21 are medium (2.1-3) and 1 was found to be bold type (1.1-2). Grain L: B ratio distribution was shown in (Table 2).

Kernel dimensions

Kernel dimensions were based on kernel length and kernel L: B ratios. Out of 41 rice genotypes, 14 were short bold (L:<6mm and L: B:<2.5), 8 are short slender (L:<6mm and L: B: ≥3), 7 were having basmati type of kernel (L:6.61mm and L: B: >3), 6 are long slender type (L: ≥6 and L: B: ≥3), 4 were long bold (L: ≥6 and L: B: <3), and 2 were medium slender (L:5.5-6mm and L: B: 2.5-3). Kernel dimensions distribution was shown in (Table 2). The physical appearance of kernel shapes of 41 genotypes was presented in (Figure 1).

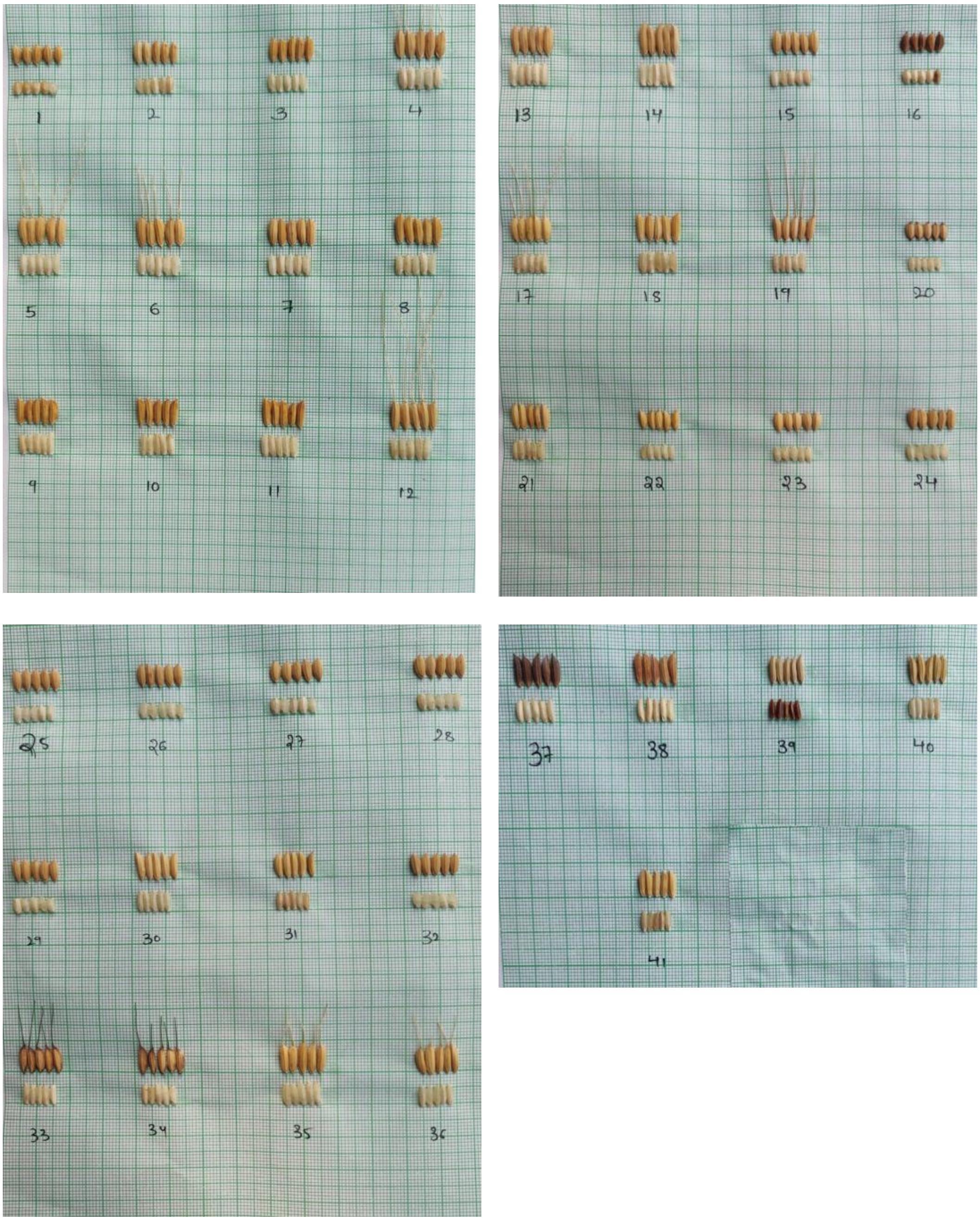


Fig. 1. Grain length and width of 41 rice genotypes plotted on graph paper

Awns

Among 41 genotypes, 10 genotypes were found to be awned and the rest 31 genotypes had no awns. Awns distribution was shown in (Table 2). The physical appearance of Awns was presented in (Figure 1).

Colour of awns

Out of 41 genotypes, 5 genotypes with yellowish brown awn colour, 3 genotypes with brown awn colour, and 2 genotypes with black awn colour. Colour of the awns distribution was shown in (Table 2). The physical appearance of colour of the awns was presented in (Figure 1).

Distribution of awns on panicle

10 genotypes showed awns on the panicle out of this, 6 genotypes showed awns on the whole length of the panicle, and 2 genotypes of each showed awns on the middle half only and awns on the tips of the panicle. Distribution of awns on panicle distribution was shown in (Table 2).

Alkali spreading values

Out of 41 genotypes, 14 were found to have medium-low alkali spreading values followed by 13 medium types, 11 low types, and 3 having high alkali spreading values. Alkali spreading of 41 rice genotypes was presented in (Figure 2). Alkali spreading value distribution among genotypes was shown in (Table 2).

Gel consistency

In 41 rice genotypes 24 were flaky (41-60mm), 11 were very flaky (≤40mm) and 6 were soft (>61mm) type. Gel consistency of very flaky, flaky and soft rice was presented in (Figure 3). Gel consistency distribution among genotypes was shown in (Table 2).

Amylose content

Out of 41 genotypes, 24 genotypes were found to have medium amylase content (20-25%), 10 were found to have low amylose content (10-19%), and 7 were found to have very low amylose content (<10%). Variation of amylose content in between genotypes was presented in (Figure 4). Amylose content distribution among genotypes was shown in (Table 2).

Grain aroma

Out of 41 genotypes, 29 genotypes were found to have a medium aroma, 9 genotypes have a strong aroma and 3 genotypes with no aroma. Grain aroma distribution was shown in (Table 2).

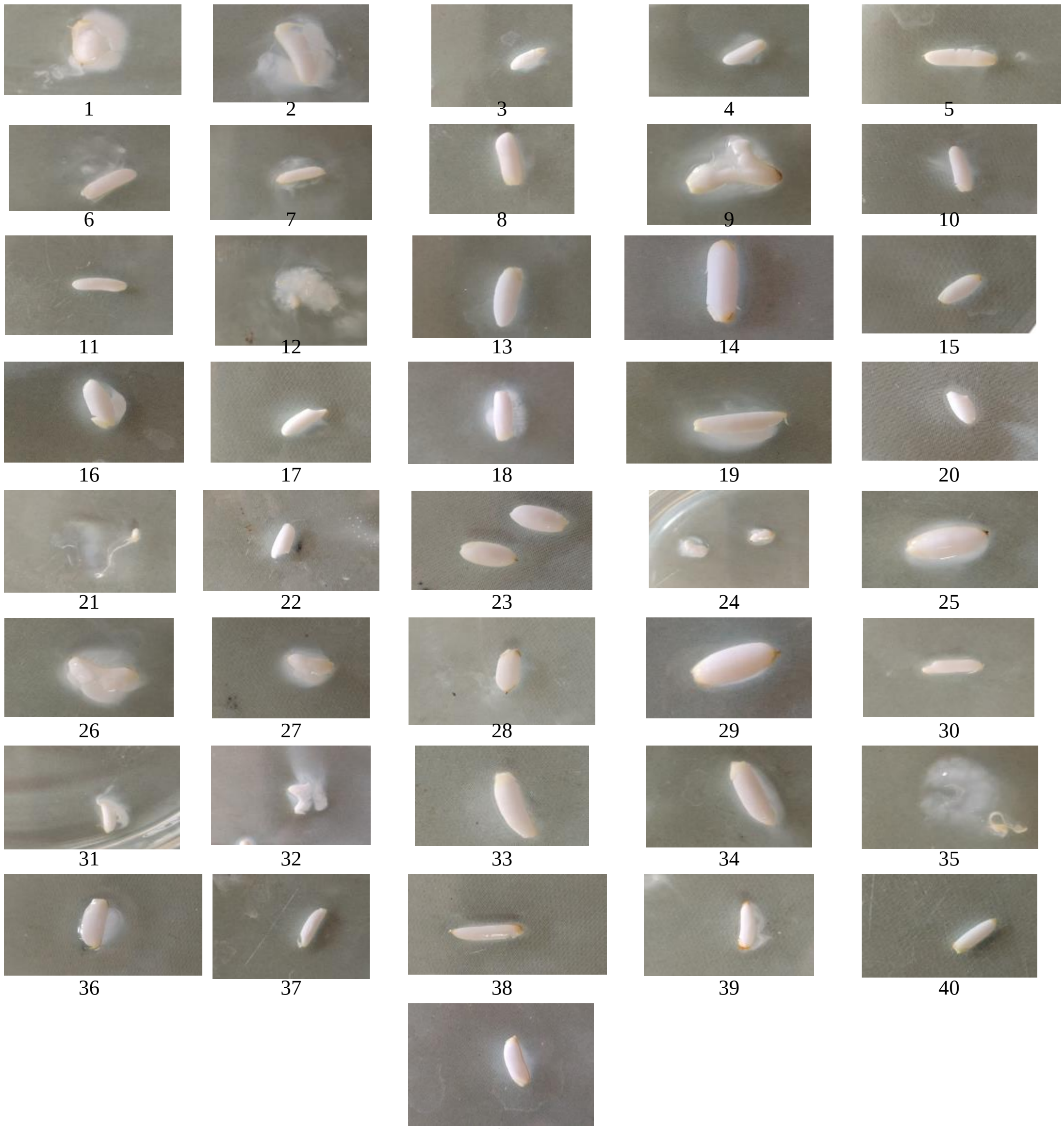

1 2 3 4 5
6 7 8 9 10
11 12 13 14 15
16 17 18 19 20
21 22 23 24 25
26 27 28 29 30
31 32 33 34 35
36 37 38 39 40
41

Fig. 2. Alkali spreading types of 41 genotypes

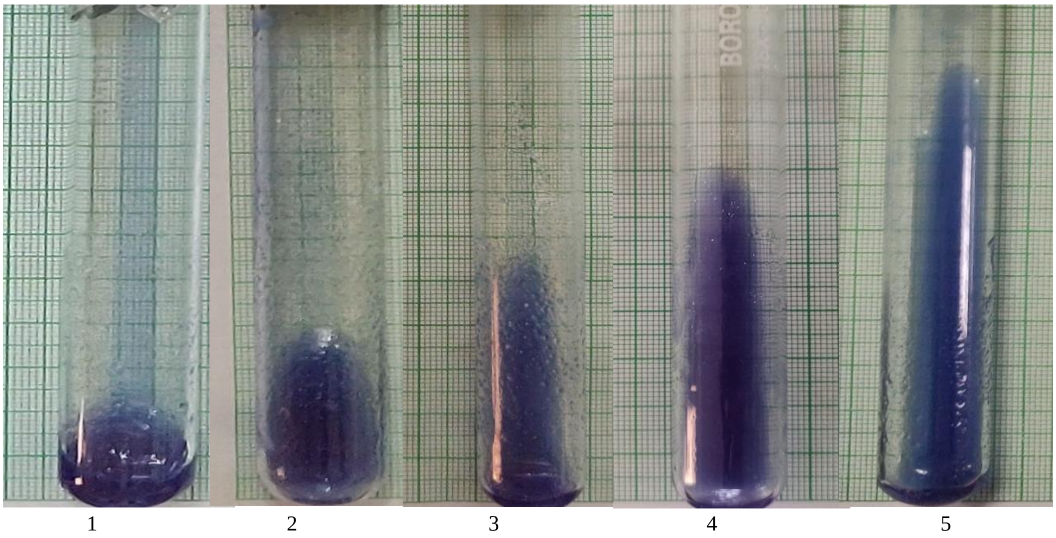


Fig. 3. 1: CG Devbhog and 2: R2054-147-1-103-1 showing very flaky and hard gel consistency; 3: R2032-87-1-23-1 showing flaky, medium gel consistency; 4: R1624-61-1-59-1 and 5: R2054-147-3-105-1 showing soft rice, soft gel consistency

Fig. 4. Quality analysis showing the variation of amylose content among genotypes (1: Samundrachini 5-50; 2: R2032-87-1-23-1; 3: R2054-147-3-105-1; 4: Nagri Dubraj Mutant-1; 5: R2281-308-1-185-1; 6: Dubraj (c))

Principal component analysis

From principal component analysis, PC1 showed the highest amount of variance (32%) with mostly related to traits like grain L: B ratio (0.355) and kernel L: B ratio (0.349). As a result, the first component mainly identifies the characters responsible for quality. PC2 showed second highest amount of variance (15.7%) with cumulative variance (47.8%) with mostly related to traits like test weight (0.469), kernel length (0.341), grain length (0.337), grain breadth (0.294), alkali spreading value (0.185), amylose content (0.237) and grain yield per plot (0.327), therefore the PC2 mainly identifies the characters related with quality and yield. Third highest variance (9%) with cumulative variance (56.8%) with mostly related to traits like harvest index (0.595), gel consistency (0.469), panicle length (0.325), head rice recovery (-0.012) and number of effective tillers per plant (0.255), therefore PC3 mainly related with yield and quality traits. PC4 was found to have the fourth highest variance (8.1%) with cumulative variance (64.8%) with mostly related with traits like plant height (0.448), days to 50% flowering (0.190) and kernel breadth (0.326) therefore PC4 mostly related with quality traits and one yield trait. PC5 was found to have the fifth highest variance (7.8%) with cumulative variance (72.7%) with mostly related to traits like number of filled grains per panicles (0.215), and kernel elongation ratio (0.468), therefore PC5 mostly contributed to the quality and yield traits. PC6 was found to have the sixth highest variance (5.4%) with cumulative variance (78.1%) with mostly related to traits like number of tillers per square meter (0.475) and number of panicles per square meter (0.466), therefore PC6 mostly contributed with yield traits. All eigenvectors were presented in (*Table 4*) with respect to characters and 6 principal components. Characters that show both positive and negative impacts on PCs are said to be the key source of variability and mainly contributed to the divergence of genotypes. The Scree plot showed the association of PCs with eigenvalues and the variance % was presented in (Figure 5). An Elbow type line is seen after PC6. The highest eigenvalue shown by PC1 was shown in (Table 3). The outcomes of the present study are in agreement with earlier findings of SAO *et al.* (2019); OJHA *et al.* (2017); GAUR *et al.* (2017), and NACHIMUTHU *et al.* (2014). The top 10 PC scores were mentioned genotype-wise in (Table 5) in 6 principal components. These scores can be used for the purpose of precised selection indices whose intensity is based on the variability shown by the respective components. A high score for a particular genotype in a particular principal component indicates the high variability for a particular character of that principal component. Based on the specific goals of a particular breeding program the genotypes based on PC scores were selected for the respective character. The correlation matrix of 21 yield and quality traits was plotted against the 6 principal components shown in (Figure 6). From the correlation matrix, the red dots show the negative relationship between the respective characters with components and the blue dot shows the positive relationship. A biplot between PC1 and PC2 for 21 characters of 41 genotypes was presented in (Figure 7). From biplot analysis revealed that genotypes are diverse for the characters under PC1 and PC2. Both components showed a negative relationship with plant height, and Kernel elongation ratio. Days to 50% flowering, and head rice recovery showed slightly negative for both components. PC1 showed higher values for grain length, grain L: B ratio, kernel length, kernel L: B ratio and test weight and contribute to maximum variance %. In PC2 gel consistency was also found to be negative. Except for plant height, days to 50% flowering, head rice recovery, gel consistency and kernel elongation ratio most of the characters are positive. From biplot of PC1 and PC2 genotypes like 1, 20, 33, 34, 38, 14, 12, 15 and 4 were highly diverse. So these genotypes can be selected for further breeding programs for improving the yield and quality of characters.

Table 3. Eigenvalues, standard deviation, variance % and cumulative variance % of 6 Principal components

	PC1	PC2	PC3	PC4	PC5	PC6
Eigenvalues	6.725	3.305	1.896	1.690	1.642	1.136
Standard deviation	2.594	1.817	1.377	1.301	1.282	1.065
Proportion of Variance %	32.0	15.7	9.0	8.1	7.8	5.4
Cumulative Proportion %	32.0	47.8	56.8	64.8	72.7	78.1

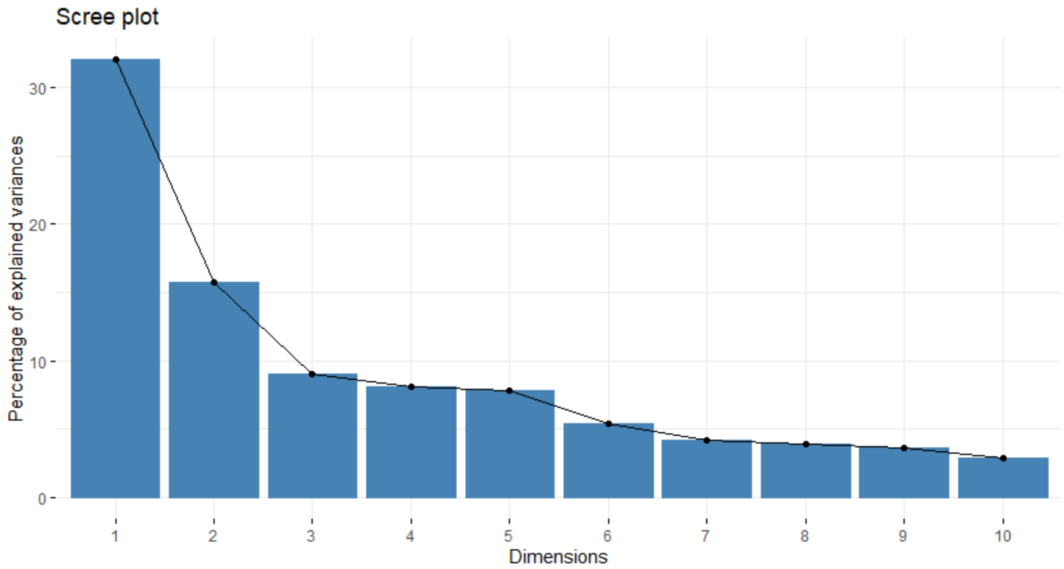


Fig. 5. Scree plot showing the % variation with respect to principal components

Table 4. Eigen vectors for 6 principal components for 21 characters

	PC1	PC2	PC3	PC4	PC5	PC6
PH	-0.1289	-0.2029	0.0875	**0.4488**	0.0741	0.3148
PL	-0.1397	0.0962	**0.3251**	-0.3743	-0.3254	0.1193
NETP	-0.0420	0.1704	**0.2554**	-0.3667	-0.1178	0.0822
TNFGP	-0.2553	0.0698	0.1442	0.1656	**0.2151**	-0.2369
NTSM	-0.2540	0.1881	0.0006	-0.0813	0.3089	**0.4417**
NPSM	-0.2520	0.1852	0.0014	-0.0799	0.3100	**0.4494**
DTF	-0.2857	-0.0485	0.0534	**0.1906**	0.1228	0.1422
HI	0.0013	0.0785	**0.5950**	0.1151	0.1063	-0.0931
TW	0.0794	**0.4694**	-0.1210	0.2552	-0.0377	0.0215
HR	-0.2463	-0.0688	**-0.0126**	-0.0211	-0.1767	-0.0524
GL	0.2878	**0.3370**	-0.0215	0.1497	0.0432	0.0078
GB	-0.2375	**0.2942**	-0.1345	0.2067	-0.3059	-0.0238
GLB	**0.3558**	0.0594	0.0684	-0.0418	0.2205	0.0077
KL	0.2756	**0.3415**	0.0143	0.1599	-0.0031	0.1306
KB	-0.2678	0.2281	-0.1132	**0.2317**	-0.3135	-0.0375
KLB	**0.3490**	0.1436	0.0733	-0.0139	0.1583	0.1159
ASV	-0.1258	**0.1855**	0.0073	0.1432	0.1590	-0.4606
GC	0.0621	-0.0953	**0.4699**	0.2571	-0.1635	0.0678
AC	-0.1606	**0.2376**	-0.2418	-0.3403	0.1950	-0.1388
KER	-0.1512	-0.1107	0.0645	0.0384	**0.4683**	-0.2904
GY	-0.1290	**0.3275**	0.3221	-0.1348	0.0355	-0.2044

Table 5. Top 10 scores of genotypes in 6 principal components wise

S.	**PC1**	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**
1	RM 504 (Mahraji)	R1624-61-1-59-1	Ker ghul	Ker ghul	Indira Sugandhit Dhan-1	Dubraj (c) Jeeraphool
2	R2032-87-1-23-1	R1624-61-2-60-1	R 2054-685-1-205-1	Banspatri	Jhilli Mutant 13-5	RL 910 (LAYCHA)
3	Maharaji	R2281-308-1-185-1	Samundrachini 5-50	R2369-480-1-257-1	Dubraj (c)	Jeeraphool Mutant 5
4	Banspatri	R1624-61-3-61-1	Banspatri	CG Devbhog (c)	R-FS-2019-2	R2282-552-1-309-1
5	R2054-147-1-103-1	Kasturi	R2054-147-3-105-1	R2281-308-1-185-1	R-FS-2019-1	Indira Sugandhit Dhan-1 (c)
6	R2054-147-2-104-1	R1896-82-1-60-1	R 1656-2151-1-412-	R1624-61-3-61-1	R2281-308-1-185-1	R2400-562-1-339-1
7	RL 910 (LAYCHA)	R2282-552-1-309-1	JDP-2520-2-4-1	Samundrachini 5-50	R 2400-562-2-340-1	R2054-147-3-105-1
8	JDP-2520-2-4-1	R 2054-685-1-205-1	R 2400-562-2-340-1	Indira Sugandhit Dhan-1 (c)	Ker ghul	CG Sugandhit Bhog (c)
9	R2054-147-3-105-1	R1915-115-1-88-1	R1624-61-1-59-1	R2054-147-3-105-1	R2282-552-1-309-1	R1624-61-1-59-1
10	Jhilli Mutant 13-5	R2054-147-2-104-1	R2369-483-1-259-1	Dubraj (c)	CG Devbhog (c)	R2032-87-1-23-1

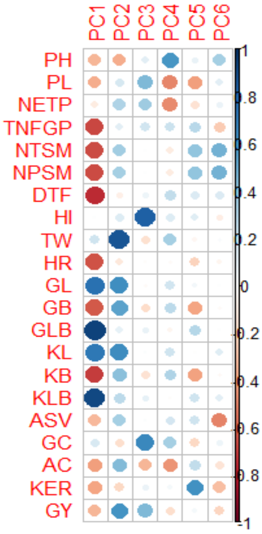


Figure 6. Correlation matrix between 21 yield and quality characters with respect to 6 principal components. The blue dots indicate positive relation whereas the red dots indicate negative relation. The intensity of colour shows the strong or weak relationship

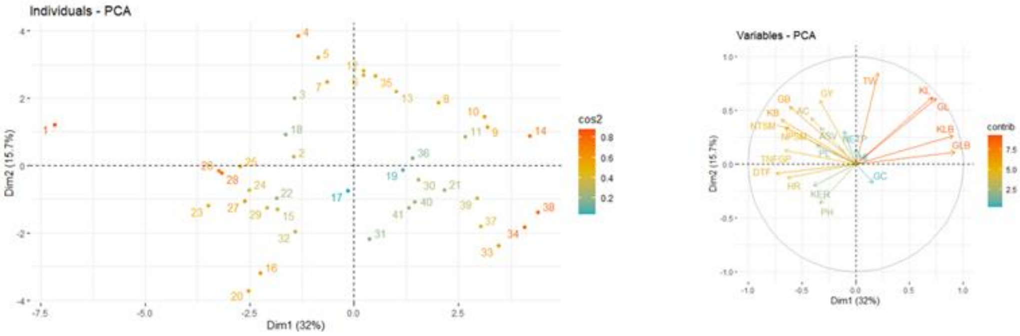


Figure 7. Biplot between PC1 and PC2 shows the distribution of genotypes and traits contribution for variance% with respective to principal components

CONCLUSION

These days people in rice-eating countries need fine slender grains with medium amylose content, medium gel consistency, good elongation ratio, high head rice recovery, less flaky, and strong aroma in rice. So characterization of 41 genotypes revealed that there is a huge diversity among the genotypes to yield contributing characters and quality characters. Genotypes like CG Devbhog (c), Indira Sugandhit Dhan-1 (c), JDP-2520-2-4-1, Maharaji, R 2400-562-2-340-1, R1896-82-1-60-1, R1915-115-1-88-1, R2032-87-1-23-1, R2054-147-2-104-1, R2054-147-3-105-1, R2369-480-1-257-1, R2400-562-1-339-1 these are genotypes which performed well in quality characters like alkali spreading value, amylose content and gel consistency. CG Devbhog (c), Jeeraphool Mutant 5, Ker ghul, R1624-61-1-59-1, R2369-479-1-256-1, R2369-481-1-258-1 are the genotypes having the long slender type of kernel. Kasturi, R2282-552-1-309-1, R2369-475-1-251-1, R2369-475-2-252-1, R2369-478-1-255-1, R2369-480-1-257-1, Vishnubhog Mutant V-74-6 these are the genotypes having basmati type of kernel. Banspatri, CG Sugandhit Bhog (c), Dubraj (c), JDP-2520-2-4-1, Kasturi, R 1656-2151-1-412-1, R2369-478-1-255-1, R2400-562-1-339-1, Vishnubhog Mutant V-74-6 these are the genotypes having strong aroma. These genotypes may be useful as pre-breeding materials as parents for developing high-yielding varieties with improved cooking and nutritional quality. This material is also used for breeding basmati type of varieties with a strong aroma that can be cultivated in a wide range of climates in central and south India. PCA revealed that there exists a lot of variation for agro-morphological and quality traits among the genotypes. PC1 showed the highest eigenvalue and elbow-type line is observed at PC6. These diverse genotypes can be used by the breeder for producing elite varieties based on the objectives of the breeder by crossing distant parents to harness the power of heterosis.

Received, November 18th, 2021
Accepted october 28th, 2022

REFERENCES

AL MAMUN, M.A., S.A.I., NIHAD, M.A.R., SARKAR, M.A., AZIZ, M.A., QAYUM, R., AHMED, N.M.F., RAHMAN, M.I., HOSSAIN, M.S., KABIR (2021): Growth and trend analysis of area, production and yield of rice: A scenario of rice security in Bangladesh. PloS one, *16*(12): e0261128.

BANFIELD, C.F. (1978): Principal component analysis for genstat. J. Stat. Comput. Simul., *6*:211-222.

BERNER, D.K., B.J., HOFF (1986): Inheritance of Scent in American Long Grain Rice 1. Crop Sci., *26*(5): 876-878.

BHATTACHARJEE, P., R.S., SINGHAL, P.R., KULKARNI (2002): Basmati rice: a review. Inter. J. Food Sci. Tech., *37*(1):1-12.

BRADBURY, L.M., R.J., HENRY, Q., JIN, R.F., REINKE, D.L., WATERS (2005): A perfect marker for fragrance genotyping in rice. Mol. Breed., *16*(4):279-283.

CRUZ, N.D., G.S., KHUSH (2000): Rice grain quality evaluation procedures. Aromatic Rices, *3*:15-28.

GOUR, L., S.B., MAURYA, G.K., KOUTU, S.K., SINGH, S.S., SHUKLA, D.K., MISHRA (2017): Characterization of rice (*Oryza sativa* L.) genotypes using principal component analysis including scree plot & rotated component matrix. UCS, *5*(4): 975-83.

GRAHAM, R. (2002): *A proposal for IRRI to establish a grain quality and nutrition research center* (No. 2169-2019-1615).

JULIANO, B.O., C.P., VILLAREAL (1993): Grain quality evaluation of world rices. IRR1, Philippines Pp 205.

KONDI, R.K.R., S., KAR, N.C., MANDAWI (2022). Study of genetic parameters, correlation and path analysis for yield and quality characters in fine scented rice genotypes. Journal: Oryza-An International Journal on Rice March, *2022*(1): 20-30.

KOR, Y.Y., J., PRABHU, M., ESPOSITO (2017): How large food retailers can help solve the food waste crisis. Harvard Business Review, *19*.

NACHIMUTHU, V.V., S., ROBIN, D., SUDHAKAR, M., RAVEENDRAN, S., RAJESWARI, S., MANONMANI (2014): Evaluation of rice genetic diversity and variability in a population panel by principal component analysis. Indian J. Sci. Technol., *7*(10): 1555-1562.

OJHA, G.C., A.K., SARAWGI, B., SHARMA, M., PARIKH (2017). Principal component analysis of morpho-physiological traits in rice germplasm accessions (*Oryza sativa* L.) under rainfed condition. UCS, *5*(5): 1875-1878.

POKHREL, A., A., DHAKAL, S., SHARMA, A., POUDEL (2020): Evaluation of Physicochemical and Cooking Characteristics of Rice (*Oryza sativa* L.) Landraces of Lamjung and Tanahun Districts, Nepal. International journal of food science, *2020*:1-11.

RANI, N.S., M.S., MADLIAV, M.K., PANDEY, R.M., SUNDARAM, G.S.V., PRASAD, I., SUDARSHAN, L.V., RAO, RAVINDRABABAU (2008). Genetics and molecular approaches for improvement of grain quality traits in rice. Indian J. Crop Sci., *3*(1):1-14.

RITA, B., A.K., SARAWGI (2008): Agro-morphological and quality characterization of badshah bhog group from aromatic rice germplasm of Chhattisgarh. Bangladesh J. of Agri. Res., *33*(3):479-492.

ROBIN, S., R., PUSHPAM, S., RAJESWARI, K., AMUDHA, P., JEYAPRAKASH, S., MANONMANI, K., GANESAMURTHY (2019). CO 52 (IET 25487): A highly remunerative medium duration fine grain rice variety. Electronic J. Plant Breeding, *10*(3): 1148-1160.

SAO, R., R.R., SAXENA, P.K., SAHU (2019). Assessment of genetic variation and diversity in rice genotypes based on principal component analysis. JPDS, *11*(12): 725-730.

SHOBHA RANI, N., L.V., SHOBHA RAO, B.C., VIRAKTAMATH, B., MISHRA (2006). National guidelines for the conduct of tests for distinctiveness, uniformity and stability. Directorate of Rice Research, 6-13.

SULTANA, S., M., FARUQUE, M.R., ISLAM (2022). Rice grain quality parameters and determination tools: a review on the current developments and future prospects. International Journal of Food Properties, *25*(1): 1063-1078.

AGRO-MORFOLOŠKA I BIOHEMIJSKA KARAKTERIZACIJA I ANALIZA GLAVNIH KOMPONENTI ZA KARAKTERISTIKE PRINOSA I KVALITETA U GENOTIPU PIRINČA FINOMIRIS

Ravi Kiran Reddy KONDI[1]*, Sonali KAR[2], Soumya SURAKANTI [3]

[1]Odsek za genetiku i oplemenjivanje biljaka na S.G.C.A.R.S, Kumhrawand, Jagdalpur, Bastar (C.G.), Indira Gani Krishi Vishwavidyalaya, Raipur
[2]Odsek za genetiku i oplemenjivanje biljaka, S.G.C.A.R.S, Kumhrawand, Jagdalpur, Bastar (C.G.), Indira Gandi Krishi Vishwavidyalaya, Raipur.
[3]Odsek za genetiku i oplemenjivanje biljaka na B.A Koledž za poljoprivredu Anand Poljoprivredni Univerzitet

Izvod

Četrdeset i jedan genotip pirinča sa finim mirisom je procenjen za 18 agromorfoloških i kvalitativnih osobina, a 21 kvantitativna osobina je odabrana za analizu glavnih komponenti u R-softveru. Karakterizacija agromorfoloških osobina, odnosno visina biljke, dana do 50% cvetanja, dužina klasa, broja efektivnih klasića po biljci, dužina zrna, širina zrna, odnos L:B zrna, dimenzije zrna, šilja, boja šiljaka, distribucija šiljaka i osobine kvaliteta, odnosno, konzistencija gela, aroma zrna i sadržaj amiloze pokazali su ogromnu raznolikost među genotipovima. PCA je otkrio da je PC1 pokazao najveći iznos varijanse (32,0%), a zatim PC2 (15,7%), PC3 (9,0%), PC4 (8,1%), PC5 (7,8%), PC6 (5,4%) za kvantitativne osobine. Od 21 glavne komponente, samo 6 je pokazalo vrednost veću od 1 i doprinelo oko 78,1% ukupnoj varijansi. Genotipovi u PC1 su pokazali veće vrednosti za odnos L:B zrna. Slično, PC2 je pokazao veće varijabilne vrednosti za osobine kao što su dužina zrna, širina zrna, prinos zrna po parceli i sadržaj amiloze. PC3 za žetveni indeks, dužinu metlice, konzistenciju gela, br. efektivnih klasova po biljci i oporavka glavice pirinča. PC4 za osobine kao što su visina biljke, širina zrna i dani do 50% cvetanja. PC5 za osobine kao što su odnos izduživanja jezgra i nalivenih zrna po klasu. PC6 za osobine poput br. Klasova u kvadratnom metru i br. Klasića u kvadratnom metru. Ova studija karakterizacije pre oplemenjivanja može biti korisna u pronalaženju potencijalnih genotipova koji imaju i karakteristike prinosa i kvaliteta I koji mogu biti korisni u oplemenjivanju sorti visokog prinosa sa dobrim kvalitetom.

Primljeno 18. XI.2021.
Odobreno 28. X. 2022.