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Genetic diversity and character association analysis of aromatic grain type non-basmati rice *(Oryza sativa)* genotypes

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Abstract
The present investigation was conducted in randomized block design (RBD) with two replications during *kharif* season on 2023-24 at the research farm of IGKV Raj Mohini Devi College of Agriculture and Research Station, Ambikapur, Chhattisgarh. A total of forty aromatic type non-basmati rice genetically diverse genotypes were considered for the study. Analysis of variance was found to be significant for all the traits, indicate that there is existence of genetic variability for all the traits varying from lower to higher coefficient of variance. Based on D^2 statistic, the 40 aromatic type non-basmati rice genotypes were grouped into six clusters. The highest intra cluster distance was recorded in cluster I and the lowest intra-cluster distance in cluster II. The highest inter cluster distance was recorded cluster V and VI (6655.99), and the lowest inter cluster distance was recorded between cluster III and V (404.54). It helps in the selection of divergent parents for their exploitation in hybridization programs.

Keywords: Non-basmati aromatic genotypes, diversity, Aroma testing of leaves, grain quality

Introduction
Rice, *Oryza sativa* (2n=24) belonging to the family poaceae subfamily, *Oryzoidea*. Rice is the stable food crop from one third of the world's population and occupies almost one fifth of the total land area covered under cereals. It is grown on 46.38 million hectares in India, producing 195.42 million tonnes overall at a productivity of 4213.7 kg. per hectares (FAOSTAT,2021) In Chhattisgarh, it is cultivated in 3.90 million hectares in total, producing 13.42 million tonnes, with an average yield of 3438 kg ha. (Directorate of Extension service Krishi Darshika 2022, IGKV Raipur). Non-basmati rice is a type of rice that lacks the characteristics of basmati rice, ranging in shapes and sizes like long-slender, short-thick, bends, or round, and has distinct properties. (Bhattacharjee *et al*., 2002) [3]. Researchers have analyzed various rice varieties globally, examining their physical, milling, physiochemical, and cooking characteristics to identify differences among global rice cultivars. (Shobhan *et al.*, 2016; Yadav *et al.*, 2014) [9, 10]. The natural chemical compound that is 2-acetyl-1-pyroline gives aromatic rice the characteristics aroma and flavour but in the aromatic varieties it is present in much higher concentrations.

Genetic diversity in basmati rice is crucial for varietal identification, purity maintenance, and breeding. With WTO regulations implementing plant variety protection rights, more attention is being paid to comprehensive characterization of elite basmati quality rice germplasm. Genetic analysis is essential for export quality, maintaining distinctiveness of varieties, and distinguishing between different grades of basmati rice. (Bligh, 2000; Nagaraju *et al.*, 2002) [4, 6].

Methods and Materials
The 40 genotypes of paddy were assessed in the field during wet season *kharif* 2023 at Instructional – cum- Research Farm, Department of Genetics and Plant Breeding, RMD CARS, Ambikapur.

The field trials were carried out under irrigated transplanted condition. The plant material was sown in a raised bed nursery, and the seedlings were transferred into the field in a Randomized Block Design (RBD) after thirty-two days. Two replications of the experimental material were planted. Each entry was transplanted in five lines with 20 cm of spacing among row to row and 15 cm between plants to plant. Fertilizer dose @ of 100:60:60 NPK Kg ha^{-1} was applied.

Data was recorded on twenty-eight morphological characters including both qualitative and quantitative characters and two quality test namely, coleoptile: colour, leaf: intensity, leaf: ligule, leaf: shape of ligule, culm: angle, flag leaf: attitude of blade, incidence of disease and pest, spikelet: colour of tips of lemma, lemma and palea: colour, panicle: awn, panicle: colour of awns, panicle: exertion, decorticated grain colour, aroma test of leaves, gelatinization temperature through alkali spreading value, days to 50% flowering, days to 80% maturity, plant height (cm), panicle length (cm), number of panicle per plant, number of panicle per sq. meter, number of tillers per plant, number of sterile spikelets per panicle, number of fertile spikelets per panicle, number of grains per panicle, decorticated grain length (mm), decorticated grain width, spikelet fertility (%), test weight (g), grain yield (q/ha).

Observation was recorded on the basis of five randomly chosen plants of each genotype per replication according to the National Test Guidelines for Distinctiveness, Uniformity and Stability (DUS) test in rice which was developed by ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad (Shobha *et al*., 2004). The observation of various characteristics was recorded at different stages of growth with appropriate procedures as per the DUS test guidelines of PPV & FR Act. 2001. The generalized distance between two populations is defined by Mahalanobis (1936) [5] as.

$$D^2 = \lambda i.\ j\ di.\ Dj.$$

Where

λij= Reciprocal matrix to the common dispersion matrix

di = Difference between the mean values of two population for ith character

dj = Difference between the mean values of two population for jth character

Results and Discussions

Genetic diversity

Based on the D^2 value, for the 40 genotypes of rice was grouped into 6 clusters. Among these clusters, Cluster I has a maximum of 29 genotypes, while Cluster Iihas 7 genotypes, but Cluster III, IV, V, and VI have 1 genotype (Table No. 7). The maximum intra cluster distance is observed in cluster I (347.03) followed by cluster II (293.92) the minimum intra cluster D^2 values are shown by cluster III, IV, V, and VI having (0.00). the highest inter cluster D^2 values are shown between cluster V and VI (6655.99) followed by cluster III and VI (5759.39), cluster II and V (4186.73). The lowest inter cluster D^2 values are shows by cluster III and V (404.54) followed by cluster I and IV (621.85), cluster I and II (897.61) (Table No. 5). Indicating that the genotypes in these clusters contain a large genetic diversity and can thus be exploited in hybridization programmes to improve grain yield. Similar findings also reported by Ali *et al*., (2012) [2], Neha and Gabrieal (2012) [7], Ovung *et al*., (2012) [8].

Contribution of various characters to divergence

The contribution of a traits to genetic divergence is a major factor in the selection and choosing of parents (Bahu *et al.,* 2003). The percentage contribution of various characters to genetic diversity is presented in table no. 6. Out of 15 characters studied, the character grain yield (q/ha) (15.67%) has highest contribution for genetic diversity followed by grain width (13.67), spikelet fertility (%) (12.22), no. of sterile spikelets per panicle (11.32), grain length (7.89), no. of grains per panicle (7.32), test weight (g) (5.38), no. of tillers per plant (5.32), no. of panicles per sq. meter (5.32), plant height (cm) (4.55), days to 80% maturity (4.5), no. of panicles per plant (4.33), days to 50% flowering (2.3), panicle length (cm) (0.26), and no. of fertile spikelets per panicle.

Quality test

- **Aroma test of leaves:** 18 genotypes (45%) exhibited low aroma of leaves, 17 genotypes (42.5%) had medium aroma of leaves, and 5 genotypes (12.5%) had high aroma of leaves. The results are shows (Table No. 1).
- **Alkali spreading value:** High alkali spreading value was exhibited by 70% of genotypes, followed by medium in 17.5%, low in 12.5%, and none of the genotypes showed low medium alkali spreading value. The results are shows (Table No. 2).
- **Gelatinization temperature:** Low gelatinization temperature was exhibited by 70%, followed by medium in 175%, high in 12.5%, and none of the genotypes showed high medium gelatinization temperature. The results are shows (Table No. 2).

Table 1: Aroma test of leaves.

S. No.	Characters	Classes	No. of genotype	Percentage of genotype	Genotype
1.	Aroma test of leaves	Low aroma	18	45	BRR-0215, TPUR-K-02, Vishunbhog, AAU-KMJ DHAN-47, Narendra Vishnu Bhog, RP 6475-CGR-1-1-IL-1-2124-1-58-ASG, KAUTB-TRV-EBC-14, Narendrajuhi Bengal, Jhilli Dhan Mutant 15-1, NVSR1054, R 2449-1032-1-462-1, TRC 138, HUR2302, TRC 171-2-5-1, RNR 15435, OR 2621-18, ORB-3GM-4, BKR 405, CR4448-1
		Medium aroma	17	42.5	Ketekijoha, Narendra Tilak Chandra, BRR219, Dubraj Sel.1, Narendra Vikram TCR, HUR2301, ORB-1-BM-1, ORB-2-KM-3, TRC 395-2-4-2, Alsakar Mutant 19, JKOJM-300-584-5, RNR 15435, OR 2594-5, BKR 405, HURS 22-6, TRC 308-1-3-5
		High aroma	5	12.5	Badshabhog Sel.1, RP 6475-CGR 1-1-IL-1-2124-1-58-ASG, CR 4448-2, JR 14, BRR2277

Table 2: Gelatinization temperature through alkali spreading value.

S. No.	Character	GT	Classes	No. of genotype	Percentage of genotype	Genotype
2.	Gelatinization temperature through alkali spreading value	High	Low	5	12.5	BRR-0215, Narendra Tilak Chandra, HUR2301, JKOJM-300-158-11, BKR 405
		Medium	Medium	7	17.5	Badshabhog Sel.1, Vishunbhog, RP 6475-CGR 1-1-IL-1-2124-1-58-ASG, CR 4448-2, Narendra Vikram TCR, NVSR1054, ORB-1-BM-1
		Low	High	28	70	TPUR-K-02, AAU-KMJ DHAN-47, Narendra Vishnu Bhog, Ketekijoha, BRR219, KAUPTB-TRV-EBC-14, Dubraj Sel.1, JR 14, Narendrajuhi Bengal, Jhilli Dhan Mutant 15-1, r 2449-1032-1-462-1, ORB-2-KM-3, TRC 395-2-4-2, TRC 138, HUR2302, TRC 171-2-5-1, Alsakar Mutant 19, JKOJM-300-584-5, R 2356-218-98-1, BRR2277, RNR 15435, OR 2621-18, ORB-3GM-4, Shobini, OR 25594-5, CR4448-1, HURS 22-6, TRC 306-1-3-5
		High Medium	Low Medium	00	00	

Table 3: Mean performance of non-basmati rice genotype.

S. No.	Genotypes	Days to 50% flowering	Days to 80% maturity	Plant height (cm)	Number of tillers per plant	Number of panicles per plant	Panicle length (cm)	Number of panicles per sq. meter	Number of grains per panicle	Number of fertile spikelets per panicle	Number of sterile spikelets per panicle	Spikelet fertility (%)	Grain length	Grain width	Grain yield (q/ha)	Test weight (g)
1	Badshabhog Sel.1	117.505	135.005	69.105	6.605	6.605	26.105	158.505	169.905	144.205	25.705	84.43	0.875	0.305	48.505	18.755
2	BRR-0215	94.005	138.505	97.905	6.005	6.005	16.605	130.505	116.805	89.405	27.405	76.57	0.765	0.305	43.005	13.255
3	TPUR-K-02	97.5sS05	129.505	81.505	6.105	6.105	22.005	160.005	167.905	122.505	45.405	71.155	0.785	0.305	45.005	21.505
4	Vishnubhog	117.505	130.505	122.605	6.705	6.705	26.705	209.005	159.605	144.405	15.205	89.865	0.855	0.405	50.005	21.255
5	AAU-KMJ DHAN-47	98.005	138.505	81.805	7.105	7.105	22.705	166.505	173.505	129.005	44.505	74.365	0.565	0.305	41.505	14.755
6	Narendra Vishnu Bhog	92.005	132.505	113.105	6.005	6.005	23.305	135.005	154.405	129.805	24.605	84.075	0.565	0.305	41.005	10.755
7	RP6475-CGR-1-1-IL-1-2124-1-58-ASG	115.005	141.505	93.005	6.505	6.505	20.405	146.505	276.105	193.605	82.505	69.485	1.02	0.405	43.505	14.255
8	Ketekijoha	109.005	144.005	87.705	7.605	7.605	25.305	170.505	108.705	53.505	55.205	49.2	0.735	0.305	46.005	16.255
9	Narendra Tilak	106.005	129.005	97.055	6.005	6.005	23.305	170.005	92.405	84.505	7.905	91.475	1.025	0.405	45.505	26.505
10	BRR219	113.005	137.005	118.005	7.205	6.705	21.805	196.005	210.705	117.405	93.305	58.555	0.815	0.305	46.505	22.755
11	CR 4448-2	113.005	137.005	107.705	6.905	6.905	22.005	210.005	163.305	122.305	41.005	74.785	0.645	0.305	43.505	13.255
12	KAUPTB-TRV-EBC-14	109.005	135.005	107.705	6.705	6.705	21.605	159.505	143.355	117.655	25.705	82.07	0.935	0.405	42.005	26.255
13	Dubraj Sel.1	107.005	142.505	130.105	6.605	6.605	21.005	206.505	164.105	114.205	49.905	69.665	0.975	0.305	45.505	11.755
14	Narendra Vikran TCR	109.505	132.505	123.605	6.805	6.405	20.605	135.505	216.305	165.105	51.205	76.32	0.965	0.305	46.505	23.005
15	HUR2301	103.505	146.005	101.905	6.605	6.605	20.105	182.005	120.605	84.005	36.605	69.465	0.985	0.305	45.005	10.755
16	JR 14	108.505	122.505	67.205	6.905	6.905	23.305	187.505	92.305	80.805	11.505	87.085	0.805	0.73	41.505	21.755
17	Narendra juhi Bengal	113.005	142.505	99.005	8.305	8.305	20.105	131.505	210.205	143.705	66.505	68.33	0.765	0.405	42.505	10.755
18	Jhilli Dhan Mutant 15-1	106.005	129.505	122.705	6.905	6.905	20.005	149.005	140.155	83.305	56.855	59.55	0.715	0.305	42.005	16.255
19	NVSR 1054	108.505	141.505	113.505	8.005	8.005	23.605	146.005	191.055	120.705	70.355	62.965	0.965	0.405	46.005	20.255
20	R 2449-1032-1-462-1	118.505	127.505	104.805	6.205	6.205	20.205	146.505	93.905	80.205	13.705	85.34	0.725	0.305	41.005	13.005
21	ORB-1-BM-1	114.005	131.005	100.505	7.505	7.505	22.405	225.005	158.805	133.805	25.005	84.25	0.395	0.305	41.005	13.005
22	ORB-2-KM-3	116.005	131.505	115.905	6.505	6.505	22.605	178.505	171.305	138.505	32.805	80.895	0.785	0.305	42.005	29.005
23	TRC 395-2-4-2	102.005	130.005	115.805	6.105	6.105	24.605	153.005	120.355	99.305	21.055	82.525	0.835	0.405	42.505	26.505
24	TRC 138	111.005	129.505	117.805	5.605	5.605	23.105	165.505	200.555	121.205	79.355	60.445	1.735	0.405	41.505	21.505
25	HUR2302	114.005	143.005	100.905	8.005	8.005	20.705	143.505	141.305	82.505	58.805	58.32	0.705	0.305	46.505	23.255
26	TRC 171-2-5-1	114.005	128.505	99.305	6.805	6.305	24.505	198.005	204.305	135.505	68.805	66.43	0.895	0.405	45.005	23.005
27	Alsakar Mutant 19	113.005	126.505	73.205	6.605	6.605	22.005	244.005	134.005	126.005	8.005	94.035	0.815	0.405	44.505	23.505
28	JKOJM 300-584-5	113.505	142.505	98.805	6.905	6.905	23.705	161.505	172.855	156.705	16.155	90.61	0.845	0.305	41.505	28.505
29	R 2356-218-98-1	107.005	140.005	100.605	7.105	7.105	21.405	182.505	161.205	111.105	50.105	68.815	0.905	0.405	46.505	19.255
30	BRR2277	100.505	141.505	106.005	6.405	6.405	22.305	159.505	168.655	110.605	58.055	65.55	0.815	0.305	41.005	15.155
31	RNR 15435	97.505	135.505	122.905	7.005	7.005	23.005	158.005	192.055	159.305	32.755	82.95	1.025	0.305	44.005	21.005
32	JKOJM-300-158-11	118.505	146.505	86.205	7.205	7.205	22.805	154.505	217.505	153.405	64.105	70.425	0.865	0.305	40.505	25.005
33	OR 2621-18	103.505	143.505	105.205	5.705	5.705	21.605	164.505	222.255	172.005	50.255	77.38	0.565	0.405	46.005	15.755
34	ORB-3GM-4	113.005	139.505	97.505	7.005	7.005	23.305	175.005	219.005	155.805	63.205	71.16	0.655	0.305	45.505	17.255
35	Shobini	99.505	138.505	105.405	7.105	7.105	22.005	147.005	163.455	124.255	39.205	76.055	1.055	0.305	43.505	22.505
36	OR 2594-5	101.505	142.505	133.005	6.305	6.305	20.305	188.005	310.655	188.805	121.855	60.76	0.575	0.305	47.005	19.255
37	CR4448-1	99.505	123.505	105.705	6.505	6.505	22.805	145.005	234.405	164.005	70.405	69.975	0.815	0.305	47.505	17.855
38	BKR 405	100.505	123.505	106.905	6.005	6.005	25.305	156.505	131.405	99.905	31.505	76.05	0.835	0.305	45.505	18.255
39	HURS 22-6	99.505	145.505	104.23	5.905	5.905	18.605	195.005	226.555	153.305	73.255	67.68	0.885	0.405	44.505	20.255
40	TRC 308-1-3-5	99.505	127.505	106.105	6.205	6.205	22.405	140.505	193.405	155.005	38.405	80.12	0.745	0.405	47.005	22.505
Mean		107.34	135.57	103.55	6.71	6.67	22.26	168.29	172.74	126.54	46.21	74.23	0.83	0.35	44.23	19.24
CV		5.51	4.94	6.11	7.17	6.2	6.33	5.99	7.2	6.88	7.49	5.99	5.84	5.81	4.68	8.23

CEm	4.18	4.74	4.47	0.34	0.29	1	7.13	8.79	6.16	2.45	3.14	0.03	0.01	1.46	1.12
CD at 5%	11.96	13.56	12.8	0.97	0.84	2.85	20.39	25.15	17.61	7	8.99	0.1	0.04	4.18	3.2
CD at 1%	16.02	18.15	17.14	1.3	1.12	3.81	27.3	33.68	23.57	9.37	12.04	0.13	0.06	5.6	4.29
Minimum	92.01	122.51	67.21	5.61	5.61	16.61	130.51	92.31	53.51	7.91	49.2	0.4	0.31	40.51	10.76
Maximum	118.51	146.51	133.01	8.31	8.31	26.71	244.01	310.66	193.61	121.86	94.04	1.74	0.73	50.01	29.01

Table 4: Genotypes groups in respective clusters in rice.

Cluster No.	No. of genotypes	Genotypes
I	29	HUR2301, RP 6475-CGR 1-1-IL-1-2124-1-58-ASG, TRC 395-2-4-2, Jhilli Dhan Mutant 15-1, Narendra Vikram TCR, Dubraj Sel.1, AAU-KMJ DHAN-47, TRC 171-2-5-1, NVSR1054, Narendra Tilak Chandra, R 2449-1032-1-462-1, Alsakar Mutant 19, OR 2621-18, TPUR-K-02, Narendrajuhi Bengal, TRC 308-1-3-5, HURS 22-6, Badshabhog Sel.1, RNR 15435, CR4448-1, BRR2277, Ketekijoha, JKOJM-300-158-11, JR 14, ORB-1-BM-1,R 2356-218-98-1, ORB-3GM-4, TRC 138, and JKOJM-300-584-5
II	**7**	BKR 405, KAUPTB-TRV-EBC-14, BRR219, Narendra Vishnu Bhog, HUR2302, Shobini, CR 4448-2
III	1	ORB-2-KM-3
IV	1	ORB-2-KM-3
V	1	Vishunbhog
VI	1	BRR-0215

Table 5: Average intra and inter cluster distance.

Cluster	I	II	III	IV	V	VI
I	347.03					
II	897.61	293.92				
III	1179.31	3234.39	0.00			
IV	621.85	1264.41	1061.30	0.00		
V	1823.72	4186.73	404.54	1663.03	0.00	
VI	2427.09	952.89	5759.39	2739.13	6655.99	0.00

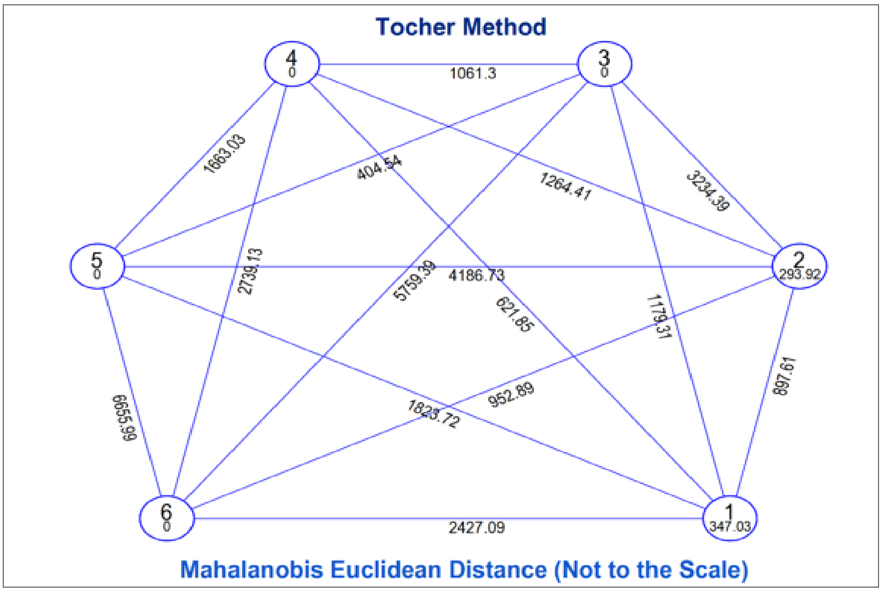

Fig 2: Intra and inter cluster distance of 40 non-Bamati rice genotypes in six cluster based on D^2 statistic (not the scle).

Table 6: Percentage contribution of various characters to diversity.

S. No.	Characters	Percentage Contribution %
1	Days to 50% flowering	2.3
2	Days to 80% maturity	4.5
3	Plant height (cm)	4.55
4	Number of tillers per plant	5.32
5	Number of panicles per plant	4.33
6	Panicle length (cm)	0.26
7	Number of panicles per sq. mt.	5.32
8	Number of grains per panicle	7.32
9	No. of Fertile Spikelets Per Panicle	0.26
10	No. of sterile spikelets per panicle	11.32
11	Spikelet fertility (%)	12.22
12	Grain length	7.89
13	Grain Width	13.36
14	Grain yield (q/ha)	15.67
15	Test weight (g)	5.38

Conclusion

The 40 genotypes were grouped into 6 clusters. The highest intra cluster distance was recorded in cluster I and the lowest intra-cluster distance in cluster II. The highest inter cluster distance was recorded cluster V and VI, and the lowest inter cluster distance was recorded between cluster III and V. It helps in the selection of divergent parents for their exploitation in hybridization programs quality characters have been widely used for descriptive purposes and are commonly used to distinguish plant varieties. Use of quality descriptors in sequential fashion is useful and convenient to discriminate the different varieties.

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