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Assessment of Genetic Diversity Using Metroglyph Analysis in Rice (*Oryza sativa* L.) Germplasm

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation was carried out to assess the genetic variability parameters, metroglyph analysis in 31 rice genotypes for 13 quantitative traits during *Kharif,2022* season at Field experimentation center, Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Uttar Pradesh using Randomized Block Design with three replications. Analysis of variance indicated high significant differences among the genotypes for all the traits. Considerable variability existed in the genotypes for all the characters studied. These were the genotypes with high mean values in desirable direction i.e., From the present investigation it is concluded that among 31 genotypes of rice, VASUMATHI showed Early flowering (80 days), and had characters like Early maturity (113days), DRR DHAN-38 showed high Plant height (155.8 cm), PUSA BASMATHI-1 showed high Panicle

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length (28.8 cm), NAGARJUNA is showing both high Biomass (69.3 g), and Grain Yield per Plant (39.7 g). Highest GCV were depicted for Grain Yield per Plant, Biological Yield per hill, Number of Spikelet's per panicle, Number of Panicles per hill, Number of Tillers per Hill, and Flag Leaf Width. The highest Heritability was observed for Number of Tillers per hill, Number of Spikelet's per Panicle, Grain yield per plant, Number of Panicles per hill, Biological Yield per Hill and Flag Leaf Width and Highest genetic advance as a percentage of mean except Plant height, Grain yield per plant, Biological yield per hill, Number of spikelet's per panicle, Number of panicles per hill, Number of total tillers, Flag leaf width and harvest index. A scatter diagram was created for 31 genotypes that formed five complexes with 13,9,4,4 and 1 genotype in each complex. The genotypes Nagarjuna, Jarva and NDR-359, which have a high index score and fall into various clusters, can be utilized as parents in hybridization to get the most variety in character combinations. This character should be given due consideration during selection for crop improvement.

Keywords: Genetic diversity; variability; metroglyph in rice.

1. INTRODUCTION

Rice (O*ryza sativa* L.) is one of the staple cereal crops of the world and it is one of the main sources of carbohydrate for nearly one half of the world population. It meets the calorie requirement of 50 percent of the population and provides livelihood to 160 million of rural poor [1].

Rice (*Oryza sativa* L.) belongs to the family Poaceae, chromosome number is 2n=24. It is probably a descendent of wild grass that was most likely cultivated in the foothills of the far Eastern Himalayas. Roughly one-half of the world population, including virtually all of the East and Southeast Asia, is mostly dependent upon rice as a staple food. It is eaten alone and in a great variety of soups, side dishes, and main dishes in Asian, Middle Eastern, and many other cuisines and other products in which rice is used as breakfast cereals, noodles, and such beverages [2-5].

The selection of parents for hybridization is very important for success of any breeding programme. The parents involved in the development in varieties should be divergent. The germplasm provides immense scope for wide variability. Crop improvement programme depends on nature and magnitude of genetic diversity present among the genotypes. Rice yield is a complex quantitative character. Selection of parents based only on yield is often misleading. Hence, it is very important to know about relationship between yield and its contributing characters is needed for an efficient selection strategy for the plant breeders to evolve an economic variety. The information about phenotypic and genotypic interactions of various economic traits is of immense importance to a plant breeder for the selection and breeding of different genotypes for increasing yield potential. Genetic divergence is an efficient tool for selection of parent for hybridization programme. Such study also include selection of the genetically divergent parents to obtain desirable combinations. Information about degree of genetic divergence and nature would help the plant breeder's in choosing the right parent for the breeding programme (Vivekananda and Subramanian, 1993) [6-8].

This study was undertaken to run a classificatory analysis on the rice genotypes by means of metroglyph statistic, which will enable us to classify the available germplasm into distinct clusters based on their genetic diversity. This information, thus obtained, will be helpful to develop an effective rice-breeding programme.

1.1 Objectives

1. To study genetic variability among 31 rice (*Oryza sativa* L.) genotypes for yield
2. To assess genetic divergence through Metroglyph analysis among 31 rice (*Oryza sativa* L.) genotypes for yield
3. To identify divergent parents for future hybridization programme

2. MATERIALS AND METHODS

The experiment was carried out at the Field Experimental Centre of the Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences,

Table 1. The details of experimental material used in the research

Sr.no	Genotype	SR.NO	Genotype
1	SAMPADA	17	KRISHNA HAMSA
2	NAGARJUNA	18	DRR DHAN-69
3	SURAKSHA	19	DRR DHAN-58
4	DRR DHAN-57	20	BINA DHAN-17
5	MANDHYA VIJAYA	21	VASUMATI
6	JARAVA	22	SALIVAHANA
7	NEDHI	23	DRR DHAN-47
8	DRR DHAN-46	24	DRR DHAN-38
9	DRR DHAN-53	25	VIKRAMARYA
10	DRR DHAN-62	26	VIKAS
11	BINA DHAN-10	27	DRR DHAN-55
12	DRRH-3	28	DRR DHAN-39
13	DRR DHAN-54	29	DRR DHAN-60
14	DRR DHAN-52	30	PUSA BASMATHI
15	PHALGUNA	31	NDR-359 (CHECK)
16	GAUTAM		

Prayagraj, U.P. during *Kharif* 2022. The site of experiment is located at 25.57^0N latitude, 81.56^0N longitude and 98 metres above mean sea level. This region has subtropical climate with extreme of summer and winter. The temperature falls as low as 1°C-2°C during Rabi season especially in the month of December and January. The mercury rises up to 46°C-48°C during Zaid. The average rainfall in this area is around 1013.4 mm annually with maximum concentration in kharif during July to September with few showers and drizzles during winter also.

The 31 rice genotypes were grown in kharif-2022 adopting Randomized Block Design with three replications each under lowland conditions. In kharif-2022 nursery sowing for all the genotypes of rice was done on 21 June 2022 and transplanted in field after 30 days i.e., on 21 July 2022. Each genotype was planted in a row of 3 meter in length with 3 replications. A spacing of 20 cm between rows and 15 cm between plants were given and the crop was raised as per the recommended package of practice and observations were recorded on randomly selected five plants for 13 quantitative traits *viz* Days to 50% Flowering, Days to Maturity, Plant Height, Flag Leaf Length, Flag Leaf Width, Number of Total tillers Number of Productive Tillers, Panicle Length (cm), Biomass (g), Harvest Index, Number of Grains per Panicle, Test Weight (g) , Grain Yield per Plant (g). The Panse and Sukhatme (1967) method were used to analyse the variance in all of the recorded data for the characters under consideration. Additionally, the genetic parameters genotypic coefficient of variation (GCV), Phenotypic coefficient of varation (PCV), Heritability in the broad sense, Genetic advance as percent of mean and Metroglyph was carried out by using the statistical methods. The additional components of variance include evenly for Phenotypic variance and Genotypic variance.

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The Software called “R – Language” was used to perform the analysis mentioned above.

2.1 Experimental Material

The experimental material for present study is obtained from ICAR-Indian Institute of Rice Research. The details of experimental material are as follows Table 1.

3. RESULTS AND DISCUSSION

3.1 Analysis of Variance

Analysis of variance for all parameters recorded in 31 rice genotypes is presented in Table 2 indicating the mean sum of squares due to replications, varieties and error for thirteen characters studied. The analysis of variance indicated the presence of sample variability in the experiment material and disclosed significant differences among the genotypes for all characters studied *viz.,* days to fifty percent flowering, plant height(cm), flag leaf length (cm), flag leaf width (cm), number of tillers per plant, number of panicles per plant, number of Spikelet’s per panicle, panicle length (cm), grains per panicle, days to maturity, Biological yield per hill (g), test weight(g), harvest index (%) and grain yield per plant(g). Highly significant mean

squares due to genotypes were observed for all traits, indicating the existence of sufficient variation among the genotypes for yield and yield component characters studied in the present investigation, and therefore, there is a scope for effective selection.

Based on mean performance, the highest Grain Yield per Plant per hill was observed for rice genotypes NAGARJUNA (39.7 g), MANDHYA VIJAYA (32.1 g), DHAN-2 (29.8 g), and DHAN-57 (25.9 g). were found to be superior in Grain Yield per Plant [9-12].

3.2 Estimation of Genotypic and Phenotypic Coefficient of Variation

GCV and PCV investigations revealed a large degree of variance and the influence of the environment on the expression of these features. PCV had a larger magnitude than GCV for all traits, which could be attributable to a higher degree of genotype-environment interaction [13].

The characters studied in the present investigation exhibited low (less than 10%), moderate (10-20%) and high (more than 20%) phenotypic and genotypic coefficient of variation.

The estimates of GCV and PCV from present investigation are presented in Table 4. Among the 13 quantitative characters, high estimates of GCV were recorded highest for Grain Yield per Plant (31.3) followed by Biological Yield per Hill (23.4) Number of Spikelet's per Panicle (21), Number of Panicles per hill (19.6), Number of Tillers per hill (18.4). Moderate estimates of GCV were recorded for Flag Leaf Width (14.9) followed by Harvest Index (12.8), Flag Leaf Length (12.2) and Days to 50% flowering (11.1). Low estimation of GCV were recorded for Panicle Length (7.2), Days to Maturity (7.6), Test Weight (8) and Plant Height (10.4).

Among the 13 quantitative characters, high estimates of PCV and were recorded highest for Grain Yield per Plant (33.6) followed by Biological Yield per Hill (25.3), Number of Spikelet's per Panicle (22.4), Number of Panicles per hill (21.1), Number of Tillers per hill (19.5). Moderate estimates of PCV were recorded for Flag Leaf Width (16.3) followed by Harvest Index (15.3), Flag Leaf Length (15.1) and Days to 50% flowering (12.1). Low estimation of PCV were recorded for Panicle Length (9.2), Days to Maturity (9.2), Test Weight (11.4) and Plant Height (11.7).

Highest GCV and PCV were depicted for Grain Yield per Plant followed by Biological Yield per Hill, Number of Spikelet's per Panicle, Number of Panicles per hill and Number of Tillers per hill [14-16].

3.3 Heritability

Estimates of genotypic coefficient of variation indicate the total amount of genotypic variability, with heritability reflecting the fraction of this genotypic variability transferred from parents to progeny. Broad sense heritability is the ratio of genotypic variance (VG) to phenotypic variance (VP). It dictates how well we may use genotypic variability in a breeding program. Burton [17] proposed that genetic variation combined with heritability would provide a better indication of projected selection effectiveness. As a result, a character with a high GCV and high heritability is beneficial in a selection procedure.

The estimates of heritability from present investigation are presented in Table 4. In the present study, heritability (broad sense) ranged from 49.4% to 88.3%. The highest heritability (above 60%) was observed for Number of Tillers per hill (88.3%) followed by Number of Spikelet's per Panicle (88.1%), Grain yield per plant (86.7%), Number of Panicles per hill (86.3%), Biological Yield per Hill (85.4%) and Flag Leaf Width (84%), Days to 50% Flowering (82.4%), Plant Height (79.5%), Harvest Index (69.3%), Days to Maturity (68.2%), Flag Leaf Length (65.1%), Panicle length (61.6%) and the lower heritability showed for Test Weight (49.4%). A higher value for heritability indicates that it may be due to higher contribution of genotypic components.

The traits with high heritability estimates showed that variation in these traits predominantly governed by heritable factors, whereas both genetics and environment played equivalent roles in the expression of traits with moderately high heritability indicated that the expression of the trait was mostly influenced by genetic rather than environment. Traits with high heritability estimates in broad sense can be utilized for genetic improvement as they are least influenced by the environmental effects and thus having a potential for large genetic determination [16,18].

Table 2. Analysis of variance of 13traits in 31 promising rice lines

Sr.No.	Trait	Mean sum of squares		
		Replication	Treatment	Error
	Degrees of freedom	2	30	60
1	Days to 50% flowering	12.87	359.4**	23.87
2	Days to maturity	52.48	338.5**	45.52
3	Plant height	6.536	596**	47.22
4	Flag leaf length	24.54	68.7**	10.43
5	Flag leaf width	0.011	0.091**	0.01
6	Panicle length	0.72	11.66**	2.01
7	Number of tillers per hill	0.75	8.88**	0.38
8	Number of panicles per hill	0.89	8.93**	0.45
9	Number of spikelet's per panicle	211.03	245.58**	105.78
10	Biological yield per hill	33.2	308.16**	16.66
11	Test weight	7.079	13.7**	3.49
12	Harvest Index	30.39	118.74**	15.26
13	Grain yield per plant	11.3	117.11**	5.68

***indicates significance at 1%*

Table 3. Mean Perfrmance of 13 traits in 31 promising rice lines

Sl. No.	Genotypes	DF50	DM	PH	FLL	FLW	PL	NTT	NPH	NSPP	BYPH	TW	HI	GY
1	**SAMPADA**	109.333	142.333	127.2	34.133	1.143	24.333	9.533	9.867	155.867	43.8	20.6	48.427	21.067
2	**NAGARJUNA**	106	139	151.4	30.073	1.167	23.68	11.533	11.533	127	69.267	22	56.187	39.667
3	**SURAKSHA**	97	130	123.733	42.3	1.15	25.1	9.667	8.933	138.667	43.667	23.833	49.833	21.733
4	**DHAN – 57**	82	115	139	33.8	1.093	24.567	8.733	8.467	165.533	45.333	24.333	57.153	25.867
5	**MANDHYA VIJAYA**	106	139	152.933	29.427	1.137	23.933	9.6	9.133	175.933	62.533	25	49.707	32.133
6	**JARAVA**	110	143	134.687	42.92	1.07	23.6	10.667	9.933	106.733	52.667	26.667	47.813	24.733
7	**PUSA BASMATHI-1**	105	138	138.967	40.9	1.22	28.753	9.133	7.333	105	51.333	22.333	37.067	18.467
8	**DHAN - 46**	81	114	135.767	35.267	1.15	26.167	9.2	8.533	143.733	42.467	24.667	45.157	20.4
9	**DHAN – 53**	92	125	108.333	28.967	1.153	21.3	9.667	9.067	132	31.6	20.333	42.243	13.333
10	**DHAN – 62**	82	115	111.067	30.633	1.07	22.8	9.533	9.2	134.533	36.667	20	42.177	14.8
11	**BINA DHAN – 10**	84	125	125.433	33.8	1.123	26.033	9.533	9	84.133	35.333	27.333	53.353	18.6
12	**DRRH – 3**	106	139	124.467	38.967	1.343	23.633	7.867	7.6	197.133	48.667	20.9	40.42	19.8

Sl. No.	Genotypes	DF50	DM	PH	FLL	FLW	PL	NTT	NPH	NSPP	BYPH	TW	HI	GY
13	**DHAN – 54**	92	125	152.053	37.933	1.153	24.767	7.2	7.067	147.267	35.6	24.2	45.707	16.133
14	**DHAN – 52**	96.667	129.667	150.267	37.267	1.213	23.833	7	7	131.533	38.733	26.333	43.533	16.533
15	**PHALGUNA**	96	129	111.94	44.033	1.383	25.6	8.6	8.067	113.067	45.733	25	34.193	16.467
16	**GAUTAM**	82.667	115.667	113.213	36.967	1	25.367	8.867	8.667	106.4	33.467	21.933	48.353	16.067
17	**KRISHNA HAMSA**	86	119	113.747	36.533	0.963	26.4	10.933	10.267	112.733	38.933	22.733	42.36	15.253
18	**DHAN – 69**	85	140	123.947	32.667	1.143	23.047	7.6	7.267	158.933	37.267	22.267	59.26	22
19	**DHAN – 58**	85	118	114.4	28.833	1.327	21.287	9.067	8.333	144	34.133	18.2	43.14	14.8
20	**NIDHI**	106	139	122.833	44.533	0.94	26.847	11.4	11.067	107.267	53.4	23.333	37.147	20.933
21	**BINA DHAN-17**	91.667	124.667	135.467	35.993	1.023	26.147	8.933	7.933	115.8	35.267	20.333	47.553	17.4
22	**VASUMATHI**	79.667	112.667	147.007	39.313	0.88	28.467	9.267	8.533	107.333	40.8	20.833	46.253	18.533
23	**SALIVAHANA**	114	147	135.767	37.787	1.117	24.64	7	5.667	134.133	33.2	21	39.53	12.533
24	**DHAN-47**	89.333	122.333	132.753	38.48	0.907	23.527	8.933	7.667	128.2	31.267	23	52.7	16.267
25	**D.DHAN-38**	95.667	128.667	155.76	36.053	1.093	25.993	9.333	9.333	157.133	58.2	22.167	47.007	29.8
26	**VIKRAMARYA**	84.667	117.667	119.4	38.993	1.047	23.24	6.733	5.933	100.6	27.133	24.333	48.947	12.667
27	**VIKAS**	116.667	149.667	126.247	43.793	1.07	25.253	8.2	8.133	105.733	35.867	22.333	34.267	12.533
28	**DHAN-55**	107.333	140.333	130.093	32.513	0.97	23.927	9.533	9.2	130.467	47.467	25.667	51.46	24.4
29	**D.DHAN-39**	94.667	127.667	130.847	32.487	1.127	28.433	8.4	6.8	114.067	40.4	23.333	45.42	18.2
30	**DHAN-60**	98.667	131.667	106.333	27.28	1.173	22.1	7	5.933	134.267	26.867	23.667	41.38	10.8
31	**NDR-359 (Check)**	105	131	125	35.81	1.833	27.967	15.6	14.003	210.6	51.497	23.107	49.52	22.663
Mean		95.71	129.45	129.68	36.08	1.13	24.86	9.17	8.56	133.09	42.21	22.96	46.04	19.5
Minimum		79.67	112.67	106.33	27.28	0.88	21.29	6.73	5.67	84.13	26.87	18.2	34.19	10.8
Maximum		116.67	149.67	155.76	44.53	1.83	28.75	15.6	14	210.6	69.27	27.33	59.26	39.67
CV		5.1	5.21	5.3	8.95	6.5	5.7	6.69	7.84	7.73	9.67	8.13	8.48	12.22
Sem		2.82	3.9	3.97	1.86	0.04	0.82	0.35	0.39	5.94	2.36	1.08	2.26	1.38
CD at 5%		7.98	11.02	11.22	5.27	0.12	2.31	1	1.1	16.8	6.67	3.05	6.38	3.89
CD at 1%		10.61	14.65	14.93	7.02	0.16	3.08	1.33	1.46	22.34	8.87	4.06	8.48	5.17

DF50: *Days to 50% flowering,* ***DM:*** *Days to maturity,* ***FLL:*** *Flag leaf length (cm),* ***FLW:*** *Flag leaf width (cm)****, PH:*** *Plant height (cm)****, NTT:*** *Number of total tillers,* ***NPH****: Number of Panicles per Hill,* ***PL:*** *Panicle length (cm),* ***NGPP****: Number of Grains per panicle,* ***BM:*** *Biological yield per hill (g),* ***HI:*** *Harvest index (%),****TW:*** *Test weight (g),* ***GYPP:*** *Grain yield per plant per plant (g)*

3.4 Genetic Advance

Genetic advance is defined as an increase in the mean of selected families over the base population [17]. However, a character with high heritability may not result in strong genetic advance. To arrive at a more solid result, Johnson et al. [17] shown that high heritability should be combined with high genetic progress. The interpretation of the type of gene activity involved in the development of distinct polygenic features is aided by the evaluation of genetic progress. Additive gene action and non-additive gene action are indicated by high and low genetic progress values, respectively.

In the present study a perusal of genetic advance (Table 4) showed that it was high for Number of Spikelet's per Panicle (54.1%) followed by Plant Height (24.8), Days to 50% Flowering (19.8) and Biological Yield per Hill (18.8) respectively [19].

3.5 Genetic Advance as Percent Mean

Heritability does not alone provide any indication of the amount of genetic improvement that would result from the selection of individual genotypes. Thus, to arrive at more reliable conclusion high heritability should be accompanied by high genetic advance [17]. Thus, knowledge of heritability and genetic advance of the character indicate the scope for the improvement through selection. In the present investigation, high genetic gain was recorded for Grain Yield per Plant (60%), Biological Yield per Hill (44.4%), Number of Spikelet's per Panicle (40.6%), Number of Panicles per hill (37.6%), Number of Total Tillers (35.6%), Flag Leaf Width (28.2%), Harvest Index (21.9%), Days to 50% Flowering (20.7), Flag Leaf Length (20.3%) [20].

3.6 Metroglyph Analysis

Metroglyph analysis is a semi graphical method for assessing the pattern of morphological variation in germplasm lines. The results obtained on Metroglyph analysis in 31 rice germplasm lines are presented in following lines.

The range of variability, index scores and signs used for 13 characters for metroglyph analysis were presented in Table 5. It was observed that maximum variability was in Number of Spikelet's per Panicle (84.13-210.6) followed by Plant Height (106.33-155.76), Days to Maturity (112.67-149.67), Days to 50% Flowering (79.67-116.67), Biological Yield per Hill (26.87-69.27), Harvest Index (34.19-59.26). The range of mean values were utilized to assess the index score 1, 2 and 3 for all the characters studied. The simple circle without rays represents index score 1, while other with values for index score 2 and 3 have short and long rays on respective circle in different directions, respectively. The mean performance and total index score of 31 genotypes are presented in Table 6. The total index score was varied from 19 (DHAN-60 and Vikramarya) to 31 (Nagarjuna, Jarva and NDR-359). The highest total index score of 31 was recorded in three germplasm line (Nagarjuna, Jarva and NDR-359) followed by total index score 29 recorded in (Mandhya Vijaya, Nidhi, D.

Table 4. Genetic parameters of 13 quantitative traits in rice genotypes

Sl.No.	Characters	GCV	PCV	h2	GA 5%	Gen.Adv as% Of mean 5%
1	Days to 50% flowering	11.1	12.2	82.4	19.8	20.7
2	Days to maturity	7.6	9.2	68.2	16.8	13.0
3	Plant height	10.4	11.7	79.5	24.8	19.2
4	Flag leaf length	12.2	15.1	65.1	7.3	20.3
5	Flag leaf width	14.9	16.3	84.0	0.3	28.2
6	Panicle length	7.2	9.2	61.6	2.9	11.7
7	Number of tillers per hill	18.4	19.5	88.3	3.3	35.6
8	Number of panicles per hill	19.6	21.1	86.3	3.2	37.6
9	Spikelet's per panicle	21.0	22.4	88.1	54.1	40.6
10	Biological Yield per plant	23.4	25.3	85.4	18.8	44.4
11	Test weight	8.0	11.4	49.4	2.7	11.6
12	Harvest Index	12.8	15.3	69.3	10.1	21.9
13	Grain yield per plant	31.3	33.6	86.7	11.7	60.0

***GCV:** Genotypic Coefficient of Variation**, PCV:** Phenotypic Coefficient of Variation**, h2:** Heritability**, GA% of Mean:** Genetic Advance at percent of mean*

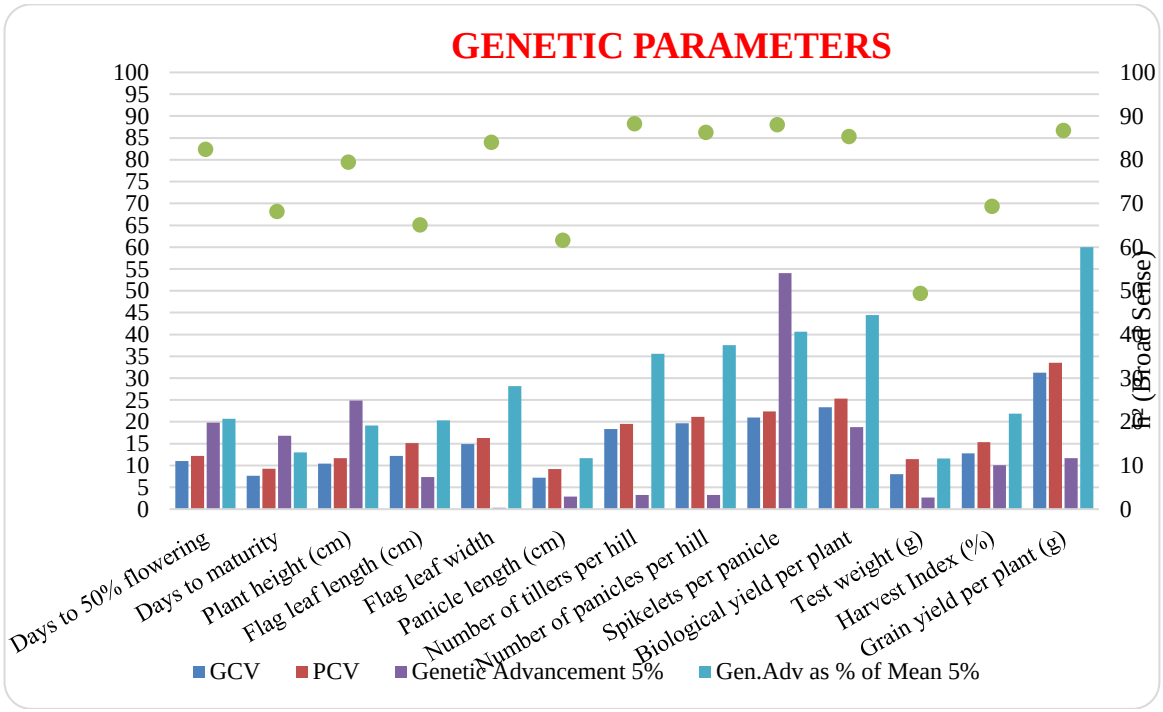

Fig. 1. Histrogram depicting GCV, PCV, heritability and genetic advance for 13 quantitative characters of rice

Dhan-38 and Dhan-55) and total index score of 28 was recorded in DRRH-3. Minimum frequency of genotypes 1occured for index score 29 and 31. The scatter diagram has been prepared by taking Spikelet's per panicle on x-axis and plant height on y-axis and five complexes could be distinguished on the basis of morphological variation. (Table 7 and Fig. 2).

The frequency diagram (Fig. 3) showed index score for 13 characters of 31 genotypes revealed that the index scores ranged from 19-31. Maximum frequency of genotypes 7 occurred for index score of 26 and 27 followed by minimum frequency of genotypes 1 occurred for index score of 20,21,22 and 28.

Table 5. Index scores and signs used for characters for Metroglyph analysis of 31 genotypes of rice

Sl.No.	Character	Range of Mean	Score 1	Sign	Score 2	Sign	Score 3	Sign
			Value <		Value from - to		Value >	
1	Days to 50% flowering	79.67-116.67	84.76	O	84.76-106.66		106.66	
2	Days to maturity	112.67-149.67	118.83	O	118.83-140.07		140.07	
3	Plant height (cm)	106.33-155.76	115.58	O	115.58-143.77	O	143.77	O
4	Flag leaf length (cm)	27.28-44.53	31.29	O	31.29-40.87		40.87	
5	Flag leaf width	0.88-1.83	0.96	O	0.96-1.31		1.31	
6	Panicle length (cm)	21.29-28.75	22.89	O	22.89-26.83		26.83	
7	Number of tillers per hill	6.73-15.6	7.45	O	7.45-10.89		10.89	
8	Number of panicles per hill	5.67-14	6.84	O	6.84-10.29		10.29	
9	Spikelets per panicle	84.13-210.6	104.51	O	104.51-161.67	O	161.67	O
10	Biological yield per plant	26.87-69.27	32.08	O	32.08-52.35		52.35	
11	Test weight (g)	18.2-27.33	20.82	O	20.82-25.1		25.10	
12	Harvest Index (%)	34.19-59.26	39.75	O	39.75-52.33		52.33	
13	Grain yield per plant (g)	10.8-39.67	13.25	O	13.25-25.75		25.75	

DFF: *Days to 50% flowering,* ***DM:*** *Days to maturity,* ***FLL:*** *Flag leaf length (cm),* ***FLW:*** *Flag leaf width (cm),* ***PH:*** *Plant height (cm),* ***NTT:*** *Number of total tillers per plant,* ***NPT:*** *Number of Productive tillers per plant,* ***PL:*** *Panicle length (cm),* ***NSP****: Number of Spikelet's per panicle,* ***BY:*** *Biological Yield per Hill (g),* ***HI:*** *Harvest Index* ***TW:*** *Test weight (g),* ***HI:*** *Harvest index (%),* ***GYP:*** *Grain yield per plant (g)*

Table 6. Mean and index score for 13 quantitative traits for 31 rice genotypes

Sl.No.	Genotypes	Days to 50% flowering	Days to maturity	Plant height (cm)	Flag leaf length (cm)	Flag leaf width	Panicle length (cm)	Number of tillers per hill	Number of panicles per hill	Spikelet's per panicle	Biological yield per plant	Test weight (g)	Harvest Index (%)	Grain yield per plant (g)	Total Index Score
1	SAMPADA	109.33 (3.00)	142.33 (3.00)	127.2 (2.00)	34.13 (2.00)	1.14 (2.00)	24.33 (2.00)	9.53 (2.00)	9.87 (2.00)	155.87 (2.00)	43.8 (2.00)	20.6 (1.00)	48.43 (2.00)	21.07 (2.00)	27
2	NAGARJUNA	106 (2.00)	139 (2.00)	151.4 (3.00)	30.07 (1.00)	1.17 (2.00)	23.68 (2.00)	11.53 (3.00)	11.53 (3.00)	127 (2.00)	69.27 (3.00)	22 (2.00)	56.19 (3.00)	39.67 (3.00)	31
3	SURAKSHA	97 (2.00)	130 (2.00)	123.73 (2.00)	42.3 (3.00)	1.15 (2.00)	25.1 (2.00)	9.67 (2.00)	8.93 (2.00)	138.67 (2.00)	43.67 (2.00)	23.83 (2.00)	49.83 (2.00)	21.73 (2.00)	27
4	DHAN – 57	82 (1.00)	115 (1.00)	139 (2.00)	33.8 (2.00)	1.09 (2.00)	24.57 (2.00)	8.73 (2.00)	8.47 (2.00)	165.53 (3.00)	45.33 (2.00)	24.33 (2.00)	57.15 (3.00)	25.87 (3.00)	27
5	MANDHYA VIJAYA	106 (2.00)	139 (2.00)	152.93 (3.00)	29.43 (1.00)	1.14 (2.00)	23.93 (2.00)	9.6 (2.00)	9.13 (2.00)	175.93 (3.00)	62.53 (3.00)	25 (2.00)	49.71 (2.00)	32.13 (3.00)	29
6	JARAVA	110 (3.00)	143 (3.00)	134.69 (2.00)	42.92 (3.00)	1.07 (2.00)	23.6 (2.00)	10.67 (2.00)	9.93 (2.00)	106.73 (2.00)	52.67 (3.00)	26.67 (3.00)	47.81 (2.00)	24.73 (2.00)	31
7	PUSA BASMATHI-1	105 (2.00)	138 (2.00)	138.97 (2.00)	40.9 (3.00)	1.22 (2.00)	28.75 (3.00)	9.13 (2.00)	7.33 (2.00)	105 (2.00)	51.33 (2.00)	22.33 (2.00)	37.07 (1.00)	18.47 (2.00)	27
8	DHAN - 46	81 (1.00)	114 (1.00)	135.77 (2.00)	35.27 (2.00)	1.15 (2.00)	26.17 (2.00)	9.2 (2.00)	8.53 (2.00)	143.73 (2.00)	42.47 (2.00)	24.67 (2.00)	45.16 (2.00)	20.4 (2.00)	24
9	DHAN – 53	92 (2.00)	125 (2.00)	108.33 (1.00)	28.97 (1.00)	1.15 (2.00)	21.3 (1.00)	9.67 (2.00)	9.07 (2.00)	132 (2.00)	31.6 (1.00)	20.33 (1.00)	42.24 (2.00)	13.33 (2.00)	21
10	DHAN – 62	82 (1.00)	115 (1.00)	111.07 (1.00)	30.63 (1.00)	1.07 (2.00)	22.8 (1.00)	9.53 (2.00)	9.2 (2.00)	134.53 (2.00)	36.67 (2.00)	20 (1.00)	42.18 (2.00)	14.8 (2.00)	20
11	BINA DHAN - 10	84 (1.00)	125 (2.00)	125.43 (2.00)	33.8 (2.00)	1.12 (2.00)	26.03 (2.00)	9.53 (2.00)	9 (2.00)	84.13 (1.00)	35.33 (2.00)	27.33 (3.00)	53.35 (3.00)	18.6 (2.00)	26
12	DRRH – 3	106 (2.00)	139 (2.00)	124.47 (2.00)	38.97 (2.00)	1.34 (3.00)	23.63 (2.00)	7.87 (2.00)	7.6 (2.00)	197.13 (3.00)	48.67 (2.00)	20.9 (2.00)	40.42 (2.00)	19.8 (2.00)	28
13	DHAN – 54	92 (2.00)	125 (2.00)	152.05 (3.00)	37.93 (2.00)	1.15 (2.00)	24.77 (2.00)	7.2 (1.00)	7.07 (2.00)	147.27 (2.00)	35.6 (2.00)	24.2 (2.00)	45.71 (2.00)	16.13 (2.00)	26
14	DHAN – 52	96.67 (2.00)	129.67 (2.00)	150.27 (3.00)	37.27 (2.00)	1.21 (2.00)	23.83 (2.00)	7 (1.00)	7 (2.00)	131.53 (2.00)	38.73 (2.00)	26.33 (3.00)	43.53 (2.00)	16.53 (2.00)	27
15	PHALGUNA	96 (2.00)	129 (2.00)	111.94 (1.00)	44.03 (3.00)	1.38 (3.00)	25.6 (2.00)	8.6 (2.00)	8.07 (2.00)	113.07 (2.00)	45.73 (2.00)	25 (2.00)	34.19 (1.00)	16.47 (2.00)	26
16	GAUTAM	82.67 (1.00)	115.67 (1.00)	113.21 (1.00)	36.97 (2.00)	1 (2.00)	25.37 (2.00)	8.87 (2.00)	8.67 (2.00)	106.4 (2.00)	33.47 (2.00)	21.93 (2.00)	48.35 (2.00)	16.07 (2.00)	23
17	KRISHNA HAMSA	86 (2.00)	119 (2.00)	113.75 (1.00)	36.53 (2.00)	0.96 (2.00)	26.4 (2.00)	10.93 (3.00)	10.27 (2.00)	112.73 (2.00)	38.93 (2.00)	22.73 (2.00)	42.36 (2.00)	15.25 (2.00)	26
18	DHAN - 69	85 (2.00)	140 (2.00)	123.95 (2.00)	32.67 (2.00)	1.14 (2.00)	23.05 (2.00)	7.6 (2.00)	7.27 (2.00)	158.93 (2.00)	37.27 (2.00)	22.27 (2.00)	59.26 (3.00)	22 (2.00)	27
19	DHAN - 58	85 (2.00)	118 (1.00)	114.4 (1.00)	28.83 (1.00)	1.33 (3.00)	21.29 (1.00)	9.07 (2.00)	8.33 (2.00)	144 (2.00)	34.13 (2.00)	18.2 (1.00)	43.14 (2.00)	14.8 (2.00)	22
20	NIDHI	106 (2.00)	139 (2.00)	122.83 (2.00)	44.53 (3.00)	0.94 (1.00)	26.85 (3.00)	11.4 (3.00)	11.07 (3.00)	107.27 (2.00)	53.4 (3.00)	23.33 (2.00)	37.15 (1.00)	20.93 (2.00)	29
21	BINA DHAN-17	91.67 (2.00)	124.67 (2.00)	135.47 (2.00)	35.99 (2.00)	1.02 (2.00)	26.15 (2.00)	8.93 (2.00)	7.93 (2.00)	115.8 (2.00)	35.27 (2.00)	20.33 (1.00)	47.55 (2.00)	17.4 (2.00)	25
22	VASUMATHI	79.67 (1.00)	112.67 (1.00)	147.01 (3.00)	39.31 (2.00)	0.88 (1.00)	28.47 (3.00)	9.27 (2.00)	8.53 (2.00)	107.33 (2.00)	40.8 (2.00)	20.83 (2.00)	46.25 (2.00)	18.53 (2.00)	25
23	SALIVAHANA	114 (3.00)	147 (3.00)	135.77 (2.00)	37.79 (2.00)	1.12 (2.00)	24.64 (2.00)	7 (1.00)	5.67 (1.00)	134.13 (2.00)	33.2 (2.00)	21 (2.00)	39.53 (1.00)	12.53 (1.00)	24
24	DHAN-47	89.33 (2.00)	122.33 (2.00)	132.75 (2.00)	38.48 (2.00)	0.91 (1.00)	23.53 (2.00)	8.93 (2.00)	7.67 (2.00)	128.2 (2.00)	31.27 (1.00)	23 (2.00)	52.7 (3.00)	16.27 (2.00)	25
25	D.DHAN-38	95.67 (2.00)	128.67 (2.00)	155.76 (3.00)	36.05 (2.00)	1.09 (2.00)	25.99 (2.00)	9.33 (2.00)	9.33 (2.00)	157.13 (2.00)	58.2 (3.00)	22.17 (2.00)	47.01 (2.00)	29.8 (3.00)	29
26	VIKRAMARYA	84.67 (1.00)	117.67 (1.00)	119.4 (2.00)	38.99 (2.00)	1.05 (2.00)	23.24 (2.00)	6.73 (1.00)	5.93 (1.00)	100.6 (1.00)	27.13 (1.00)	24.33 (2.00)	48.95 (2.00)	12.67 (1.00)	19
27	VIKAS	116.67 (3.00)	149.67 (3.00)	126.25 (2.00)	43.79 (3.00)	1.07 (2.00)	25.25 (2.00)	8.2 (2.00)	8.13 (2.00)	105.73 (2.00)	35.87 (2.00)	22.33 (2.00)	34.27 (1.00)	12.53 (1.00)	27
28	DHAN-55	107.33 (3.00)	140.33 (3.00)	130.09 (2.00)	32.51 (2.00)	0.97 (2.00)	23.93 (2.00)	9.53 (2.00)	9.2 (2.00)	130.47 (2.00)	47.47 (2.00)	25.67 (3.00)	51.46 (2.00)	24.4 (2.00)	29
29	D.DHAN-39	94.67 (2.00)	127.67 (2.00)	130.85 (2.00)	32.49 (2.00)	1.13 (2.00)	28.43 (3.00)	8.4 (2.00)	6.8 (1.00)	114.07 (2.00)	40.4 (2.00)	23.33 (2.00)	45.42 (2.00)	18.2 (2.00)	26
30	DHAN-60	98.67 (2.00)	131.67 (2.00)	106.33 (1.00)	27.28 (1.00)	1.17 (2.00)	22.1 (1.00)	7 (1.00)	5.93 (1.00)	134.27 (2.00)	26.87 (1.00)	23.67 (2.00)	41.38 (2.00)	10.8 (1.00)	19
31	NDR-359 (Check)	105 (2.00)	131 (2.00)	125 (2.00)	35.81 (2.00)	1.83 (3.00)	27.97 (3.00)	15.6 (3.00)	14 (3.00)	210.6 (3.00)	51.5 (2.00)	23.11 (2.00)	49.52 (2.00)	22.66 (2.00)	31

Table 7. Genotypes in different complex in Metroglyph analysis

Complex	Name of complex	No. of lines	Name of lines	Range and average score
I	Low Spikelet's per panicle with lower plant height	13	DHAN - 53, DHAN - 62, PHALGUNA, GAUTAM, KRISHNA HAMSA, DHAN - 58, NIDHI, DHAN-47, VIKRAMARYA, VIKAS, DHAN-55, D. DHAN-39 and DHAN-60	19.00-29.00 (21.00)
II	High Spikelet's per panicle with higher plant height	9	NAGARJUNA, SURAKSHA, DHAN - 57, MANDHYA VIJAYA, DHAN - 46, DHAN - 54, DHAN - 52, SALIVAHANA, D. DHAN-38	24.00-31.00 (27.11)
III	Low Spikelet's per panicle with higher plant height	4	JARAVA, PUSA BASMATHI-1, BINA DHAN-17, VASUMATHI	25.00-31.00 (27.00)
IV	Higher Spikelet's per panicle with lower plant height	4	SAMPADA, DRRH-3, DHAN - 69, NDR-359 (Check)	27.00-31.00 (28.25)
V	Moderate Spikelet's per panicle with moderate plant height	1	BINA DHAN – 10	26

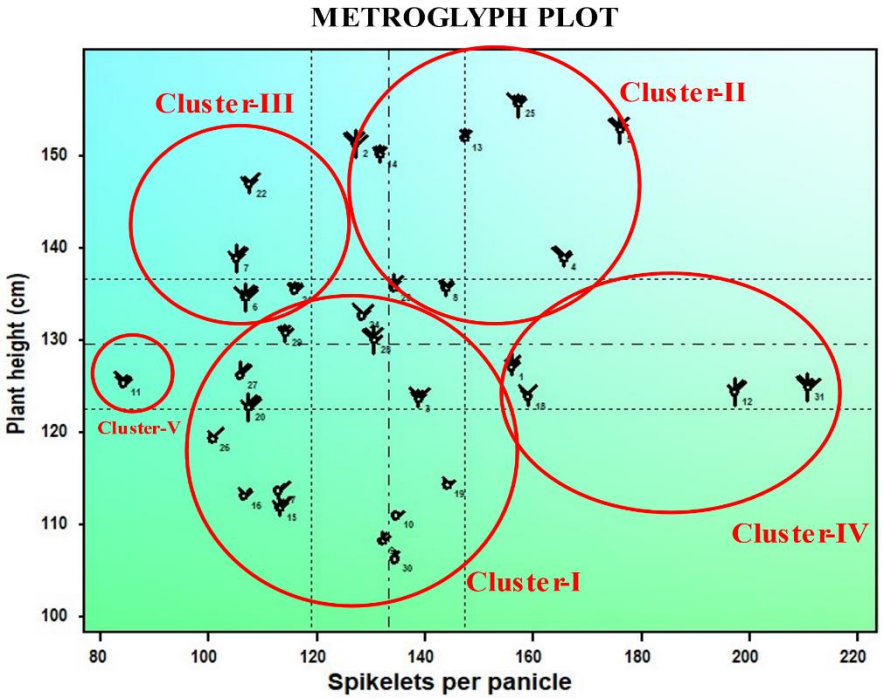

Fig. 2. Scattered diagram of Metroglyph analysis showing 31 genotypes of rice

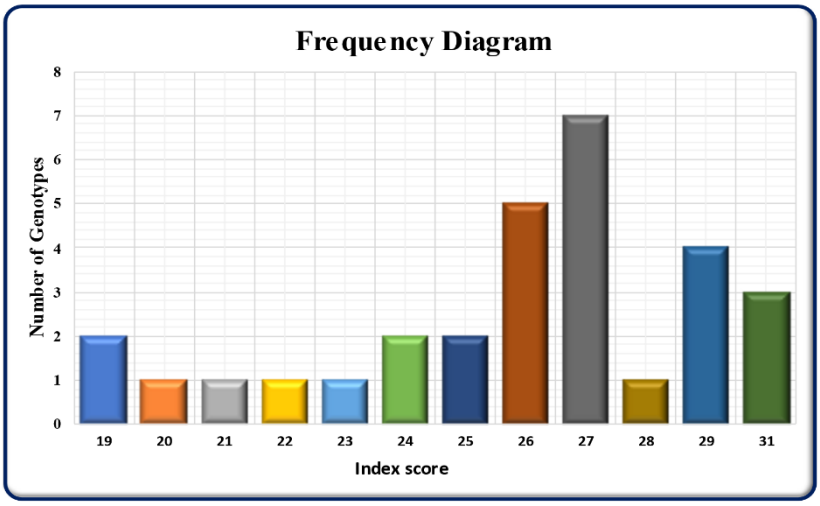

Fig. 3. Metroglyph frequency diagram showing 31 genotypes of rice

Highest index score of 31 recorded by three lines (Nagarjuna, Jarva and NDR-359) followed by index score of 29, 28 and 27 by 4, 1, and 7 lines [21].

4. CONCLUSION

Considerable variability existed in the genotypes for all the characters studied. These were the genotypes with high mean values in desirable direction i.e., From the present investigation it is concluded that among 31 genotypes of rice, VASUMATHI showed early flowering (80 days), and had characters like early maturity (113days), D. DHAN-38 showed high plant height (155.8 cm), PUSA BASMATHI-1 showed high Panicle length (28.8 cm), NAGARJUNA is showing both high Biomass (69.3 g), and Grain Yield per Plant (39.7 g). Highest GCV were depicted for Grain Yield per Plant, Biological Yield per Hill, Number of Spikelet's per panicle, Number of Panicles per hill, Number of Tillers per Hill, and Flag Leaf Width. The highest Heritability was observed for Number of Tillers per hill, Number of Spikelet's

per Panicle, Grain yield per plant, Number of Panicles per hill, Biological Yield per Hill and Flag Leaf Width. And highest genetic advance as a percentage of mean except plant height, Grain Yield per Plant, Biological Yield per Hill, Number of Spikelet's per Panicle, Number of Panicles per hill, Number of Total Tillers, Flag Leaf Width and Harvest Index. A scatter diagram was created for 31 genotypes that formed five complexes with 13,9,4,4 and 1 genotype in each complex. The genotypes Nagarjuna, Jarva and NDR-359, which have a high index score and fall into various clusters, can be utilized as parents in hybridization to get the most variety in character combinations. This character should be given due consideration during selection for crop improvement.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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