The Bioscan 8(4): 1445-1451, 2013 (Supplement on Genetics & Plant Breeding)
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

STUDY OF GENETIC VARIABILITY OF INDIAN AND EXOTIC RICE GERMPLASM IN ALLAHABAD AGROCLIMATE

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KEYWORDS
GCV
PCV
Genetic advance and Heritability

Received on :
20.09.2013

Accepted on :
18.11.2013

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ABSTRACT
Experiment was conducted on Indian and Exotic rice germplasm to study the genetic variability in Allahabad agroclimate. Genotypic coefficient of variation was played a major role for the expression of the traits ranged from 7.9 (panicle length) to 37.78 (total biomass per plant). Heritability in broad sense ranged from 0.72 (panicle length) to 1.00 (days to 50 percent flowering and plant height). High genetic advance was observed for the traits, plant height (35.44), 1000 grain weight (40.23), harvest index (48.05), spikelet/panicle (53.12), grain yield/plant (64.98) and total biomass/plant (77.54), coupled with high heritability, indicating the preponderance of additive gene action; suggesting that mass selection and other breeding methods based on progeny testing will be effective. The highest contribution in manifestation of genetic variability was exhibited by plant height (32.91) followed by days to 50 percent flowering (29.45), total biomass/plant (12.14) and spikelet per panicle (8.60); suggesting that these traits should be given top priority during selection.

INTRODUCTION

Rice (*Oryza sativa* L.) is the world's largest food crop, providing the caloric needs of millions of people daily. It plays a pivotal role in Indian economy being the staple food for two third of the population. India stands second with 108.0 million tons as China occupies the first place with 144.0 million tons in the world's production table of 479.3 million tons (USDA. May, 2013). It is of great concern to note that the rate of growth in rice production has started declining during 90s and there has been a plateauing effect. The population growth in most of the Asian countries, except China, continues to be around 2 percent per year. Hence it is very pertinent to critically consider whether the rice production can be further increased to keep pace with population growth. With the current green revolution technologies it is estimated that by 2020 at least 115-120 million tons of milled rice is to be produced in India to maintain the present level of self sufficiency. The total production could be enhanced either by making horizontal expansion in area, which is not possible owing to high population growth, so none of the option left other than vertical expansion, which could be done opting a suitable breeding method.

Information on the nature and degree of genetic divergence would help the plant breeder in choosing the right parents for breeding programme (Vivekanandan and Subramanian, 1993). The D^2 technique is based on multivariate analysis developed by Mahalanobis (1936) had been found to be a potent tool in quantifying the degree of divergence in germplasm. Success in recombination breeding depends on the suitable exploitation of genotypes as parents for obtaining high heterotic crosses and transgressive segregants. For this, the presence of genetic variability in a base population is essential so research should be done for creating of variation. The crosses between parents with maximum genetic divergence are generally the most responsive for genetic improvement (Arunachalam, 1981). Recognizing the importance of genetic variability in plant breeding experiments, the main objective of present research work was to assess the genetic variability for yield and yield contributing character.

MATERIALS AND METHODS

The experiment which comprising seventy three international rice genotypes including one local check procured from IRRI, Philippines through NBPGR, New Delhi, were grown during kharif 2009 in a Randomized Block Design with two replication at Central Research Farm of Sam Higginbotom Institute of Agriculture, Technology and Sciences (formerly known as AAIDU), Allahabad. Each genotype was grown in a plot of size 2 x 1 square meters with a spacing of 20 x 15 cm row to row and plant to plant. Data were recorded on five randomly tagged plants for eleven agro-morphological traits viz., days to initial flowering, days to 50% flowering, productive tillers per plant, plant height (cm), panicle length (cm), number of grains per panicle, days to maturity, total biomass per plant (g), 1000 grain weight (g), harvest index (%) and grain yield per plant (g). The formulae used to calculate PCV, GCV and ECV as per method given by Burton (1952) and heritability in broad sense by Lush (1949) and Burton and Devane (1953).

Table 1: Analysis of variance for 11 quantitative characters of 73 rice genotypes.

S.No.	Characters	Mean sum squares Replication(df = 01)	Treatment(df = 72)	Error(df = 72)
1.	Days to Initial Flowering	7.92	288.79	1.49
2.	Days to 50% Flowering	14.49	303.77	0.59
3.	Fertile Tillers/ Plant	1.54	80.51	2.71
4.	Panicle Length(cm)	12.39	9.17	1.49
5.	Plant Height (cm)	28.96	682.14	1.32
6.	Spikelet/ Panicle	173.16	3542.86	19.69
7.	Days to Maturity	20.72	242.05	1.15
8.	Total Biomass/ Plant (gm)	499.32	4112.76	15.63
9.	Grain Weight/ Plant (gm)	596.06	674.64	6.13
10.	1000 Grain Weight (gm)	3.41	79.31	1.80
11.	harvest Index %	152.76	310.39	11.36

** indicate significance at 1% level of significant; * indicate significance at 5% level of significant.

The estimates of genetic advance were obtained by the method given by Johnson *et al*. (1955).

RESULTS AND DISCUSSION

A reasonable amount of differences among the genotypes were observed for all the traits under study as evident from the table 1; indicating the presence of sufficient variability among the experimental materials.

Days to initial flowering ranged from 54.0 to 110.5 comprising the general mean of 84.7 days as per the Table 2; indicating that majority of genotypes in experiment are delayed in days to initial flowering, days to 50 per cent flowering ranged from 59.5 to 115.5 days having the general mean of 92.7 days which is closer to the late genotype, days to maturity ranged from 95.5 to 142.0 days comprising the general mean 123.1; suggesting that most of the genotypes belong to late maturity group, Plant height varied from 75 to 154 (cm) having the general mean 107 (cm); it showed that all the genotypes are not having the tall stature, some of them are of medium stature, fertile tillers per plant ranged from 9.0 to 51.5 with a general mean of 18.9 ; suggesting that very few genotypes are closer to the higher range of the traits, panicle length varied from 17.0 to 29.7 (cm) with a general mean of 24.8 (cm); indicating that most of the genotypes tends to long panicle, grains per panicle ranged from 66.5 to 322.5 having the general mean of 161.9; suggesting that the maximum genotypes are closer to less number of grains per panicle, total biomass per plant varied from 35 to 272.5 (g) having the general mean of 119.8 (g); indicating that majority of genotypes having lesser total biomass per plant, 1000 grain weight ranged from 15.9 to 48.9 (g) with a general mean of 31.2 (g); suggesting that maximum genotypes exhibiting average 1000 grain weight, harvest index ranged from 21.1 to 82.6 having general mean of 50.5; indicating that most of the genotypes having medium harvest index and grain yield per plant 27.5 to 142.5 (g) with the general mean of 57.4 (g); revealed that majority of genotypes showing medium grain yield per plant ranged from and very few genotypes were having the higher yield. This finding is corroborated with Ishwar *et al*. (2007), Jamal *et al*. (2009), Jayasudha and Sharma (2010), Pandey *et al*. (2010), Tiwari *et al*. (2011), Chanbeni *et al*. (2012) and *Yaqoob et al*. (2012).

Phenotypic coefficient of variation (PCV) was slightly higher in magnitude than the genotypic coefficient of variation (GCV) for all the characters indicating the influence of environmental factors on these traits as revealed by the Table 3**.** All the traits exhibited high heritability in broad sense. Since all the traits were comprising the low to high genetic advance as percent of mean coupled with the high heritability; suggesting that there is a preponderance of additive gene action for the traits, total biomass per plant, fertile tillers per plant, grain yield per plant, spikelet per panicle, harvest index, 1000 grain weight and plant height which exhibiting high genetic advance as percent of mean. This type of characters could be improved by mass selection and other breeding methods based on progeny testing. While the lowest genetic advance as percent of mean coupled with high heritability was observed for panicle length, days to maturity, days to 50 percent flowering and days to initial flowering which is indicative of non-additive gene action in their inheritance. Therefore heterosis breeding could be used to improve these traits. The high heritability is being exhibited due to favorable influence of environment rather than genotype and selection for such traits may not be rewarding. Similar results were also obtained by Sharma and Richharia (1995), Nayak *et al* (2002), Bihari *et al*. (2004), Vivek *et al*. (2004), Das *et al*. (2005), Elayaraja *et al*. (2005), Girish *et al*. (2006) Vaithiyalingan *et al*. (2006), Tandekar *et al*. (2010), Pandey and Anurag (2010), Singh *et al*. (2011) and Idris *et al*. (2012).

The use of Mahalanobis D^2 statistics for estimating genetic divergence has been emphasized by many workers (Roy and Ponwar, 1993; Ramya and Senthilkumar, 2008). Hence, based on relative magnitude of D^2 statistics the73 genotypes of rice were grouped into 9 clusters as shown in Table 4. Cluster I having 17 genotypes forming the largest group followed by cluster VIII (15), cluster IX (14), cluster VI (9) and cluster V (8); while cluster II (4), Cluster VII (3), cluster IV (2) and cluster III (1) forming the smallest group. The pattern of group constellation proved the existence of significant amount of variability. Genotypes from the same center of origin were distributed in different clusters which may be due to differential adaptation to varied agro-ecosystems as explained by Sabesan *et al*. (2009) and Banumathy *et al*. (2010).

The intra and inter cluster average distances among 9 clusters were variable as indicated in table 5. The highest intra-cluster distance was recorded for cluster V followed by cluster II, cluster VIII, cluster VI, cluster I, cluster IX, cluster IV, cluster VII

Table 2: Mean performance of 73 rice genotypes for 11 quantitative characters during kharif 2009.

Sr. no.	Genotype	Days to Initial Flowering	Days to 50% Flowering	Fertile Tillers/ Plant	Plant Height (cm)	Panicle Length (cm)	Grains per Panicle	Days to Maturity	Total Biomass/ Plant (g)	1000 Grain Weight(g)	Harvest Index (%)	Grain Yield/ Plant(g)
1	IR61979-1 3 8-1-3-2-3 (ANGELICA)	97.50	100.50	21.50	93.25	27.50	142.50	132.00	52.50	35.16	71.36	37.50
2	BPI 76(NS)	96.00	110.50	23.50	143.25	20.50	186.00	129.50	152.50	32.50	47.53	72.50
3	DV85	84.50	92.00	38.00	141.60	28.20	66.50	125.50	157.50	28.35	39.72	62.50
4	IR 20	93.00	99.50	21.00	99.75	26.80	150.50	137.00	57.50	34.69	82.58	47.50
5	IR 22	103.00	111.50	14.50	78.30	24.35	141.00	137.50	80.00	29.47	53.53	42.50
6	IR24	86.50	93.50	11.00	79.55	19.40	72.00	124.50	67.50	25.38	55.77	37.50
7	IR 26	84.00	92.00	14.00	96.60	25.55	126.00	124.00	127.50	25.99	56.85	72.50
8	IR28	69.00	75.50	21.00	97.43	25.40	123.00	104.50	132.50	24.90	51.00	67.50
9	IR29	69.50	81.50	26.50	97.80	25.25	123.50	111.50	162.50	28.10	47.73	77.50
10	IR30	68.50	81.50	23.00	99.00	22.50	162.50	111.00	110.00	27.07	47.73	52.50
11	IR32	85.50	92.00	22.50	118.20	20.00	187.50	106.50	92.50	29.53	78.51	72.50
12	IR 36	82.00	90.50	20.00	84.70	22.60	188.00	124.00	122.50	34.09	51.00	62.50
13	IR 38	104.00	105.50	13.50	98.70	29.70	106.00	130.50	92.50	37.86	45.91	42.50
14	IR 40	103.00	111.00	18.00	85.70	25.70	215.50	136.50	122.50	30.21	51.08	62.50
15	IR 42	86.00	101.00	19.00	97.00	24.70	186.00	124.00	107.50	25.85	34.85	37.50
16	IR 43	94.50	101.50	19.50	132.15	26.20	134.50	124.50	112.50	41.21	64.53	72.50
17	IR 44	101.00	109.50	51.50	97.15	26.15	156.00	132.50	272.50	37.45	21.09	57.50
18	IR 45	98.00	102.00	23.00	103.25	22.80	200.00	131.50	242.50	29.93	30.93	75.00
19	IR 46	92.50	103.50	14.50	103.90	23.05	192.00	133.00	107.50	36.07	44.16	47.50
20	IR 48	101.50	107.50	18.00	101.00	22.95	155.50	140.50	92.50	45.30	62.13	57.50
21	IR 50	71.50	75.00	15.50	75.00	22.40	122.00	103.50	82.50	21.82	45.40	37.50
22	IR 52	74.50	93.50	11.50	90.90	25.65	152.50	125.00	82.50	29.24	57.54	47.50
23	IR 54	103.50	109.50	20.00	97.50	25.95	171.50	137.50	97.50	37.41	58.95	57.50
24	IR 56	77.50	84.50	15.50	96.00	23.95	137.50	110.50	82.50	15.91	54.41	45.00
25	IR 58	66.00	69.50	24.00	100.85	23.48	191.00	95.50	112.50	22.33	46.64	52.50
26	IR 60	77.50	85.00	25.00	87.70	24.12	160.50	110.00	107.50	35.68	62.77	67.50
27	IR 62	88.00	111.00	24.50	131.80	26.90	147.50	131.00	137.50	25.87	52.78	72.50
28	IR 64	88.50	94.50	16.50	101.80	23.61	130.50	126.00	132.50	36.78	47.15	62.50
29	IR 65	87.50	94.00	17.50	85.30	25.70	150.50	137.00	127.50	31.46	49.08	62.50
30	IR 66	83.00	89.50	13.00	94.70	23.80	118.50	124.50	92.50	32.54	56.72	52.50
31	IR 68	110.50	115.50	15.00	106.90	27.30	233.00	127.50	52.50	34.66	80.91	42.50
32	IR 70	93.00	106.00	18.50	117.80	24.05	137.50	132.50	90.00	29.41	52.77	47.50
33	IR 72	79.50	88.50	22.00	107.80	26.95	250.50	125.00	222.50	39.92	64.06	142.50
34	IR 74	104.00	110.50	23.00	88.50	27.80	195.50	133.00	182.50	35.78	39.71	72.50
35	IR 08	95.00	102.00	28.50	106.00	26.50	184.00	132.50	222.50	48.94	39.34	87.50
36	K39-96-1-1-1-2	54.00	59.50	21.00	116.80	23.45	157.50	96.50	82.50	27.51	51.84	42.50
37	IR69726-116-1-3(MATATAG1)	92.00	100.50	17.50	100.80	24.40	132.00	124.00	147.50	32.62	49.14	72.50
38	IR 6976-29-1-2-2-2 (MATATAG2)	94.50	102.00	10.50	95.75	25.80	156.00	130.50	82.50	29.01	33.27	27.50
39	IR 68305-18-1-1(MATATAG3)	67.50	75.50	9.00	100.00	25.50	145.00	104.50	87.50	24.15	48.53	42.50
40	IR 73885-1-4-3-2-1-	92.50	97.00	19.50	106.50	25.70	188.50	124.50	117.50	44.12	48.91	57.50
41	N22	70.50	74.00	20.00	139.00	26.05	158.00	96.50	92.50	35.08	67.54	62.50
42	IR 61920-3B-22-2-1 (NSICRC106)	67.50	75.50	18.00	97.20	25.92	174.50	124.00	87.50	27.57	60.13	52.50
43	IR 71600-1-1-4-2-3-1-2(NSICRC110)	70.00	86.00	20.50	104.10	25.76	132.00	124.50	127.50	31.21	47.08	60.00
44	IR 72102-4-159-1-3-3-3(NSICRC112)	82.50	91.50	15.00	93.70	22.97	182.00	125.00	127.50	23.22	51.00	65.00
45	P2025-F4-	103.00	109.50	19.50	96.40	17.01	148.50	142.00	107.50	23.75	44.16	47.50

Table 2: Cont.....

	159-3-1B											
46	IR 55423-01(NSICRC9)	87.50	90.50	12.00	130.10	24.40	185.50	125.50	100.00	26.79	52.51	52.50
47	PSB RC 1	86.50	91.50	15.00	147.80	25.10	322.50	124.00	147.50	25.49	39.17	57.50
48	PSB RC 10 (IR50404-57-2-2-3)	69.50	72.50	16.50	92.90	23.98	200.00	112.00	92.50	25.60	40.50	37.50
49	PSB RC 2 (IR32809-26-3-3)	72.50	80.50	21.00	95.50	23.92	148.50	111.50	97.50	26.30	56.32	55.00
50	PSB RC 20(IR5730 1-195-3-3)	81.00	89.50	14.00	105.50	27.76	179.00	131.00	100.00	38.12	27.44	27.50
51	PSB RC 28 (IR56381-139-2-2)	74.50	101.00	19.50	105.00	23.50	203.00	126.00	162.50	27.82	41.57	67.50
52	PSB RC 30 (IR58099-41-2-3)	73.50	92.50	12.50	84.86	21.60	106.50	125.50	112.50	28.82	37.75	42.50
53	PSB RC 4	69.50	73.50	10.00	86.76	23.68	197.00	104.50	35.00	32.1179.17		27.50
54	IR 59468 B-B-3-2	77.50	81.50	18.00	133.80	26.90	179.50	111.00	92.50	29.67	62.28	57.50
55	IR 25976-12-2-2-2-1-1(PSB RC46)	75.50	84.50	19.50	139.00	22.40	147.00	125.50	162.50	38.82	29.21	47.50
56	PSB RC 5 (IR 47686 -30-3-2)	91.50	95.00	18.00	140.50	25.08	223.00	126.00	182.50	28.08	45.19	82.50
57	IR 51500-AC-11-1(PS BRC50)	82.00	91.00	18.50	113.60	24.82	95.00	125.50	107.50	43.22	44.16	47.50
58	IR 59682-132-1-1-2(PS BRC52)	95.00	96.00	20.50	147.70	24.98	164.00	124.00	170.00	33.86	45.58	77.50
59	PSB RC 54 (IR6081 9-34-2-1)	68.50	73.50	11.50	88.50	25.70	184.00	111.50	77.50	22.43	61.55	47.50
60	PSB RC 60 (IR41431-6 8-1-2-3)	93.50	103.50	15.00	95.70	25.30	169.50	131.50	112.50	32.74	33.30	37.50
61	PSB RC 64 (IR59552-21-3-2-2)	96.50	104.00	25.50	103.80	27.30	169.50	132.00	182.50	39.70	39.71	72.50
62	PSB RC 68	85.50	89.50	13.50	124.05	25.30	181.00	125.00	142.50	28.56	63.18	90.00
63	IR 60267-11-2-2-1(PS BRC70)	101.50	107.50	11.00	100.50	22.70	166.00	142.00	137.50	37.86	60.05	82.50
64	IR 62141-1 14-3-2-2-2(PS B RC 80)	83.50	90.50	14.50	115.98	27.20	215.00	124.50	157.50	29.27	46.06	72.50
65	IR 64683-8 7-2-2-3-3(PS B RC 82)	91.00	104.00	19.00	123.60	24.60	157.00	124.00	137.50	41.11	52.78	72.50
66	IR 65185-3 B-8-3-2(PSB RC 84)	75.00	80.50	21.50	99.90	23.15	85.50	124.50	102.50	26.72	36.54	37.50
67	IR 65195-3 B-13-2-3(PS B RC 86)	85.50	91.00	18.50	125.40	23.90	87.00	123.50	107.50	35.77	53.46	57.5
68	IR 52713-2 B-1-2(PSB RC 82)	89.50	92.50	18.00	116.10	25.70	187.50	124.00	110.00	25.69	43.16	47.50
69	IR 9202-2 5-1-3(PSB RC 92)	72.00	76.50	18.50	130.60	27.02	220.00	103.00	80.00	26.16	40.58	32.50
70	IR 61336-4	71.50	78.50	15.50	105.00	26.65	166.00	111.50	40.00	26.88	69.04	27.50

Table 2: Cont.....

	B-14-3-2(PS B RC 94)											
71	IR 61606-3 B-20-2-2-1-1 (PSB RC 96)	76.50	80.50	18.00	115.30	27.10	161.00	125.00	97.50	30.66	59.12	57.50
72	WC1240 (ACC 13742)	81.50	97.50	31.50	154.00	22.70	84.50	124.00	207.50	29.36	37.34	77.50
73	Pant Dhan 10	85.50	94.50	18.00	104.42	27.20	160.50	125.00	140.00	21.99	44.63	62.50
	Mean	84.74	92.67	18.89	107.03	24.81	161.86	123.11	119.80	31.16	50.54	57.44
	Range Max	110.5	115.50	51.50	154.00	29.70	322.50	142.00	272.50	48.94	82.58	142.50
	Min	54	59.50	9.00	75.00	17.01	66.50	95.50	35.00	15.91	21.10	27.50
	C.V.	1.44	0.83	8.71	1.07	4.91	2.74	0.87	3.30	4.30	6.67	4.31
	C.D. 5%	2.43	1.53	3.28	2.29	2.43	8.85	2.14	7.88	2.68	6.72	4.94
	S.E.	0.86	0.54	1.16	0.81	0.86	3.14	0.76	2.80	0.95	2.38	1.75

Table 3: Genetic parameters for 11 quantitative characters of 73 rice genotypes.

S.No.	Characters	Variance			GCV	PCV	h^2(bs)	GA	GA as % of mean
		σ^2g	σ^2p	σ^2e					
1.	Days to initial flowering	143.65	145.14	1.49	14.14	14.22	0.99	24.56	28.99
2.	Days to 50% Flowering	151.59	152.18	0.59	13.29	13.31	1.00	25.31	27.32
3	Fertile Tillers per Plant	38.90	41.61	2.71	33.03	34.16	0.93	12.42	65.79
4.	Plant Height(cm)	340.41	341.73	1.32	17.24	17.27	1.00	37.93	35.44
5.	Panicle Length(cm)	3.84	5.33	1.49	7.90	9.30	0.72	3.43	13.82
6.	Spikelet per Panicle	1761.58	1781.28	19.70	25.93	26.08	0.99	85.98	53.12
7.	Days to maturity	120.45	121.60	1.15	8.92	8.96	0.99	22.50	18.28
8.	Total Biomass per Plant(g)	2048.56	2064.20	15.63	37.78	37.93	0.90	92.88	77.54
9.	1000 Grain Weight (g)	38.75	40.55	1.80	19.98	20.44	0.96	12.54	40.23
10.	Harvest Index (%)	149.52	160.88	11.36	24.20	25.10	0.93	24.28	48.05
11.	Grain yield per Plant (g)	334.26	340.39	6.13	31.83	32.12	0.98	37.32	64.98

Table 4: Distribution of 73 genotypes of rice into different clusters

Cluster No.	Number of genotypes	Name of genotypes included
I	17	IR61979-138-1-3-2-3(ANGELICA), IR20, IR38, IR70, IR42, IR69726-29-1-2-2-2(MATATAG2), IR46, PSB RC 60, IR73885-1-4-3-2-1-6(MATATAG9), IR22, P-2925-F4-159-3-1B, IR48, IR54, IR60267-1 1-2-2-1(PSB RC70), IR40, IR74, IR68
II	4	IR8, PSB RC 64, IR44, IR45.
III	1	IR72
IV	2	DV85, W C 1240
V	8	IR43, PSB RC 82, IR62, BP176(NS), PSBRC5, PSB RC 52, PSB RC46, PSB RC1
VI	9	IR55423-01(NSICRCS), PSB RC 88, PSBRC20, PSB RC 96, PSB RC 50, PSB RC 86, PSB RC 68, PSB RC80, IR32
VII	3	IR59468-B-B-3-2, PSB RC 92, N22
VIII	15	IR28, IR29, IR30, PSBRC2, IR60, IR56, IR68305-18-1-1(MATATAG3), IR58, IR50, PSBRC10, PSB RC 54, IR61920-3B-22-2-1(NSICRC106), PSB RC 4, PSB RC 94, K39-96-1-1-1-2
IX	14	IR36, IR65, IR64, IR69726-116-1-3(MATATAG1), IR72102-4-159-1-3-3-3(NSICRC112), PANT DHAN 10, IR26, PSBRC28, IR52,IR66, PSBRC30, IR24, IR71606-1-1-4-2-3-1-2(NSICRC110), PSB RC 84

and lowest for cluster III. The genotypes grouped into same cluster displayed the lowest degree of divergence from one another and in the case where crosses are made between genotypes belonging to the same cluster; no transgressive segregants are expected from such combinations. The lowest inter-cluster distance was found between cluster VI and IX indicating a close relationship between them where as the highest inter cluster distance was observed between cluster II and cluster VII; suggesting the maximum variability among them. Therefore, hybridization programmes should always be formulated in such a way that the parents belonging to different clusters with maximum divergence could be utilized to get desirable transgressive segregants. This is corroborated with Allard (1960), Mishra *et al*. (2003), Chaturvedi and Maurya (2005) and Bhadru *et al*. (2012).

A comparison of the mean values of different clusters and per cent contribution towards divergence for 11 characters has been presented in table 6. For the days to initial flowering and days to 50 per cent flowering largest mean shown by cluster I, for fertile tillers per plant, plant height and panicle length cluster IV, for spikelet per panicle, 1000 grain weight, harvest index and grain yield per plant cluster III, for days to maturity cluster

Table 5: Intra (diagonal) and inter cluster average distance (D^2) in rice genotypes

	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI	Cluster VII	Cluster VIII	Cluster IX
Cluster I	759.267	2366.699	4671.396	3747.272	2285.121	1677.336	3793.549	3582.399	1530.556
Cluster II		915.771	3198.693	3633.472	3045.365	3145.682	5851.378	5202.583	2643.461
Cluster III			0.000	5226.078	4012.765	3582.600	4998.590	4364.112	3296.246
Cluster IV				491.900	1820.372	2022.733	2636.714	4360.573	3043.604
Cluster V					1068.072	1448.212	2254.080	4299.401	2742.412
Cluster VI						760.513	1307.577	1974.213	1233.863
Cluster VII							361.241	1952.057	2647.025
Cluster VIII								817.106	1491.321
Cluster IX									628.263

Table 6: Mean values of nine clusters for11 morphological characters in 73 rice genotypes and % contribution

Cluster No.	Days to Initial flowering	Days to 50% flowering	Fertile tillers per plant	Plant height (cm)	Panicle length (cm)	Spikelet per panicle	Days to maturity	Total biomass per plant (g)	1000 grain weight (g)	harvest index %	Grain yield per plant (g)
I	98.618	105.941	17.176	97.832	25.080	167.941	133.647	99.559	34.082	52.802	49.853
II	97.625	104.375	32.125	102.550	25.686	177.375	132.125	230.000	39.006	32.771	73.125
III	79.500	88.500	22.000	107.800	26.950	250.500	125.000	222.500	39.925	64.065	142.500
IV	83.000	94.750	34.750	147.800	27.300	75.500	124.750	182.500	28.855	38.529	70.000
V	89.750	99.250	19.938	138.225	24.469	185.188	126.063	150.313	33.368	47.097	69.375
VI	84.056	89.667	16.611	118.247	25.131	164.278	123.389	112.778	31.956	51.957	58.333
VII	73.333	77.333	18.833	134.467	26.655	185.833	103.500	88.333	30.305	56.804	50.833
VIII	69.333	76.100	18.200	95.762	24.393	159.500	108.167	92.667	25.893	54.851	48.833
IX	81.357	92.429	16.286	94.738	23.763	138.536	125.679	119.464	29.135	48.702	57.500
Contribution %	2.05	29.45	0.15	32.91	0.04	8.60	2.97	12.14	5.37	0.42	5.90

I and for total biomass per plant cluster II; indicating that largest mean for more characters shown by cluster III followed by cluster IV and cluster I. This indicated that these clusters could be utilized in the hybridization program for obtaining desirable transgressive segregants. The highest contribution in manifestation of genetic divergence was exhibited by plant height followed by days to 50% flowering, total biomass per plant and spikelet per panicle; suggesting that these characters can be used to choice of parents for hybridization program; moderate contribution shown by the traits grain yield per plant, 1000 grain weight, days to maturity and days to initial flowering while lowest contribution exhibited by panicle length, fertile tillers per plant and harvest index. The selection and choice of parents mainly depends upon contribution of characters towards divergence also reported by Nayak *et al*. (2004), Baradhan and Thangavel (2011).

ACKNOLEDGEMENT

I pay my sincere thanks to NBPGR, New Delhi which procured the experimental material.

REFERENCES

Allard, R. W. 1960. Principles of Plant Breeding. *J. Wiley and Sons Inc.,* New York. pp.115-128.

Arunachalam, V. 1981. Genetic divergence in plant breeding. *Indian J. Genet*. **(14):** 226-236.

Banumathy, S., Manimaran, R., Sheeba, A., Manivannan, N., Ramya, B., Kumar, D. and Ramasubramanian, G. V. 2010. Genetic diversity analysis of rice germplasm lines for yield attributing traits. *Electron. J. Plant Breed.* **1(4):** 500-504.

Baradhan, G. and Thangavel, P. 2011. D^2 analysis in rice (*Oryza sativa* L.). *Plant Archives*. **11(1):** 373-375.

Bhadru, D. V., Rao, T., Chandra Mohan, Y. and Bharathi, D. 2012. Genetic variability and diversity studies in yield and its component traits in rice (*Oryza sativa* l.). S*abrao J. breeding and genetics*. **44(1):** 129-137.

Bihari, P. K., Richharia, A. K. and Sahu, R. S. 2004. Genetic advance for yield attributes in aromatic rice. *J. Applied Bio*. **14(2):** 1-5.

Burton, G. W. 1952. Quantitative inheritance in grasses. Proc. 6th Interaction. *Grassland Cong. J.* **1:** 227-283.

Burton, G. W. and Devane 1953. Estimating heritability in tall Fescue from replicated clonal material. *Agron. J.* **(45):** 474-481.

Chanbeni, Y. O., Lal, G. M. and Rai, P. K. 2012. Studies on genetic diversity in rice. (*Oryza sativa* L.). *J. Agricultural Technology*. **8(3):** 1059-1065.

Chaturvedi, H. P. and Maurya, D. M. 2005. Genetic divergence analysis in rice (*Oryza sativa* L.). *Advances Pl. Sciences*. **18(1):** 349-353.

Das, R., Borbora, T. K. and Sharma, M. K. 2005. Genetic variability for grain yield in semi-deep water rice (*Oryza sativa* L.). *Oryza*. **42(4):** 313-314.

Elayaraja, K., Prakash, M., Saravana, K., Kumar, B. S. and Ganesan, J. 2005. Studies on variability, heritability and genetic advance quantitative characters in rice (*Oryza sativa* L.). *Crop Res., Hisar*. **29(1):** 134-137.

Girish, T., Gireesha, T., Vaishali, M., Hanamareddy, B. and Hittalmani, S. 2006. Response of a new IR50/Moroberekan recombinant inbred population of rice (*Oryza sativa* L.) from an indica × japonica cross for growth and yield traits under aerobic conditions. *Euphytica*. **152:** 149-161.

Idris, A. E., Justin, F. J., Dagash, Y. M. I. and Abuali, A. I. 2012. Genetic Variability and Inter Relationship between Yield and Yield Components in Some Rice Genotypes. *American J. Experimental Agriculture*. **2(2):** 233-239.

Ishwar D., Mehla, B. S. and Singh, J. 2007. Multivariate analysis in rice *(Oryza sativa L.). National J. Plant Improvement*. **9(2):** 115-118.

Jamal, Ifftikhar, Khalil, H., Abdul, B., Khan, S. and Islam, Z. 2009. Genetic variation for yield and yield components in rice. *Arpn. J. Agricultural and Biological Science*. **4(6):** 60-64.

Jayasudha, S. and Sharma, D. 2010. Genetic parameters of variability, correlation and path coefficient for grain yield and physiological traits in Rice (*Oryza sativa* L.) under shallow lowland situation. *Electronic J. Plant Breed*. **1(5):** 33-38.

Johnson, R. E., Robinson, H. W. and Comstock, H. F. 1955. Estimates of genetic and environmental variability in soybeans. *Agron. J.* **47:** 314-318.

Lush, J. L. 1949. Inter-se, correlation and regression of characters. *Proceeding of American Society of Animal Production*. **33:** 293-301.

Mahalanobis, P. C. 1936. On the generalized distance in statistics. *Proc. Natl. Inst. Sci. India*. **(2):** 49-55.

Mishra, L. K., Sarawgi, A. K. and Mishra, R. K. 2003. Genetic diversity for morphological and quality traits in rice (*Oryza sativa* L.). *Advances in Plant Sciences*. **16(1):** 287-293.

Nayak, A. R., Chaudhury, D. and Reddy, J. N. 2002. Genetic variability, heritability and genetic advance in scented rice. *Indian Agric*. **46(12):** 45-47.

Nayak, A. R., Chaudhury, D. and Reddy, J. N. 2004. Genetic divergence in scented rice. *Oryza*. **41(384):** 79-82.

Pandey, P. and Anurag, P. J. 2010. Estimation of genetic parameters in indigenous rice. *AAB, Bioflux*. **2(1):** 79-84.

Pandey, P., Anurag, P. J. and Rangare, N. R. 2010. Genetic parameters for yield and certain yield contributing traits in rice (*Oryza sativa* L.). *Annals of Plant and Soil Research*. **12(1):** 59-61.

Ramya, K. and Senthilkumar, K. 2008. Genetic divergence in rice. Crop Improv. **35(2):** 119-121.

Roy, A. and Ponwar, D. V. S. 1993. Genetic divergence in rice. *Oryza*. **30:** 197-201.

Sabesan T., Suresh, R. and Saravanan, K. 2009. Genetic variability and correlation for yield and grain quality characters of rice grown in coastal saline low land of Tamilnadu. *Electron. J. Plant Breed*. **1:** 56-59.

Sharma, M. K. and Richharia, K. 1995. Genetic variability and diversity in rice under irrigated transplanted condition. *J. Agric. Sci. Soc. of North East India*. **8(2):** 152-157.

Singh, S. K., Singh, C. M. and Gil, G. M. 2011. Assessment of genetic variability for yield and its component character in rice. *Research in Plant Biol*. **1(4):** 73-76.

Tandekar, K., Agrawal, K. and Tirky, P. 2010. Genetic variability, heritability and genetic advance for quantitative traits in rice (*Oryza sativa* L.) accession. *Agric. and Biological Res*. **26:** 1, 13-19.

Tiwari, D. K., Pandey, P., Tripathi, S., Giri, S. P., Dwivedi, J. L. 2011. Studies on genetic variability for yield components in rice (*Oryza sativa* L.). *AAB Bioflux*. **3(1):** 76-81.

USDA 2013. http://www.ers.usda.gov/publications /*Rice Outlook*/ RCS-13e/May 14, 2013, Economic Research Service, USDA.

Vaithiyalingan, M. and Nadarajan, N. 2006. Genetic variability, heritability and genetic advance in rice. *Crop Res*. **31(3):** 416-417.

Vivekanandan, P. and Subramanian, S. 1993. Genetic divergence in rainfed rice. *Oryza*. **30:** 60-62.

Vivek, S., Surendra, S., Singh, S. K., Singh, H., Shukla, V. and Singh, S. 2004. Analysis of variability and heritability in new plant type tropical Japonica rice (*Oryza sativa* L.). *Env. and Ecology*. **22(1):** 43-45.

Yaqoob, M., Hussain, N. And Rashid, A. 2012. Assessment of genetic variability in rice (*Oryza sativa* l.) genotypes under rainfed conditions. *J. Agric. Res*. **50(3):**