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Studies on genetic variability for yield and root traits in rice under moisture stress and moisture non stress conditions

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Abstract
Present investigation was carried out during *Kharif* 2017 at Research Farm of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh to study the genetic variability in the cross Azucena x BPT-5204 under moisture stress (rainfed) and moisture non stress (irrigated) conditions grown in PVC pipes because root traits were also the part of observations. The experiment was comprising of P_1 (Azucena), P_2 (BPT-5204) and 38 F_2 plants. Mean phenotypic performance of F_2 individuals were within the mean values observed for both the parents under both the environments except number of panicle bearing tillers and number of grains per panicle. Analysis of variance revealed the significant differences for most of the trait studied. Highest PCV was recorded for grain yield under both the environments. Highest GCV was observed for grain yield under moisture stress condition but it was highest for root volume followed by grain yield under moisture non stress condition indicating the significant variation present for grain yield under both the regimes. Higher heritability along with high genetic advance per cent of mean (GAM) were recorded for penicle bearing tillers, root to shoot ratio and root volume under irrigated condition. Similarly, higher heritability along with high genetic advance per cent of mean (GAM) were observed for plant height, number of panicle bearing tillers, root to shoot ratio and root volume under rainfed condition. Based on these observations, it may be concluded that selection based on number of panicle bearing tillers, root to shoot ratio and root volume will be rewarding under both the conditions.

Keywords: Genetic variability, Azucena, BPT-5204, grain yield, root volume and heritability

Introduction
Rice (*Oryza sativa* L.) belongs to genus *Oryza* from the gramineae family. There are 24 species under this genus out of which only two species i.e. *O. sativa* and *O. glaberrima* is cultivated and rest 22 species are considered as wild in nature. This genus represents 20=24 chromosome. Rice is the number one cereal crop in the world as about half of the population directly depends on it for their survival. In human diet it supplies 23% of its calories (Khush, 1997) [2]. It is considered as rich source of energy. It contains reasonable amount of nutrients like protein (6-10%), carbohydrate (70-80%), Minerals (1-2%) and VITAMINS (Riboflavin, thiamine, niacin and vitamin E). In India, drought is a major constraint of rice production and yield losses due to drought ranged from 30 to 70% (Singh *et al.*, 2004) [8]. Drought, the major abiotic stress has become a recurring phenomenon in the 21st century. The frequency of droughts has been increasing over time. There were six droughts between 1900 and 1950 compared to 12 in the following 50 years and 3 droughts have already occurred since the beginning of the 21st century. Again drought is on the edge of to become the next pandemic and present efforts are insufficient to stop it. About 1.5 billion people so far directly affected by the drought and in this century and this number will grow dramatically in coming years (Mizutori, 2021) [4]. However, with the greatest water requirement of all cereal crops, rice often experiences drought due to inadequate rainfall in rainfed areas (Henry *et al.*, 2012). In Asia and Africa, drought is considered severe abiotic stress for rice production in rainfed areas of Asia and Africa (Pandey, 2007) [5]. Furthermore, because of its shallow rooting compared with other cereal crops, rice is particularly susceptible to drought stress, which results in serious yield losses (Uga *et al.*, 2011) [10]. Therefore, enhancing drought resistance in rice is a key strategy to stabilize rice production in rain-fed areas. Genetic variability studies is the key component for broadening the gene pool of rice which would require reliable estimates of coefficient of variance and heritability in order to plan an efficient breeding program (Paswan *et al.*, 2014) [6].

The process of breeding is primarily conditioned by the magnitude and nature of interactions of genotypic and environmental variations in plant characters. Partitioning the available variability into its heritable and non-heritable components and to have knowledge of parameters, such as, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV) is necessary. Therefore, present study was carried out to investigate the different components of variability in the cross Azucena x BPT-5204 under moisture stress (rainfed) and moisture non stress (irrigated) conditions.

Material and Methods

Present investigation was carried out in PVC pipes for the cross Azucena x BPT-5204 comprising the individuals of Azucena (P_1), BPT-5204 (P_2) and their F_2 plants under moisture stress and moisture non stress conditions. A variability study was carried out with 240 PVC pipes of 4 inch diameter which were also filled with maximum compactness with the soil. A total of 40 treatments comprising 38 F_1 plant progenies along with the two parents (P_1 and P_2) were grown in these pipes under moisture stress and moisture non stress conditions replicating three times. Two F_2 seeds were planted in each pipe under both the conditions. After germination, only one seedling in each pipe was maintained by removing the extra germinated seed. Parents were also grown along with F_2 population. Observations on each plants were recorded for plant height, number of panicle bearing tillers, 100 seed weigh t, grain yield per plant, chlorophyll content, leaf rolling, stomatal conductance, proline content, root to shoot ratio, root volume, root dry weight, lateral root length and maximum root length.

Results and Discussion

Phenotypic performance and analysis of variance studies

Mean performance of parents and F_2 population along with minimum and maximum ranges are presented in table 1 and 2. Mean performance of F_2 was observed within parental means for all the characters under both the conditions except number of panicle bearing tillers, number of grains per panicles and root dry weight. Mean value for root to shoot ratio and lateral root length were falling outside the mean performance of parents under irrigated and rainfed conditions, respectively. Analysis of variance revealed the significance for all the traits under rainfed condition at ($P< 0.001$). But under irrigated condition, leaf rolling and stomatal conductance were found non significant and it indicated the considerable amount of variation for the study of genetic variability. These results were in the line of findings of Yue *et al.* (2012) [11].

Table 1: Phenotypic performance various traits of Azucena x BPT-5204 cross in rice under moisture non stress condition

S. N.	Characters	Parental Mean		Performance in F2 Population			SE
		Azucena	BPT-5204	Mim.	Max.	Mean	
1	Plant Height (cm)	162	94	89	171	117.03	3.56
2	Number of panicle bearing tillers	19	24	26	10	16.10	0.53
3	Number of grains per panicle	133	145	91	204	149.15	4.56
4	100-Seed weight (g)	2.07	1.98	1.84	2.24	2.05	0.06
5	Grain yield per plant (g)	17.05	25.30	9.25	26.25	21.23	1.19
6	Chlorophyll content	45.00	39.60	35.78	48.50	42.00	1.24
7	Leaf Rolling	1.00	1.00	1.00	2.00	1.07	0.21
8	Stomatal conductance (m mol/m^2/s)	1055.00	968.00	897	1132	1039.03	71.76
9	Proline content (mg/g)	38.40	31.20	24.50	41.60	32.26	1.53
10	Root-Shoot ratio	0.84	0.70	0.31	0.90	0.69	0.02
11	Root volume (cm^3)	27.00	21.00	12.00	31.00	22.23	0.58
12	Root dry weight(g)	9.20	7.60	3.90	10.20	7.13	0.29
13	Lateral root length (cm)	47.00	28.00	8.00	74.00	51.21	2.86
14	Maximum root length (cm)	58.00	33.00	12.00	86.00	55.67	3.84

Table 2: Phenotypic performance various traits of Azucena x BPT-5204 cross in rice under moisture stress condition

S. N.	Characters	Parental Mean		Performance in F2 Population			SE
		Azucena	BPT-5204	Mim.	Max.	Mean	
1	Plant Height (cm)	153	88	78	126	102.50	3.19
2	Number of panicle bearing tillers	16	20	8	22	15.11	0.54
3	Number of grains per panicle	128	140	88	154	124.28	3.73
4	100-Seed weight (g)	1.93	1.88	1.79	2.08	1.92	0.06
5	Grain yield per plant	16.31	19.25	8.65	24.45	17.52	0.84
6	Chlorophyll content	41.80	47.80	32.20	44.25	39.44	1.19
7	Leaf Rolling	1.81	3.57	2.33	5.67	3.37	0.94
8	Stomatal conductance (m mol/m^2/s)	1073	990.45	915	1042	1048.65	72.38
9	Proline content (mg/g)	39.20	32.20	25.50	42.20	33.06	1.56
10	Root-Shoot ratio	0.86	0.72	0.34	0.92	0.72	0.02
11	Root volume (cm^3)	24.00	19.00	11.00	29.00	20.23	0.53
12	Root dry weight(g)	9.80	8.50	4.50	11.50	7.41	0.35
13	Lateral root length (cm)	52.00	30.00	12.00	86.00	58.21	0.86
14	Maximum root length (cm)	66.00	39.00	13.00	94.00	61.67	6.84

Table 3: Analysis of Variance (ANOVA) for various traits of Azucena x BPT-5204 cross in rice under moisture non stress condition.

Source of variation	DF	PH	PBT	NGP	100-SW	GYPP	CC	LR	SC	PC	RSR	RV	RDW	LRL	MRL
Replication	02	496.80	10.07	879.47	0.17	441.63	70.09	0.23	321.33	1.12	0.03	0.43	0.15	26.82	011
Treatment	39	456.06**	34.89**	277.62**	0.03**	68.21**	46.09**	0.12	131.70	100.52**	0.07**	30.94**	8.09**	66.34**	44.9*
Error	78	37.92	0.84	62.27	0.01	16.24	4.61	0.13	157.57	7.01	1.2	1.00	0.24	2.35	1.96

Table 4: Analysis of Variance (ANOVA) for various traits of Azucena x BPT-5204 cross in rice under moisture stress condition.

Source of variation	DF	PH	PBT	NGP	100-SW	GYPP	CC	LR	SC	PC	RSR	RV	RDW	LRL	MRL
Replication	02	415.55	11.03	644.80	0.13	452.32	60.49	11.63	354.12	1.20	0.02	0.64	0.05	16.82	0.08
Treatment	39	1646.04**	34.54**	106.46**	0.03**	61.54*	20.20**	3.07	105.62	94.24**	0.07**	13.01**	7.14**	654.34**	22.7.9*
Error	78	30.46	0.88	41.77	0.01	1.59	4.22	2.68	162.97	7.32	0.14	0.83	0.36	0.12	1.25

Alphabets in the parenthesis indicates

DF= Degree of freedom; PH= Plant Height (cm); PBT= Number of panicle bearing tillers; NGP = Number of grains per panicle; SW= Seed Weight (g); GYPP= Grain yield per plant (g); CC= Chlorophyll content; LR= Leaf Rolling; SC= Stomatal conductance (m mol/m^2/s); PC= Proline Content (mg/g); RSR= Root to shoot ratio; RV= Root volume (cm^3); RDW= Root dry weight (g); LRL= lateral root length; MRL= maximum root length

Genetic Variability parameters of different traits under irrigated and rainfed conditions

The analysis of variance was computed to estimate the genetic variance for phenotypic traits as well as drought tolerant traits under both the conditions and is presented in Table 5 and 6. Highest genotypic coefficient of variance (GCV) was recorded for grain yield per plant (29.62) followed by root volume (26.43), plant height (22.64) root to shoot ratio (20.64) and lowest GCV was recorded for stomatal conductance (0.01) under rainfed condition. Similarly, in case of irrigated condition, highest GCV was found for root volume (39.87) followed by grain yield per plant (38.95) and root dry weight (22.68) whereas lowest GCV was recorded for leaf rolling (0.01). Likewise highest phenotypic coefficient of variance (PCV) under irrigated regime was observed for grain yield per plant (36.12) followed by leaf rolling (33.57), root dry weight (23.72) and number of tillers (23.13) and lowest was recorded for 100 seed weight (6.31). In case of rainfed condition, highest PCV was observed for grain yield (31.12) followed by leaf rolling (29.78), root volume (29.01) and plant height (23.27) whereas lowest PCV was observed for chlorophyll content (7.83). The existence of high variability for grain yield in rice has also been reported earlier by Mustafa and Elsheikh (2007) [3], Singh *et al*. (2008) [9], Raut *et al*. (2009) [7], Idris *et al*. (2012) [1].

Heritability (h^2) was also studied for the traits under observation to know the heritable potion of total variation and were classified in three categories *i.e.* high heritability (>60%), moderate heritability (31-60%) and low heritability (<30%) as suggested by Johnson *et al*. (1955). In irrigated regime, majority of the traits showed high heritability except 100 seed weight (31.53) which showed moderate heritability and leaf rolling (2.00) and stomatal conductance (3.98) displayed low heritability. Highest heritability was recorded for panicle bearing tillers (93.08) followed by number of grains per panicle (91.89), root to shoot ratio (93.31) and root volume (90.91). Likewise, under rainfed condition, most of the traits studied indicated high heritability except chlorophyll content (55.82) and grain yield per plant (42.96), which were showing moderate heritability. Low heritability was displayed by leaf rolling (4.72) and stomatal conductance (12.96). Highest heritability was observed by plant height (94.65) followed by number of tillers (92.73) and root to shoot ratio (92.61).

Table 5: Genetic **v**ariability parameters of various traits under moisture non stress (irrigated) conditions for Azucena x BPT-5204 cross in rice

S. No.	Characters	GCV	PCV	h^2	GA	GAM (%)
1	Plant height (cm)	10.09	11.38	78.61 (H)	21.56	18.43
2	Number of panicle bearing tillers	22.31	23.13	93.08 (H)	6.70	44.34
3	Number of grains per panicle	17.80	18.57	91.89 (H)	22.44	35.16
4	100-Seed weight (g)	3.54	6.31	31.53(M)	0.08	4.10
5	Grain yield per plant (g)	38.95	36.12	62.58 (H)	4.52	18.64
6	Chlorophyll content	8.85	10.22	74.98 (H)	6.63	15.79
7	Leaf rolling	0.01	33.57	2.00 (L)	0.01	0.38
8	Stomatal conductance (m mol/m^2/s)	0.02	11.73	3.98 (L)	1.27	0.96
9	Proline content (mg/g)	17.31	19.15	81.64 (H)	10.39	32.21
10	Root-Shoot ratio	21.08	21.82	93.31 (H)	0.29	41.94
11	Root volume (cm^3)	39.87	41.82	90.91 (H)	6.21	78.32
12	Root dry weight (g)	22.68	23.72	91.48 (H)	3.19	44.69
13	Lateral root length (cm)	16.89	21.54	88.64 (H)	5.89	32.45
14	Maximum root length (cm)	18.36	31.52	86.52 (H)	8.36	21.69

Table 6: Genetic **v**ariability parameters of various traits under moisture stress (rainfed) conditions for Azucena x BPT-5204 cross in rice

S. No.	Characters	GCV	PCV	h^2	GA	GAM (%)
1	Plant height (cm)	22.64	23.27	94.65 (H)	46.51	45.37
2	Panicle bearing tillers	22.17	23.02	92.73 (H)	6.64	43.98
3	Number of grains per panicle	14.43	15.34	88.50 (H)	34.75	27.96
4	100-Seed weight (g)	4.36	7.05	38.14(M)	0.11	5.54
5	Grain yield per plant	29.62	31.12	42.96(M)	3.69	12.12

6	Chlorophyll content	5.85	7.83	55.82(M)	3.55	9.01
7	Leaf rolling	10.81	29.78	4.72 (L)	0.16	4.84
8	Stomatal conductance (m mol/m^2/s)	0.01	11.25	12.96 (L)	08.50	2.00
9	Proline content (mg/g)	16.28	18.22	79.84 (H)	9.91	29.97
10	Root-Shoot ratio	20.64	21.45	92.61 (H)	0.29	40.91
11	Root volume (cm^3)	26.43	29.01	83.00 (H)	3.78	49.60
12	Root dry weight	20.28	21.85	86.13 (H)	2.87	38.77
13	Lateral root length	18.19	26.24	78.96	4.69	35.96
14	Maximum root length	22.21	32.36	84.36	7.69	19.84

Alphabets in the parenthesis indicates: *H = High; M= Moderate; L=Low*
GCV= Genotypic coefficient of variance
PCV = Phenotypic coefficient of variance
H2= Heritability (Broad sense)
GA = Genetic advance

Genetic advance was also investigated and it was highest for number of grains per panicle (22.44) followed by plant height (21.56) and proline content (10.39) under moisture non stress (irrigated) condition. Lowest genetic advance under moisture non stress (irrigated) condition was recorded for leaf rolling (0.01) followed by 100 seed weight (0.08) and root to shoot ratio (0.29). In case of moisture stress condition, highest genetic advance was displayed by plant height (46.51) followed by number of grains per panicle (34.75) and root to shoot ratio (0.29). Lowest genetic advance was observed for 100 seed weight (0.11) followed by leaf rolling (0.16) and root to shoot ratio (0.29).

Genetic advance as percentage of mean (GAM%) was also investigated and found highest for root volume (78.32) followed by root dry weight (49.69), number of panicle bearing tillers (44.34) and root to shoot ratio (41.94) whereas lowest was reported for leaf rolling (0.38) followed by stomatal conductance (0.96) and 100 seed weight (4.10) under moisture non stress (irrigated) condition. In moisture stress (rainfed) condition, highest GAM (%) was displayed by root volume (49.60) followed by plant height (45.37), number of panicle bearing tillers (43.98) and root to shoot ratio (40.910 whereas lowest was recorded for stomatal conductance (2.00) followed by leaf rolling (4.84) and 100 seed weight (5.54).

In general, PCV was higher than GCV for all traits in both the environments. These results were in agreement with the findings of Paswan *et al*. (2014) [6]. The results revealed that the diversity was highest for the trait, root volume in both the environments which was reflected in terms of highest GCV (39.87% and 26.43%) and PCV (41.82% and 29.01%) values. Lowest values of GCV (0.02% and 0.01%) for Stomatal conductance and PCV (6.31% and 7.05%) for 100-Seed weight (g) under moisture non stress (irrigated) and moisture stress (rainfed) conditions, respectively revealed lowest variation present in the traits as compared to any other traits studied. Highest value of heritability was recorded for plant height (94.65%) under moisture stress (rainfed) condition and root to shoot ratio (93.31%) under moisture non stress (irrigated) condition. Lowest value of heritability was noted for leaf rolling under both the conditions. Genetic advance mean (GAM) was the highest for number of grains per panicle (52.44) under moisture non stress (irrigated) and root volume (78.32) under moisture stress (rainfed) condition whereas genetic advance as per cent of mean (GAM) was the lowest for leaf rolling (0.01) under moisture non stress (irrigated) condition and 100 seed weight (0.11) under moisture stress (rainfed) environment.

The characters which were showing high heritability indicated that particular character is leas influenced by the environment. The broad sense heritability is based on total genetic variance which includes both fixable (additive) and non fixable (non additive) variances. But the characters which were showing high magnitude of heritability along with high genetic advance indicated that those characters are governed by additive genes and selection will be rewarding for improvement of such traits.

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