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RESEARCH ARTICLE

Genetic analysis of drought tolerance rice genotypes under diverse ecosystem (*Oryza sativa* L.)

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SUMMARY

Drought is the most divesting one and the most recalcitrant abiotic stress to the breeder's effort. In its different forms, it is the source of one third of the yield losses from technical constraints for rice in Eastern India. The present study was undertaken to carry out the genetic analysis of 45 rice genotypes, which included advanced breeding material and standard checks during *Kharif* 2011 for drought tolerance, and to find out the association of different morpho- physiological traits with grain yield under managed different levels of water stress conditions. The mean performance of three environmental conditions indicates substantial reduction in yield under rainfed direct seeded condition and terminal stage drought condition. The analysis of variance showed highly significant difference among the genotypes for all the traits under all the locations. The genotype IR 84887-B-15 performed well under irrigated (transplanted) condition. It was found that genotype R-RF-65 did well under rainfed condition and genotype R-RF-78 performed well under terminal stage drought condition. So concluded that genotype IR 84887-B-15 consistently performed well under irrigated control and terminal stage drought condition, therefore, it is one of good genotype had drought tolerance capacity. The magnitude of PCV estimates was higher than GCV estimates whereas moderate GCV along with PCV was recorded for grain yield followed by number of filled grains per panicle. The high heritability estimates were observed for the characters *viz*., days to 50% flowering and grain yield and the traits like grain yield, biological yield and harvest index showed high genetic advance as percentage of mean.

Key Words : Drought tolerance, Variance, GCV, PCV, Heritability, Genetic advance, Diverse ecosystem

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Rice (*Oryza sativa* L.) is one of the world's most important crop, particularly in Asia, here, above 90% of the world's rice is produced and consumed. Average daily intake of rice provides 20-80 per cent of dietary energy and 12-17 per cent dietary proteins for Asians (Chopra, 2001).Drought frequently reduces grain yield of rainfed lowland rice. A series of experiments were conducted to study the magnitude and consistency of yield responses of diverse, rainfed lowland rice genotypes to drought stress environments and to examine ways to identify genotypes that confer drought resistance. Crop performance like yield is a cumulative effect of its component traits which is largely influenced by environment. Therefore, genotype × environment interaction is major concern for the plant breeder to develop improved variety. To evaluate the relative performance of the genotypes to varying environments, Multi environmental trials (METs) are widely conducted by plant breeders. Thus, the present study was conducted to identify the high heritable and advance genotypes of rice for different yield component under diverse ecosystem.

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MATERIAL AND METHODS

The experimental material comprised of 45 rice breeding lines and varieties which included 37 advanced generation material (F_7 onwards) of various crosses, along with 8 check varieties *viz*., R-RF-69, R-RF-84, R-RF-74, R-RF-75, R-RF-85, R-RF-88, R-RF-90, R-RF-82, R-RF-83, R-RF-92, R-RF-93, R-RF-94, R-RF-95, R-RF-97, R-RF-104, R-RF-87, R-RF-78, R-RF-81, R-RF-65, R-RF-23, R-RF-82 , IR 83376-B-B-150-3, IR 84882-B-120-CRA-6-1-1, IR 84887-B-153-CRA-25-1, PM 4 22, IR 86840-16-1-1-4, IR 86857-101-2-1-2, IR 83929-B-B-132-2, IR 83929-B-B-132-3, IR 82635-B-B-47-1, IR 85735-42-1-4-4, IR 86857-46-1-1-2, IR 86781-3-3-1-1, IR 83381-B-B-38-3, IR 83383-B-B-129-3, IR 83372-B-B-133-2, IR 83383-B-B-140-4, IR 86857-101-2-1-2, Annada, MTU 1010, IR 64, Mahamaya, Poornima, Samleshwari, Vandana, and Danteshwari were sown in randomized complete design with two replications in paired row of 5 meter length, spacing between plant and row was maintained at 20 × 15 cm. For these analysis plants were sown in diverse condition at different time *viz*., under rainfed situation, the materials were sown as direct seeded on 1st July for rainfed direct sown in clay soil, for terminal stage drought, the sowing was delayed by 17 days *i.e*. on 18th July as compared to the rainfed situation and sowing of irrigated transplanted condition (control) was done on June 25th 2011). The data on various characters were recorded either on five-plant basis or on plot basis. The observations were taken like, plant height (cm), panicle length (cm), number of filled grain panicle^{-1}, number of unfilled grain panicle^{-1}, number of total grain panicle^{-1}, biological yield (g/sqm), grain yield (g/sqm), harvest index (%), seed weight (g), L/B ratio and leaf rolling per plant whereas, data were recorded for days to 50% flowering on plot basis and the analysis was done for GCV and PCV, heritability and genetic advance.

RESULTS AND DISCUSSION

The 45 genotypes including advanced breeding material, parent lines and standard checks were evaluated under rainfed (direct sown), terminal stage drought (transplanted) condition and irrigated (transplanted) as control condition. The analysis of variance showed highly significant difference among the genotypes for all the traits under all the locations (Table 1). This suggested the presence of substantial variability among the material. This was also expected as the genotypes involved in the evaluation had entirely different expressions for large number of traits including morphological, phenological and reaction to water stress. These results are in agreement with the results of Singh *et al.* (1984); Rahangdale and Khorgade (1988) and Gomez and Kalamani (2003) who have reported lot of genetic variability for these traits.

The mean data of individual lines were statistically analyzed to generate over all mean and other genetical parameters. The mean and variability parameters for different quantitative characters, under present study are presented in

Table 1: Analysis of variance for twelve quantitative characters under different conditions

Characters	Conditions	Irrigated (transplanted)			Rainfed (direct seeded)			Terminal stage drough(transplanted)		
	Source	Replication	Genotype	Error	Replication	Genotype	Error	Replication	Genotype	Error
	d.f.	1	44	44	1	44	44	1	44	44
Days to 50% flowering	MSS	3.6	48.12**	0.5	10.0	81.82**	1.5	16.0	517.22**	10.1
Plant height (cm)	MSS	138.1	212.0**	24.2	168.1	137.13**	26.8	19.3	281.83**	23.3
Panicle length (cm)	MSS	2.6	4.66*	3.0	2.2	5.43**	2.4	1.2	5.7**	2.3
No. of filled grain panicle^{-1}	MSS	828.1	17394.3**	5828.9	17696.0	9204.7**	3228.6	3121.1	11369.6**	437.5
No. of unfilled grain panicle^{-1}	MSS	28765.3	3856**	1530.6	1432.0	3126.4**	839.4	86.0	8539.8**	142.0
No. of total grain panicle^{-1}	MSS	19832.2	26589.6**	9067.7	9060.1	13385.1**	4176.8	4243.6	23014.5**	619.6
Biological yield (g/sq.m)	MSS	26778.5	138327.09**	20514.2	18265.6	75161.14**	7610.1	2866.7	100072.3**	18613.0
Grain yield (g/sq.m)	MSS	13913.9	20172.5**	1112.9	268600	19518.5**	1391.1	525.5	24750.3**	2291.1
Harvest index (%)	MSS	1.3	26.1*	22.4	0.0	108.2**	17.7	26.5	83.8**	18.9
Seed weight (g)	MSS	0.0	0.121**	0.1	0.1	0.156**	0.0	0.2	0.21**	0.1
Leaf rolling	MSS	-	-	-	10.0	5.9**	1.8	-	-	-
L/B ratio	MSS	0.1	0.71*	0.3	0.1	0.596**	0.5	0.0	1.09**	0.0

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 3 and 4. Under irrigated condition, early flowering was taken by Vandana (check) while, IR 64 took delayed flowering. In rainfed condition, R-RF-82 flowered earliest while IR 86857-101-2-1-2 took maximum days for flowering and under TSD condition R-RF-75 flowered normally but IR 86857-101-2-1-2 flowered delayed. The delay in flowering under stress condition compared to irrigated condition is a typical feature of most of the rice genotypes. More delay indicates more susceptibility to water stress and *vice versa*. But the findings in the present study were found to be contradictory to the earlier findings. When mean value of terminal stage drought condition was compared with the mean value of irrigated condition, it was found that the genotypes showed reduction in days to 6.9 days for flowering under terminal stage drought condition (due to genotype R-RF-75 and PM-4 22) which is an unusual feature as far as rice, is concerned. Although the above attribute was found to be at par when means of rainfed and irrigated conditions were compared. It has been reported by Angus and Moncor (1977) in case of wheat. The genotypes in the present study also showed similar results as far as plant height is concerned. Irrigated condition showed more plant height than other conditions which was 12.2 cm more than rainfed condition and 8.2cm than terminal stage drought condition, IR 86840-16-1-1 showed highest plant height (137.5cm) and R-RF-74 (92cm) showed lowest plant height under irrigated condition. Under rainfed condition genotype PM 4 22 showed highest plant height and R-RF-69 showed lowest plant height and under terminal stage drought condition IR 83372-B-B-133-2 showed highest plant height and R-RF-69 showed lowest plant height. Reduction in plant height under water stress has been reported by many workers such as Kumar (1992) and Nadarajan and Kumaravelu (1994).

The panicle length also showed similar patterns to that of plant height. Irrigated condition showed more panicle length rather than other conditions which was 1.2 cm more than rainfed condition and 0.4 cm more than terminal stage drought condition. Reduction in panicle length under water stress has been reported by many workers such as Nandarajan and Kumaravelu (1994) and Imanywoha *et al.* (2004). Highest panicle length was recorded for IR 86840-16-1-1 (27.36 cm) under irrigated condition and (28.6 cm) under rainfed condition, IR 86781-3-3-1-1 (27.78 cm) under terminal stage drought condition which is higher than normal condition's panicle length. Least values for panicle length were recorded by IR 83381-B-B-38-3 (19.7cm) under irrigated condition, Vandana (check) (20.41 cm) under rainfed and R-RF-74 (19.46 cm) under terminal stage drought condition. The decrease in the mean value of number of filled grains per panicle was observed under stress condition compared to the irrigated condition. It was 104.03 for rainfed condition and 156.9 for terminal stage drought condition, as compared to the irrigated condition (409.53). Under rainfed condition, R-RF-81 showed highest (522.5) filled grains per panicle while, R-RF-78 showed lowest (220.5) filled grains per panicle. Under terminal stage drought condition PM-4 22 showed highest (391.5) filled grains per panicle while IR 64 showed lowest (118) filled grains per panicle. In irrigated condition PM-4 22 showed highest (605) filled grains per panicle while R-RF-78 showed lowest (226.5) filled grains per panicle. The decrease in grains filling per cent in rainfed and terminal stage drought (TSD), due to water stress has been reported by Jin *et al.* (2004). An increase in the mean value of unfilled grains per panicle under rainfed condition was observed as compared to the irrigated condition. Under rainfed condition genotype IR 83383-B-B-140-4 showed highest (156.0) unfilled grains and under terminal stage drought condition highest (242.5) unfilled grains was observed for genotype IR 82635-B-B-47-1. In irrigated condition genotype IR 86857-101-2-1-2 showed highest unfilled grain *i.e.*177.5.

The mean value for hundred seed weight was recorded as 2.63 g under irrigated, 2.41 g under rainfed and 2.33 g under terminal stage drought conditions, respectively. R-RF-84 remarkably showed highest value for hundred seed weight under irrigated conditions (3.4 g). Under rainfed condition, IR 83372-B-B-133-2 (2.9 g) and under terminal stage drought condition I R-RF-74 (3.3 g) showed highest value for hundred seed weight. R-RF-90 (2.1 g) showed least hundred seed weight in irrigated, Samleshwari (check) (1.63g) showed lowest in rainfed and IR 83383-B-B-140-4 (1.73 g) showed lowest hundred seed weight in terminal stress drought. Reduction in seed weight due to water stress has also been reported by Joseph and Havanagi (1988) and Das *et al.* (2005). The observation of biological yield was highest under irrigated condition for R-RF-95 (1460.42 g/sq.m), under rainfed condition for R-RF-69 (868.33 g/sq.m), and under TSD condition for IR 84887-B-15 (1378.68 g/sq.m). Under irrigated condition for IR 85735-42-1-4-4 (205.769 g/sq.m), under rainfed condition for Vandana (104.16 g/sq.m) and under TSD condition for R-RF-93 (351.47 g/sq.m) showed least value of biological yield. For harvest index, the mean value of irrigated condition was 41.66%. IR 85735-42-1-4-4, (48.58%) showed highest and IR 64 (34.54%) showed lowest harvest index in this condition. The mean value of harvest index under rainfed condition was 40.12%, R-RF-65 (49.79%) showed highest and Samleshwari (check) (22.36%) showed lowest harvest index in this condition, the mean value of harvest index under TSD condition was 34.93%, R-RF-78 (48.46%) showed highest and Mahamaya (check) (12.18%) showed lowest harvest index in this condition. The mean value for L/B ratio of paddy was recorded as 3.84 for irrigated condition and 3.8 for rainfed condition while under terminal stage drought condition it was 3.93. R-RF-93 showed least value (3.12) for L/B ratio of paddy in irrigated condition and (2.59) for TSD condition, and Annnada (check) (2.55) showed least value in rainfed condition. The highest value for L/B ratio of paddy was recorded for R-RF-75 (6.05) under irrigated

Table 2 : Yield (g/sq.m) of best five genotypes under different conditions

Irrigated		Rainfed		TS Drought	
Entries	Yield (g/sq.m)	Entries	Yield (g/sq.m)	Entries	Yield (g/sq.m)
IR 84887-B-15	573.07	R-RF-65	393.05	R-RF-78	639.45
R-RF-95	533.65	R-RF-82	363.89	IR 84887-B-15	560.09
PM 4 22	510.57	R-RF-81	363.88	R-RF-94	541.95
Samleshwari	494.23	R-RF-69	362.5	R-RF-92	467.12
IR 83376-B-B-150-3	480.76	R-RF-75	345.83	Poornima	464.85

Table 3 : Genetic variability of different characters for different genotypes in wet season 2011

Characters	Condition	Parameters								
		1	2	3	4	5	6	7	8	9
Days to 50% flowering	Irrigated	77.8	87.5	69.0	29.6	6.2	6.3	97.9	9.9	12.7
	Rainfed	84.8	94.5	72.0	18.5	7.4	7.6	96.3	12.7	15.0
	TSD	70.9	81.0	67.0	14.0	22.4	22.8	96.1	9.9	14.0
Plant height (cm)	Irrigated	108.1	137.5	92.0	45.5	8.9	10.0	79.5	17.8	16.4
	Rainfed	94.7	116.6	82.0	26.6	7.8	9.5	67.3	12.6	13.3
	TSD	95.5	128.0	76.1	51.8	11.8	12.9	84.6	21.4	22.4
Panicle length (cm)	Irrigated	24.5	27.3	19.7	7.6	3.6	7.9	21.3	0.8	3.5
	Rainfed	23.3	28.6	20.4	8.1	5.3	8.4	39.3	1.5	6.8
	TSD	24.1	27.7	19.4	8.3	5.1	7.9	41.5	1.7	6.7
No. of filled grain	Irrigated	409.5	605.0	226.5	378.5	18.5	26.3	49.8	109.9	26.8
panicle^{-1}	Rainfed	305.5	522.5	220.5	302.0	17.8	25.8	48.0	78.8	25.8
	TSD	246.7	391.5	118.0	273.5	29.9	31.1	92.5	146.1	59.2
No. of unfilled grain	Irrigated	89.1	177.5	21.5	156.0	38.2	58.2	43.1	48.5	54.5
panicle^{-1}	Rainfed	68.9	156.0	15.0	141.0	49.0	64.5	57.6	52.8	76.5
	TSD	131.7	242.5	20.0	222.5	49.1	50.0	96.7	130.5	99.1
No. of total grain	Irrigated	498.7	716.0	254.0	462.0	18.7	26.7	49.1	135.2	27.1
panicle^{-1}	Rainfed	374.5	524.0	235.5	288.5	18.1	25.0	52.4	101.2	27.0
	TSD	378.5	601.0	185.0	416.0	27.9	28.7	94.7	211.4	55.8
Biological yield (g/sq.m)	Irrigated	958.3	1460.3	205.7	1245.5	25.3	29.4	74.1	428.9	44.7
	Rainfed	517.0	863.3	104.1	759.1	35.5	39.3	81.6	340.9	65.9
	TSD	984.2	1378.6	351.4	1027.2	20.5	24.7	68.6	342.5	3.8
Grain yield (g/sq.m)	Irrigated	392.2	573.0	92.3	480.7	24.8	26.2	89.5	190.6	48.5
	Rainfed	212.8	393.0	41.6	351.3	44.7	48.0	86.6	181.8	85.4
	TSD	343.8	639.4	124.7	514.7	30.8	33.8	83.0	197.8	57.5
Harvest index (%)	Irrigated	41.6	48.5	34.5	14.0	3.2	11.8	7.6	0.7	1.8
	Rainfed	40.1	49.7	22.2	27.4	16.7	19.7	71.9	11.6	29.1
	TSD	34.9	16.3	20.5	63.1	9.2	26.6	48.4	12.1	36.2
Seed weight (g)	Irrigated	2.6	3.3	2.1	1.2	6.9	11.3	37.6	0.2	8.7
	Rainfed	2.4	2.9	1.6	1.3	9.7	13.2	53.6	0.3	14.6
	TSD	2.3	3.3	1.7	1.6	12.1	15.8	58.9	0.4	19.2
Leaf rolling	Irrigated	-	-	-	-	-	-	-	-	-
	Rainfed	4.2	7	1	6	33.8	46.5	52.8	2.1	51.1
	TSD	-	-	-	-	-	-	-	-	-
L/B ratio	Irrigated	3.8	6.0	2.6	3.3	9.3	19.8	22.2	0.3	9.0
	Rainfed	3.8	4.8	2.5	2.3	10.7	17.1	39.2	0.5	13.8
	TSD	3.9	5.6	2.5	3.0	18.6	19.0	95.4	1.4	37.2

TSD = Terminal stage drought;
1= mean; 2=maximum; 3=minimum; 4=range; 5=Genotypic coefficient of variation (GCV); 6=Phenotypic coefficient of variation (PCV);
7= heritability; 8=genetic advance and 9=genetic advance as percent of mean

condition, (4.88) under rainfed condition, and (5.65) under terminal stage drought condition. Grain yield *per se* is very important from the farmer's point of view and the yield is more important as compared to survival under stress. Noticeable reduction was observed among the genotypes for grain yield, under rainfed and terminal stage drought condition when compared to irrigated condition as control. During *Kharif* 2011, the mean grain yield was lowest under rainfed condition (212.87 g/sq.m), which was expected as the plant experienced drought. However, the reduction in yield was different for different genotypes. The yield performance of best five genotypes under each condition is presented in Table 2.

The estimates of GCV and PCV for the genotypes under all the three sets of conditions are presented in Table 5. The magnitude of PCV estimates was higher than the GCV under all the conditions. The estimates of GCV and PCV for grain yield ranged from low to high under all condition. Wide range of variability for yield attributing traits has been reported earlier by other workers (Chauhan and Tandon, 1984; Singh *et al.*, 1984; Gomathinayagam *et al.*, 1990; Patil *et al*., 2003). Characters plant height, L/B ratio and seed weight showed low GCV along with low PCV and moderate GCV along with moderate PCV was recorded for grain yield followed by number of filled grains per panicle under all the three condition. Under irrigated condition maximum characters like days to 50% flowering, panicle length, and harvest index showed low GCV along with low PCV. Grain yield showed

Table 4 : Lines showing highest and lowest mean value for different characters under the three sets of conditions

Sr. No.	Characters	Condition	Lines showing highest value		Lines showing lowest value	
			Name	Value	Name	Value
1.	Days to 50% flowering	Irrigated	IR-64	87.5	Vandana	69.0
		Rainfed	IR 86857-101-2-1-2	94.5	R-RF-82	72.0
		TS D	IR 86857-101-2-1-2	81.0	R-RF-75	67.0
2.	Plant height (cm)	Irrigated	IR 86840-16-1-1	137.5	R-RF-74	92.0
		Rainfed	PM-4-22	116.6	R-RF-69	82.0
		TS D	IR 83372-B-B-133-2	122.0	R-RF-69	76.1
3.	Panicle length (cm)	Irrigated	IR 86840-16-1-1	27.3	IR 83381-B-B-38-3	19.7
		Rainfed	IR 86840-16-1-1	28.6	Vandana	20.4
		TS D	IR 86781-3-3-1-1	27.7	R-RF-74	19.4
4.	No. of filled grain panicle^{-1}	Irrigated	IR 86857-101-2-1-2	177.5	R-RF-83	21.5
		Rainfed	IR 83383-B-B-140-4	156.0	R-RF-78	15.0
		TS D	IR 82635-B-B-47-1	242.5	R-RF-88	20.0
5.	No. of unfilled grain	Irrigated	PM-4-22	605.0	R-RF-78	226.5
	panicle^{-1}	Rainfed	R-RF-81	522.5	R-RF-78	220.5
		TS D	PM-4-22	391.5	IR-64	118.0
6.	No. of total grain panicle^{-}	Irrigated	R-RF-81	716.0	R-RF-78	254.0
		Rainfed	IR 86840-16-1-1	524.0	R-RF-78	235.5
		TS D	IR 86781-3-3-1-1	601.0	R-RF-78	186.0
7.	Biological yield (g/sq.m)	Irrigated	IR 84887-B-15	573.0	R-RF-93	92.3
		Rainfed	R-RF-65	393.0	Vandana	41.6
		TS D	R-RF-78	639.0	Mahamaya	124.7
8.	Grain yield (g/sq.m)	Irrigated	R-RF-95	1460.4	IR 85735-42-1-4-4	205.7
		Rainfed	R-RF-69	868.3	Vandana	104.1
		TS D	IR 84887-B-15	1378.6	R-RF-93	351.4
9.	Harvest index (%)	Irrigated	IR 85735-42-1-4-4	48.5	IR-64	34.5
		Rainfed	R-RF-65	49.7	Samleshwari	22.3
		TS D	R-RF-78	48.4	Mahamaya	12.1
10.	Seed weight (g)	Irrigated	R-RF-84	3.4	R-RF-90	2.1
		Rainfed	IR 83372-B-B-133-2	2.9	Samleshwari	1.6
		TS D	R-RF-74	3.3	IR 83383-B-B-140-4	1.7
11.	L/B ratio	Irrigated	R-RF-75	6.0	R-RF-93	2.6
		Rainfed	R-RF-75	4.8	Annada	2.5
		TS D	R-RF-75	5.6	R-RF-93	2.5

moderate GCV along with moderate PCV followed by other characters like biological yield, number of filled grains per panicle and number of total grains per panicle. High GCV along with high PCV recorded for number of unfilled grains per panicle under this condition. Under rainfed condition low GCV along with low PCV recorded for days to 50% flowering followed by plant height, panicle length, L/B ratio and seed weight. Characters like number of filled grains per panicle, number of total grains per panicle, harvest index and leaf rolling showed moderate value of GCV and PCV and other characters like grain yield, biological yield and no. of unfilled grains per panicle showed high GCV along with high PCV. Under terminal stage drought condition characters like plant height, panicle length, test weight and L/B ratio showed low GCV and low PCV. Moderate GCV along with low PCV was recorded for grain yield followed by biological yield, harvest index, days to 50% flowering, number of filled grains per panicle and number of total grains per panicle. High GCV and high PCV was only recorded for the character number of unfilled grains per panicle. High estimates of GCV and PCV for number of unfilled grains per panicle have been reported by Hussain *et al.* (1987) and Borbora and Hazarika (1998). Hazarika (1998) have reported moderate estimates of GCV and PCV for grain yield. Low GCV for days to 50% flowering and panicle length was reported by Kaw *et al*. (1999).

Heritability in the broad sense was recorded for all characters in all the genotypes under each set of condition presented in Table 3. The high heritability estimates (>70%) were observed for the characters *viz*., days to 50% flowering and grain yield under all the three conditions. In irrigated condition the high heritability estimates (>70%) were observed for the characters *viz*., days to 50% flowering (97.99%), plant height (79.52%), grain yield (89.54%) and biological yield (74.17%). Low levels of heritability (<50%) were found for panicle length (21.34%), harvest index (7.63%), no. of filled grains per panicle (49.80%), no. of unfilled grains per panicle (43.16%), no. of total grains per panicle (49.1%), seed weight (37.61%) and L/B ratio (22.21%). Under this condition moderate heritability was not estimated for any character. Under rainfed condition high heritability estimates (>70%) were observed for the characters like days to 50% flowering (96.39%), grain yield (86.69%), biological yield (81.61%) and harvest index (71.94%). Moderate estimate of heritability (50-70%) was found for plant height (67.3%), no. of unfilled grains per panicle (57.66%), no. of total grains per panicle (52.43%), leaf rolling (52.87%) and seed weight (53.63%). Low estimate of heritability (<50%) were found for panicle length (39.31%), no. of filled grains per panicle (48.06%) and L/B ratio (39.25%). In terminal stage drought condition the high estimates of heritability were observed for the characters *viz*., days to 50% flowering (96.15%), plant height (84.69%), grain yield (83.05%), no. of filled grains per panicle (92.58%), no. of unfilled grains per panicle (96.72%), no. of total grains per panicle (94.75%) and L/B ratio (95.44%). Moderate estimate of heritability was found for biological yield (68.63%) and harvest index (63.16%) and low levels of heritability were found for panicle length (41.56%). The high estimates of heritability was observed for days to 50% flowering which is in accordance with the findings of Chauhan *et al.* (1993); Verma *et al.* (2000) and Chandra and Pradhan (2003). High heritability for number of filled grains has been reported by Chauhan *et al.* (1993). High heritability for grain yield has been reported by Chauhan and Tandon (1984); Singh (1990); Patil *et al.*(1993); Singh *et al.* (2005); Shukla *et al.* (2005) and Baber *et al*.(2007). Moderate estimates of heritability have been reported by Gomathinayagam *et al.* (1990) for biological yield.

A perusal of data of genetic advance presented in Table 3 reveals that for the genotypes under study showed a similar pattern for grain yield to that of heritability, genetic advance

Table 5 : Summary of estimates of genotypic co-efficient of variation (GCV), phenotypic co-efficient of variation (PCV), heritability (h^2) and genetic advance as percentage of mean ($\overline{GA}$) for different characters at different conditions

Sr. No.	Characters	Irrigated				Rainfed				TS Drought			
		GCV	PCV	h^2	$\overline{GA}$	GCV	PCV	h^2	$\overline{GA}$	GCV	PCV	h^2	$\overline{GA}$
1.	Days to 50% flowering	L	L	H	L	L	L	H	L	M	M	H	L
2.	Plant height (cm)	L	L	H	L	L	L	M	L	L	L	H	M
3.	Panicle length (cm)	L	L	L	L	L	L	L	L	L	L	L	L
4.	Number of filled grains per panicle	M	M	L	M	M	M	L	M	M	M	H	H
5.	Number of unfilled grains per panicle	H	H	L	H	H	H	M	H	H	H	H	H
6.	Number of total grains per panicle	M	M	L	M	M	M	M	M	M	M	H	H
7.	Biological yield per square meter (kg/sqm)	M	M	H	H	H	H	H	H	M	M	M	L
8.	Grain yield (kg/sq.m)	M	M	H	H	H	H	H	H	M	M	H	H
9.	Harvest index (%)	L	L	L	L	M	M	H	M	M	M	M	M
10.	Hundred seed weight	L	L	L	L	L	L	M	L	L	L	M	L
11.	L/B ratio of paddy	L	L	L	L	L	L	L	L	L	L	H	H
12.	Leaf rolling	-	-	-	-	M	M	M	M	-	-	-	-

H = High value M = Moderate value L = Low value

also showed a sequential increase from well watered to water stress condition. Under irrigated condition the high genetic advance as percentage of mean (>30%) were recorded for grain yield (48.59 %), biological yield (44.76 %), no. of unfilled grains per panicle (54.5%). The moderate genetic advance as percentage of mean (20-30%) was observed for no. of filled grains per panicle (26.84%) and no. of total grain per panicle (27.11%). The low genetic advance as percentage of mean (<20%) was recorded for plant height (16.47%), panicle length (3.508%), days to 50% flowering (12.72%), harvest index (1.84%), seed weight (8.74%) and L/B ratio (9.02%). In rainfed condition the high genetic advance as percentage of mean (>30%) were recorded for grain yield (85.42%), biological yield (65.94%), no. of unfilled grain per panicle (76.55%) and leaf rolling (52.87%). The moderate genetic advance as percentage of mean (20-30%) was observed for harvest index (29.13%) , no. of filled grain per panicle (25.81%) and no. of total grains per panicle (27.02%). The low genetic advance as percentage of mean (<20%) was recorded for plant height (13.33%), panicle length (6.83%), days to 50% flowering (15.05%) seed weight (14.66%) and L/B ratio (13.83%). Under terminal stage drought condition the high genetic advance as percentage of mean (>30%) were recorded for grain yield (57.54%), no. of filled grains per panicle (59.22%), no. of unfilled grains per panicle (99.1%), no. of total grains per panicle (55.85%) and L/B ratio (37.25%). The moderate genetic advance as percentage of mean (20-30%) was observed for plant height (22.44%) and harvest index (26.60%). The low genetic advance as percentage of mean (<20%) was recorded for panicle length (6.77%), days to 50% flowering (14.00%) and biological yield (3.8%).The highest genetic advance as percentage of mean was recorded for number of unfilled grains per panicle which is in confirmation to the findings of Satyanarayan *et al.* (2005). High genetic advance as percentage of mean for grain yield has been reported by Patil *et al.* (1993); Rao and Shrivastava (1994); Shukla *et al.*(2005) and Muthuswamy and Kumar (2006). High genetic advance as percentage of mean for biological yield has been reported by Gomathinayagam (1990); Patil *et al.* (1993); Gomez and Kalamani (2003) and Shukla *et al.* (2005). High genetic advance as percentage of mean for harvest-index has been reported by Chauhan *et al.* (1993) and Shukla *et al.* (2005). Low genetic advance as percentage of mean for panicle length has been reported by Chandra and Pradhan (2003). Low genetic advance as percentage of mean plant height has been reported by Gomathinayagam (1990).

Conclusion:

The analysis of variance showed highly significant difference among the genotypes for all the traits under all the locations. The 45 genotypes were evaluated under three conditions. IR 84887-B-15 performed well under irrigated condition yielded high whereas under rainfed condition R-RF-65 and in TSD condition R-RF-78 gave highest yield followed by IR 84887-B-15, R-RF-94, R-RF-92 and Poornima. It was found that genotype IR 84887-B-15 consistently performed well under irrigated control and terminal stage drought condition, so it is one of good genotype had drought tolerance capacity. Hence, selection for these traits would be effective for genetic improvement of quantitative traits. The magnitude of PCV estimates was higher than GCV estimates in all the condition. Characters plant height, L/B ratio and seed weight showed low GCV along with PCV and moderate GCV along with PCV was recorded for grain yield, biological yield, harvest-index and number of filled grains per panicle under all the condition. The high heritability estimates were observed for the characters *viz*., days to 50% flowering and grain yield under the three conditions. Biological yield also showed high heritability under maximum traits. The traits like grain yield, biological yield, harvest index and no. of unfilled grains per panicle showed high genetic advance as percentage of mean.

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