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Genetic Variability Analysis in Rice Genotypes under Drought Stress

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ABSTRACT: Rice production is hindered by various environmental factors, among which the most important one is water crisis. Crop improvement under drought stress condition is a crucial and challenging task. To develop high yielding genotypes combined with drought tolerance, population with high variability serves as a principal source for effective and successful selection. Hence the present study aims to assess the variability parameters among the rice genotypes under normal and drought environments. The field experiments were laid out in two environments *viz*., normal and drought conditions using RBD design with three replications at the research field of Pandit Jawaharlal Nehru College of Agriculture and Research Institute (PAJANCOA & RI), Karaikal. Drought environment was maintained up to peak tillering phase until the drought symptoms appeared over the crop. Traits such as days to 50 per cent flowering, plant height, productive tillers, panicle length, grains per panicle, grain weight, grain yield, relative water content, leaf senescence, leaf rolling, leaf drying and stress percentage were observed. The genotypes IW Ponni and Moroboreken had registered the maximum grain yield under normal and drought environments respectively. The results shown that PCV and GCV were high for grains per panicle and grain yield under both normal and drought environments. In drought related traits, leaf senescence, leaf rolling, leaf drying and stress percentage had recorded high magnitude of PCV and GCV. High heritability combined with high to moderate genetic advance were observed for days to 50 per cent flowering, productive tillers, grains per panicle and grain yield under both normal and drought environments. Leaf senescence, leaf drying and stress percentage had shown high heritability accompanied with high genetic advance under drought environment. Hence, it was concluded that these traits offer much scope for drought tolerance improvement through simple selection techniques.

Keywords: Rice, Drought, PCV, GCV, Heritability.

INTRODUCTION

Rice is considered as a prime most food intake for about 2.5 billion of World population. It plays a vital role in the Indian agriculture as it is a staple food for more than 70% of population (Devi *et al*., 2022). It was predicted that 15–20 million hectares of irrigated rice will face water crisis by 2025 (Venkateshwarlu *et al*., 2022; Wu *et al.*, 2017). In Cauvery delta zone rice occupies a pivotal place as it is acting as a rice bowl for Tamilnadu and Puducherry regions. Here rice is cultivated in irrigated lowland under puddled flooded condition using Cauvery River water. Karaikal, U.T of Puducherry falls under tail end region of Cauvery delta zone. The rice crop cultivated in this region faces late receipt and inadequate supply of Cauvery River water, which is the major irrigation source of this region and further deficit, irregular and frequent failures of monsoons resulted in water shortage leading to steady reduction or decrease in area under rice cultivation in this highly productive region. Therefore, water stress is a major factor limiting rice production that causes a great threat to food security (Fellahi *et al*., 2013). To reduce yield losses of rice crops in water deficient areas and to increase the overall rice production, rice varieties with greater adaptation to drought stress are essential.

Although plenty of studies are reported on drought tolerance of crops, crop improvement in this part is hampered due to several unknown mechanisms involved in respond to drought stress (Aghaei *et al.*, 2017; Zu *et al.*, 2017; Zhu *et al.*, 2016). Drought tolerance is a complex trait associated with number of morphophysiological traits (Ahmed *et al*., 2021). A judicious phenotypic evaluation may be helpful in direct selection of drought tolerant genotypes with good yield potential.

Keeping the known fact in the mind that crop improvement depends on the magnitude of genetic variability and the extent to which the desirable traits are heritable, the present study was aimed to assess the variability parameters among the rice genotypes under normal and drought environments.

MATERIALS AND METHODS

The plant material includes forty-eight rice genotypes in which 32 advanced breeding lines are medium duration from the AICRIP - Initial variety Trial – irrigated medium (Kharif, 2018). The aim of including advanced breeding lines is to study their performance among each other (i.e., between genotypes) under drought and normal environments. Varieties included in the trial are popularly cultivated in Cauvery delta region. Here the main aim is to compare these varieties between normal and drought environment for their relative performance. Along with these genotypes six drought tolerant lines were also planted. The details of these genotypes are presented in Table 1.

The experiments *viz*., normal and drought environment were conducted simultaneously in two adjacent plots of 20 cents field area at Pandit Jawaharlal Nehru College of Agriculture and Research Institute (PAJANCOA & RI), Karaikal. Forty-eight rice genotypes were sown in three lines per entry under raised bed nursery. Twenty-five days old seedlings were planted in the experimental blocks, where they were equally partitioned to two separate experiments one under normal environment and other under drought environment in randomized block design (RBD) with three replications. Each genotype was planted in three rows with the spacing of 20 × 10 cm within genotype and 30 cm spacing between two genotypes. Both the fields were in puddled condition during transplanting of seedlings. The total amount of rainfall during the crop period was 96.9 cm (IMD, 2018) with dry spell of 4 weeks. The trial is under sufficient water stress during the vegetative period.

Table 1: Details of rice genotypes used in the experiment.

G. No.	Genotype	G. No.	Genotype	G.No.	Genotype
	Drought lines		**Advanced lines**	G32	IVT-119/1511
G1	DRR DHAN-42	G16	TKM 13	G33	IVT-120/1534
G2	DRR DHAN-44	G17	IVT-101/1563	G34	IVT-121/1529
G3	DULAR	G18	IVT-102/1557	G35	IVT-122/1517
G4	KALIUS	G19	IVT-103/1531	G36	IVT-123/1521
G5	MOROBOREKEN	G20	IVT-104/1551	G37	IVT-125/1558
G6	N-22	G21	IVT-105/1528	G38	IVT-127/1547
	Varieties	G22	IVT-106/1540	G39	IVT-128/1555
G7	ADT 39	G23	IVT-107/1507	G40	IVT-129/1519
G8	ADT 43	G24	IVT-109/1501	G41	IVT-130/1530
G9	ADT46	G25	IVT-110/1508	G42	IVT-132/1535
G10	ADT49	G26	IVT-111/1526	G43	IVT-134/1560
G11	CO(R)50	G27	IVT-112/1509	G44	IVT-135/1518
G12	CO(R)52	G28	IVT-113/1550	G45	IVT-136/1527
G13	CR1009	G29	IVT-115/1520	G46	IVT-137/1523
G14	IW PONNI	G30	IVT-141/1537	G47	IVT-138/1502
G15	MDU 1010	G31	IVT-118/1503	G48	IVT-139/1542

*significance at 5% level **significance at 1% level

Vegetative stage drought is more experienced in Cauvery delta zone, in which Karaikal region is most vulnerable for transplanted seedlings stage during late samba because of late receipt and inadequate supply of Cauvery River water. Hence, water stress is imposed after 15 days of transplanting in the drought field while the normal field was irrigated for 5 cm of water depth at frequent intervals. The drought environment was allowed for drying for the disappearance of water till the formation of fine cracks or hairline cracks indicating the moisture level below the soil surface (>15cm) and this condition was maintained up to peak tillering phase (20 days) until the drought symptoms appeared over the crop as reported by Manickavelu *et al*. (2006) (Fig. 1) while the normal field was kept flooded (Fig. 2). In rice once the plants attain 70% RWC, it indicates real physiological stress of the plant irrespective of environment (Manickavelu *et al*., 2006). Hence the RWC was taken at 5 days intervals after 2 weeks of draining water. When most of the recorded entries reach RWC of 70% on clay loam soil, then drought scores related traits were recorded. Here we have taken RWC as criteria to predict physiological stress occurrence.

Observations were recorded on five randomly selected plants of each genotype per replication in both the experiments for yield component traits *viz*., days to 50% flowering (DF), plant height (PH), productive tillers (PT), panicle length (PL), grains per panicle (GP), grain weight (GW) and grain yield per plant (GY). Additionally, when most of the genotypes attained 70% RWC level, the scoring of leaf rolling

(LR), leaf drying (LD) and leaf senescence (LS) were observed according to Standard Evaluation System adopted for rice (IRRI, 1996) in drought environment.

Fig. 1. Moisture stress imposed during active tillering stage in drought field.

Fig. 2. Maintenance of flooded environment during active tillering stage in normal field.

Statistical analysis. Mean, variance and standard deviation were worked out by adopting the standard method suggested by Panse and Sukhatme (1967). The analysis of variance was carried out individually for each environment (Table 2). Pooled analysis of variance was also performed for normal and drought environment to assess the significance of genotypes across the environments, between the environments and interaction of genotypes with environments as suggested by Singh and Chaudhary (1977). The phenotypic and genotypic variances were estimated as per Lush (1940). The phenotypic and genotypic coefficient of variations were estimated using the formula suggested by Burton (1952) and expressed in percentage. Heritability in broad sense was calculated according to Lush (1940) and expressed in percentage. Genetic advance as per cent of mean was worked out based on the formula given by Johnson *et al*. (1955).

Table 2: Analysis of variance for observed traits under drought and normal environment.

Traits	Mean sum of square	
	Drought	**Normal**
Days to 50 % flowering	232.26**	278.32**
Plant height	280.15**	333.40**
Productive tillers	7.83**	5.37**
Panicle length	9.16**	13.28*
Grains per panicle	5106.00**	7323**
Grain weight	0.42**	0.33**
Grain yield	113.71**	111.11**
Relative water content	101.71*	NA
Leaf senescence	8.21**	NA
Leaf rolling	1.22	NA
Leaf drying	1.18**	NA
Stress %	1109.90**	NA

RESULTS AND DISCUSSION

Mean Performance. Forty-eight genotypes were evaluated for their mean performance of twelve characters *viz*., seven characters under both normal and drought environment and additional five characters under drought environment.

The genotypes Moroboreken and N-22 had exhibited early flowering in normal and drought environments respectively. The shortest genotypes observed are IVT-129/1519 and IVT-132/1535 while tallest genotypes are Moroboreken and Dular under normal and drought environments respectively. Maximum number of productive tillers was produced by TKM 13 and IVT-137/1523 under normal and drought environments respectively. The genotype IVT-134/1560 under normal environment and IVT-138/1502 under drought environment had enlisted for maximum panicle length. Grains per panicle for genotype IVT-130/1530 under normal environment and for genotype IVT-141/1537 under drought environment were recorded high. The genotypes IW Ponni and Moroboreken had registered the maximum grain yield under normal and drought environments respectively. The genotype IVT-105/1528 had shown the highest relative water content under drought environment. The overall mean of these traits of the genotypes were greatly influenced by drought stress. Mean performance data were shown in Table 5 & 6.

In the present study, significant grain yield reduction was noticed under drought environment over normal environment condition by considering the overall mean performance of all the forty-eight genotypes. Venkateshwarlu *et al*. (2022) reported the same trend of yield decline under water deficit condition compared to irrigated situation. The stress prevailed in drought environment reduced greatly the number of productive tillers, grains per panicle, panicle length and grain weight. Days to 50 per cent flowering, plant height and relative water content also reduced under drought environment. This poor performance of the yield contributing traits was responsible for yield reduction realized under drought environment compared to normal environment as reported by earlier workers (Kamoshita *et al*., 2008; Ndjiondjop *et al*., 2010; Sandhu and Kumar, 2017; Bhattarai and Subudhi, 2018). However, genotypes which flowered and matured earlier may favored by partial escape from drought and have an ability to complete their life cycle. The decrease in plant height in response to drought stress may be due to decreased relative water content (Arnon, 1972). Sinclair and Ludlow (1985) proposed that RWC was better measure for plant's water status than thermodynamic state.

The visual symptoms which show that the plant is under stress condition are leaf senescence, leaf rolling and leaf drying which differed significantly among the genotypes under drought environment. The genotype DRR DHAN-44 have recorded the highest score of 3 under drought stress and the genotype IVT-102/1557 and IVT-123/1521 have recorded the lowest score of 0 (Table 6). Mitchell *et al*. (1998) had reported that mean drought score changes with time as a result of the development of plant water deficit and using drought score measured as an indirect selection criterion for grain yield, it is possible to achieve a positive response to selection for grain yield under drought environment.

Variability analysis. Variability parameters such as phenotypic variance (PV), genotypic variance (GV), phenotypic coefficient of variance (PCV), genotypic coefficient of variance (GCV), heritability (h2) and genetic advance (GA) were calculated for the traits under study separately for each environment (Table 3 & 4). Large genotypic and phenotypic variation was observed for traits such as productive tillers, grains per panicle and drought scores which indicated that these traits would respond for effective selection programme for their improvement in both the environments. This was in accordance with Mini and Mohanan (2009); Abarshahr *et al*. (2011). Henderson *et al*., 1995 have reported inconsistency of genotypic drought score measurements across environments. These results suggest that the genotypes will respond to drought stress differently, as measured by drought score, when the pattern of development of soil-plant water deficit is different. Thus, the genotypic differences in drought score are strongly influenced by the growing environment. Therefore, the environment used for screening genotypic variation of drought score at vegetative state must correspond to the target environment's wet season. The traits such as plant height and grain weight have recorded moderate genetic variation and this was same as given by Lakshmi *et al*. (2016).

Table 3: Variability parameters for the traits observed under normal environment.

Parameters	DF	PH	PT	PL	GP	GW	GY
PV	135.39	111.33	2.07	9.56	2443.00	0.17	39.01
GV	71.46	111.03	1.65	1.86	2440.00	0.08	36.05
EV	63.93	0.30	0.42	7.69	3.00	0.09	2.96
PCV	13.50	10.68	14.54	13.30	28.68	19.11	23.76
GCV	9.81	10.67	12.99	5.87	28.66	13.23	22.84
ECV	9.27	0.55	6.53	11.93	1.01	13.78	6.55
h2	52.78	99.73	79.83	19.50	99.88	47.95	92.41
GA % mean	14.67	21.95	23.91	5.34	59.01	18.87	45.24

Table 4: Variability parameters for the traits observed under drought environment.

Parameters	DF	PH	PT	PL	GP	GW	RW	LS	LR	LD	SP	GY
PV	81.00	105.27	2.71	4.85	1718.00	0.17	75.16	2.88	0.97	0.43	392.43	36.60
GV	75.63	87.44	2.56	2.38	1694.00	0.13	13.27	2.66	0.13	0.38	358.73	31.36
EV	5.37	17.83	0.16	2.47	24.00	0.04	61.89	0.22	0.84	0.05	33.70	5.24
PCV	10.62	11.38	20.86	10.03	34.14	18.91	11.12	41.57	86.27	93.12	61.19	36.65
GCV	9.65	11.03	20.26	7.02	33.90	16.42	4.67	39.96	31.17	87.55	58.50	33.92
ECV	2.73	4.68	4.99	7.16	4.04	9.38	10.09	11.49	80.45	31.72	17.93	13.87
h2	93.37	83.06	94.29	49.02	98.60	75.38	17.66	92.37	13.05	88.40	91.41	85.68
GA % mean	20.43	19.47	40.53	10.12	69.35	29.37	4.05	79.11	23.20	169.56	115.23	64.69

Table 5: Mean performance for the traits observed under normal environment.

G.No.	DF (Days)	PH (cm)	PT (No.)	PL (cm)	GP (No.)	GW (g)	GY (g)
G1	75.33	83.07	12.00	24.54	83.47	2.68	22.77
G2	80.00	101.13	11.33	22.78	144.27	2.53	28.55
G3	78.33	115.33	8.33	24.91	136.67	2.40	27.67
G4	83.67	112.67	10.33	21.39	83.07	2.59	24.68
G5	59.67	117.67	9.67	18.17	124.89	1.94	40.05
G6	74.67	102.67	9.00	17.33	92.33	1.93	12.27
G7	89.33	80.80	11.33	21.98	173.53	1.83	19.61
G8	77.33	80.27	9.33	20.34	130.47	1.77	14.01
G9	90.33	106.00	11.33	25.81	136.80	2.65	30.24
G10	90.33	105.73	11.33	23.94	165.67	1.54	31.92
G11	103.00	108.47	11.67	23.47	190.80	2.47	36.89
G12	89.00	104.27	11.33	25.80	237.20	1.73	37.27
G13	123.00	95.67	11.33	24.87	193.00	1.98	22.81
G14	97.00	106.80	9.67	23.40	259.40	1.99	44.73
G15	78.00	87.80	10.33	21.20	97.67	2.40	20.67
G16	89.67	81.23	12.33	20.93	157.67	1.49	22.69
G17	87.67	102.60	8.67	21.91	224.73	2.04	28.85
G18	87.67	109.73	8.00	24.00	171.13	2.67	27.09
G19	79.67	88.93	11.00	21.90	116.33	2.91	29.27
G20	78.33	89.08	8.67	21.47	138.20	1.87	19.30
G21	86.67	103.67	10.00	22.50	247.47	1.87	23.47
G22	76.00	98.00	9.33	24.37	181.07	2.43	21.07
G23	97.00	97.00	8.67	23.62	175.20	1.89	27.16
G24	95.67	110.93	9.00	26.49	173.47	2.32	24.29
G25	78.33	89.08	8.67	21.47	138.20	1.87	19.30
G26	91.33	90.93	8.67	22.99	197.00	1.93	29.26
G27	84.33	94.73	7.67	23.65	199.87	2.07	26.86
G28	89.67	101.93	10.33	24.55	186.33	2.19	26.38
G29	83.00	87.95	11.00	21.63	177.27	1.56	21.54
G30	98.67	105.47	10.67	25.27	262.67	1.94	24.73
G31	96.67	108.87	11.00	26.97	166.00	2.41	32.13
G32	75.33	95.33	7.33	23.75	165.20	2.60	26.70
G33	87.00	94.33	8.67	26.43	209.67	2.12	28.02
G34	89.00	102.67	9.00	24.93	194.47	2.29	29.30
G35	89.33	102.13	8.00	24.25	257.40	2.13	31.60
G36	79.33	98.60	11.00	23.00	159.00	2.27	23.09
G37	80.00	113.73	9.67	23.80	126.73	2.25	23.29
G38	86.00	103.53	11.67	22.07	104.53	2.47	25.51
G39	87.67	108.87	10.67	25.91	187.27	1.96	29.55
G40	87.00	70.93	10.67	20.55	98.13	2.25	17.52
G41	90.67	99.07	8.33	23.93	295.73	2.26	33.56
G42	80.00	85.67	10.33	21.00	199.33	1.79	26.20
G43	85.33	111.53	10.33	27.71	235.67	1.87	27.81
G44	88.33	89.80	9.00	22.27	163.73	1.82	19.30
G45	74.00	95.40	11.67	21.77	149.20	2.13	24.08
G46	94.33	105.27	8.00	24.17	166.80	2.01	23.38
G47	92.00	96.80	7.67	22.77	197.53	1.87	26.39
G48	83.00	103.73	10.67	22.98	145.07	2.52	26.48
Mean	86.20	98.87	9.89	23.23	171.19	2.14	26.24
Min	59.67	70.93	7.33	17.33	83.07	1.49	12.27
Max	123.00	117.67	12.33	27.71	295.73	2.91	44.73

Table 6: Mean performance for the traits observed under drought environment.

G.No.	DF (Days)	PH (cm)	PT (No.)	PL (cm)	GP (No.)	GW (g)	RW (%)	LS (Score)	LR (Score)	LD (Score)	SP (%)	GY (g)
G1	74.00	82.27	9.00	21.33	118.53	2.39	75.13	5.00	1.67	1.00	39.18	13.27
G2	80.00	85.45	6.00	20.10	84.20	2.50	74.12	5.00	3.00	0.33	30.00	11.04
G3	75.00	111.40	10.33	21.15	74.53	2.28	82.97	5.00	2.33	1.00	56.11	19.66
G4	79.67	106.60	11.33	20.89	73.07	2.57	80.59	5.00	1.00	1.00	34.63	20.98
G5	84.67	103.87	4.33	24.60	157.33	2.99	79.72	5.00	1.00	0.00	40.26	32.00
G6	73.67	76.20	6.00	17.60	49.60	1.76	65.82	5.00	1.00	0.33	26.67	11.02
G7	86.00	77.84	9.67	21.12	102.00	1.94	81.07	5.00	1.67	1.00	39.52	17.40
G8	77.00	78.67	9.33	21.23	78.27	1.78	80.38	5.00	2.33	1.00	43.67	14.41
G9	98.33	96.20	9.00	23.07	89.40	2.71	61.03	1.00	1.00	0.00	12.41	19.04
G10	87.67	84.03	10.00	21.63	134.20	1.47	72.44	1.00	1.00	1.00	30.19	14.44
G11	91.00	100.80	6.00	23.84	115.20	2.09	80.10	1.00	0.67	1.00	28.59	11.85
G12	88.67	95.01	8.00	23.10	108.60	1.80	73.07	5.00	0.67	0.00	24.29	13.91
G13	118.00	87.67	10.00	22.47	165.22	1.89	67.86	5.00	0.67	0.00	18.41	19.19
G14	98.67	107.93	9.00	22.67	133.07	1.94	74.64	1.00	1.00	0.00	24.11	19.73
G15	75.00	76.91	9.00	18.79	119.60	2.51	80.38	5.00	0.67	0.00	17.54	9.21
G16	83.00	78.13	10.00	19.25	108.80	1.65	81.20	1.00	1.00	1.00	19.18	18.12
G17	83.00	92.13	7.00	21.15	197.13	1.69	74.20	5.00	2.33	3.00	76.78	30.81
G18	83.00	103.07	6.00	21.14	130.40	2.76	76.18	5.00	0.00	2.33	75.23	22.56
G19	83.00	81.55	6.00	20.93	90.80	2.90	83.86	5.00	1.33	1.00	43.63	12.74
G20	80.67	80.97	8.00	20.17	104.53	2.02	79.30	5.00	1.00	0.67	41.57	9.03
G21	89.67	89.14	8.00	19.20	122.60	2.12	91.73	5.00	0.67	0.00	9.67	18.55
G22	75.67	87.90	7.00	22.72	156.93	2.47	82.32	5.00	1.67	1.00	39.67	14.58
G23	94.00	89.33	9.00	21.75	134.27	1.86	70.06	5.00	1.67	0.00	13.56	20.54
G24	91.67	99.01	7.00	24.77	157.93	1.87	73.80	5.00	0.67	0.00	17.11	25.21
G25	83.00	85.35	7.00	21.83	147.60	2.09	70.00	5.00	1.67	0.00	28.85	13.43
G26	91.00	86.70	7.00	21.29	167.20	2.02	75.15	5.00	1.00	1.00	39.74	13.74
G27	83.00	81.17	9.00	21.43	99.13	1.56	76.20	5.00	1.00	1.00	93.37	22.86
G28	87.33	93.55	8.00	22.45	123.07	2.39	78.37	5.00	1.67	1.00	35.81	19.12
G29	83.00	84.79	8.67	20.05	147.73	1.67	81.78	5.00	1.33	0.00	75.30	15.80
G30	82.00	108.33	10.33	24.53	295.73	2.13	77.99	5.00	0.67	0.00	21.48	25.14
G31	97.00	100.41	7.00	24.00	132.13	2.58	81.95	5.00	1.00	0.00	26.85	31.30
G32	75.00	90.20	4.67	23.08	137.20	2.71	81.11	1.00	0.33	1.00	27.44	13.11
G33	85.33	81.23	6.67	23.81	125.33	1.95	78.02	5.00	0.33	1.00	22.41	10.11
G34	83.00	89.39	6.67	21.93	108.73	2.21	81.09	1.00	0.67	1.00	13.04	13.75
G35	83.00	87.17	6.33	22.42	95.00	2.12	83.47	1.00	0.67	1.00	26.41	13.85
G36	80.00	85.61	7.67	21.94	107.00	2.33	79.72	5.00	0.00	1.00	14.63	16.46
G37	80.00	100.53	6.67	23.79	95.60	2.43	86.81	1.00	2.00	0.00	3.15	10.14
G38	74.00	91.57	8.33	22.90	100.47	2.31	79.14	5.00	1.67	1.00	30.78	12.20
G39	86.33	98.21	8.67	23.68	116.53	2.04	85.66	5.00	0.67	1.00	50.00	18.98
G40	78.33	76.49	8.67	21.31	93.20	2.52	76.05	5.00	1.67	1.00	33.52	14.21
G41	86.33	89.40	7.33	22.99	125.80	1.87	80.26	1.00	0.33	1.00	29.33	14.68
G42	74.67	74.50	6.33	18.41	108.93	1.63	85.30	5.00	0.67	1.00	15.63	18.34
G43	83.00	96.03	7.67	25.12	75.00	2.41	79.31	5.00	1.67	1.00	65.30	15.04
G44	83.00	85.17	8.33	21.79	145.87	1.82	76.64	5.00	1.67	1.00	28.18	11.55
G45	74.33	78.80	6.33	20.51	77.80	2.31	75.62	5.00	0.67	0.00	17.44	9.70
G46	96.33	96.47	11.33	23.80	117.13	2.48	84.71	5.00	1.33	0.00	14.63	24.68
G47	105.00	99.33	8.33	25.67	205.53	1.98	66.21	2.33	1.33	1.00	12.15	23.15
G48	83.00	95.43	7.00	21.10	73.20	2.64	79.65	3.67	0.67	1.00	26.56	13.37
Mean	84.75	90.16	7.90	21.97	121.40	2.17	77.96	4.08	1.14	0.70	32.37	16.96
Min	73.67	74.50	4.33	17.60	49.60	1.47	61.03	1.00	0.00	0.00	3.15	9.03
Max	118.00	111.40	11.33	25.67	295.73	2.99	91.73	5.00	3.00	3.00	93.37	32.00

Heritability estimates in broad sense alone do not serve as the true indicator of genetic potential of the genotypes since the scope is restricted by their interaction with the environment. The heritability estimates along with genetic advance would be more useful and valid for phenotypic selection than heritability estimates alone. Further, the heritability in broad sense includes both additive and epistatic gene effects and hence it is reliable to ascertain the worthiness of the trait only if it is accompanied with the genetic advance. High heritability accompanied with low genetic gain indicates the presence of dominance or epistatic effects. In the present investigation, estimates of genetic variability were quantified by the broad sense heritability and genetic advance as per cent mean among other genetic parameters. High heritability combined with high genetic advance was exhibited by traits such as days to 50 per cent flowering, productive tillers, grains per panicle, grain weight, grain yield, leaf senescence, leaf drying and stress percentage under drought environment. This is in accordance with Mahto *et al*. (2003) for days to 50 per cent flowering, Mini and

Mohanan (2009) for productive tillers, Sharma and Sharma (2007) for grain weight, for grain yield and Manickavelu *et al*. (2006) for leaf senescence, leaf drying and stress percentage. High heritability accompanied with high genetic advance indicates that most likely the heritability is due to additive gene effects and selection may be effective for these traits.

The trait plant height had shown high heritability with moderate genetic advance under drought condition which was similar as said by Kumar *et al*. (2014). Low heritability with low genetic advance was registered for relative water content. The condition of low heritability accompanied with low genetic advance indicates that the character is highly influenced by environmental effects. The heritability for the drought score measurements were moderate to high which was in accordance with Pantuwan *et al*. (2004). Heritability for overall stress percentage which was derived from drought score in present study was found to be lower than grain yield as reported by Pantuwan *et al*. (2004).

CONCLUSION

The results shown that the mean performance of grain yield was higher in normal environment (26.24 g) than drought environment (16.96 g). The overall mean grain yield of forty-eight rice genotypes had recorded 33.59 per cent reduction in drought environment compared to normal environment. The genotypes IW Ponni and Moroboreken had given the maximum grain yield under normal and drought environment respectively. PCV and GCV were high for grains per panicle and grain yield under both normal and drought environments. In drought related traits, leaf senescence, leaf rolling, leaf drying and stress percentage had recorded high magnitude of PCV and GCV. High heritability combined with high to moderate genetic advance were observed for days to 50 per cent flowering, productive tillers, grains per panicle and grain yield under both normal and drought environments. Leaf senescence, leaf drying and stress percentage had shown high heritability accompanied with high genetic advance under drought environment.

FUTURE SCOPE

Identifying the traits showing optimum range of genetic variability and considering these traits in breeding program are the important factors for effective crop improvement. The present studies results revealed the existence of genetic variability along with high heritability and genetic advance for most of the traits under study, which will facilitate direct selection of high yielding genotypes combined with drought tolerance. Focus on genetic variability may also effectively improve our pre-breeding line developments which can be further utilized in hybridization program for drought tolerance. Thus, it appears that the identified traits with good amount of variability among the genotypes under the present study will give a novel scope for breeding more efficient varieties with higher yield and adaptation under drought condition.

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Conflict of Interest. None.

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