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Research Article

Investigation on frequency distribution of traditional rice landraces for drought tolerance at seedling stage

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Abstract
Drought is the major constraint, adversely affecting the rice productivity in India. Emerging climate change scenario demands potential donors to develop climate resilient genotypes in order to increase the productivity of rice. In the present study, 85 traditional rice landraces and 15 improved cultivars were screened for drought tolerance potential under hydroponics, along with IR 64 and IR 64 Drt 1 as drought susceptible and tolerant checks respectively. Moisture stress was induced using PEG 6000 over a range of osmotic potentials*viz.,*(-) 1.0 Mpa, (-) 1.25 Mpa and (-)1.5 Mpafor a period of 30 days. Fifty two landraces survived under maximum osmotic potential of (-) 1.5 Mpa. Based on the phenotypic scores, six genotypes viz., *Kuliyadichan*, Rajalakshmi, Sahabhagidhan, *Nootripathu, Chandaikar* and *Mallikar* were identified to have higher degree of drought tolerance .. The investigation concluded that these six genotypes can serve as potential donors for developing drought resilient rice cultivars.

Key words
rice landraces, hydroponics, poly ethylene glycol, frequency distribution, normality

INTRODUCTION

Drought is one of the most important constraint adversely affecting the rice productivity in Asia, as it occurs for varying spells of time and intensity (Barnabas *et al*. 2008). Current and expected food requirements include the substantial increase in crop productivity on drought-prone rainfed lands (Pandey and Shukla, 2015). According to WHO, an estimated population of 55 millions were affected by drought every year, globally. Water scarcity impacts approximately 40% of the global population, and it has been predicted that 700 millions of people are at-risk by 2030 (WHO reports, https://www.who.int/health-topics/drought). In the 21st century, food security will increasingly rely on the release of cultivars with enhanced drought resistance and high return stability (Chapman *et al.,* 2012).

Drought tolerance is a dynamic quantitative trait regulated by several genes. It is a dynamic phenomenon highly affected by the climate that is challenging the development of drought-resistant crops (Maazou *et al.,*2016). The use of genotypic heterogeneity in diverse natural environments under various water stress conditions are one of the most effective strategies for enhancing drought tolerance traits (Mishra *et al.,* 2019). In vitro selection of genotypes through media stress screening with different levels of polyethylene glycol (PEG) were effective in the identification of drought-tolerant genotypes (Biswas *et al.*, 2002). Germination rate, root length, shoot length, R/S ratio showed broad variations under intense reduction of osmotic potential (Kaydan and Yagmur, 2008). Continuous data showing bell-shaped dispersion is said to be natural. Assessing normality of the screened traditional rice landraces was important for any further statistical inference assuming that sampling done from the normally distributed population. Histogram and Q-Q plot were the most popular visual methods available to assay the normality of the continuous data. For normally distributed data, observed data are statistically equal to the expected data (Mishra *et al.,* 2019). The purpose of the present investigation is to categorize the rice landraces on the basis of their competence against early moisture stress and to identify potential donors for further use in plant breeding.

MATERIALS AND METHODS

About 100 rice germplasm including 85 traditional rice landraces from different regions of Tamil Nadu and Meghalaya, India were subjected to *in-vitro* screening for drought tolerance under hydroponics along with drought tolerant check IR64 *Drt*1 and drought susceptible check IR 64. The seed materials were soaked overnight and surface sterilized with sodium hypochlorite to avoid the microbial growth. To ensure the germination, these seeds were incubated at 28^0C for 48hrs. The germinated seeds are then transferred to the holes made in fabricated seedling float with a nylon mesh to hold the seedlings and are placed in the plastic tubs containing Yoshida nutrient medium modified for rice and adjusted to the pH 5.0 (Yoshida *et al.,* 1971).Water stress was artificially induced using poly ethylene glycol (PEG 6000) and screening done over a range of osmotic potentials (-)1.0 Mpa, (-)1.25Mpa and (-)1.5 Mpa (Michel and Kaufmann, 1973) for a period of 30 days, whereas for non-stress conditions, the landraces were grown on modified Yoshida medium. The pH of the medium was maintained at 5.0 under both moisture stress and non- stress environments. The experiment was conducted in a progressive manner and the stress was imposed on 7 DAS with three replications in a completely randomized design (CRD) under glass house conditions. Seedlings were visually scored for drought tolerance at 18 d and 26 days after stress imposition according to the Standard Evaluation System (SES) for rice (IRRI, 1996) (**Table 1**).

Observations on survival percentage, shoot length (cm), root length (cm), root/shoot ratio, fresh weight, turgid weight, dry weight and seed vigour were recorded on 30 DAS. Relative water content was calculated according to (Pieczynski *et al*., 2013).

Relative Water Content= (Fresh weight-dry weight)/ (turgid weight-dry weight)

The frequency distribution of these parameters was visualized in the form of histogram using hist function in R studio. The dispersion of data was checked for normality using dnorm and qqnorm functions in R Programme.

RESULTS AND DISCUSSION

Development of drought-resistant crop plants remained to be a challenging task as drought tolerance is a quantitative trait with more environmental interactions. However, scouting genetic variation is the first step towards the development of drought-resistant crop plants (Basu *et al*. 2016). In the present investigation, 100 landraces from various agro-climatic zones of Tamil Nadu, India were characterized and evaluated for their drought tolerance (DT) along with the respective checks, IR 64 *Drt* 1 (drought tolerant) and IR 64 (drought susceptible).

Phenotypic scoring on leaf tip drying was done based on the standard evaluation scoring system (SES) of IRRI (1996) and the rice landraces screened were categorized as highly tolerant, tolerant, moderately tolerant and sensitive. The results showed that, only 52 per cent of landraces survived on maximum osmotic potential, (-) 15 bars or -1.5 MPa. Further, among the 52 landraces that survived, only 21 landraces managed to withstand drought stress at 18 DAS (score of 0 and 1), while 21 were moderately resistant (score 3). Similarly, scoring on 26 DAS with the maximum osmotic potential of (-)1.5Mpa revealed that ten genotypes namely *Kuliyadichan, Chandaikar, Mallikar, Nootripathu,* Rajalakshmi,Sahabhagidhan, *Arubathamkodai, Arikiraavi, Chenkayama* and *Oheruchitteni* were highly resistant with a score of 0 and 1 in comparison with the drought tolerant IR64 *Drt 1*(score 0 and 1). The results also showed that 23 land races were categorized as moderately resistant with score 3 on 26 DAS as the stress prolongs (**Table 2**). Similar categorization of 50 traditional rice landraces based on visual scoring was made by (Kumar *et al.,*2019).

The survival per cent varied from 64.96 to 88.94% among the landraces with the highest survival per cent registered in *Kuliyadichan* compared to drought tolerant check (IR64 Drt 1). The result on survival percentage revealed that the response of landraces significantly varied (P<0.05) under moisture stress. Survival per cent of

Table 1. Drought scoring system in Rice (IRRI, 1996)

Score	Description
0	Highly resistant: no symptoms
1	Resistant: light tip drying
3	Moderately resistant: tip drying to ¼ length in most leaves
5	Moderately susceptible: ¼ to ½ of leaves fully dried
7	Susceptible: more than 2/3 of leaves fully dried
9	Highly susceptible: all plants apparently dead

landraces survived in our study showed a decreasing trend with increase in moisture stress which is in accordance with the previous studies done with fifteen rice landraces (Gampala *et al*. 2015). The results indicated that the induced moisture stress using PEG 6000 lowers the osmotic potential, affecting the water availability for germinating seeds. However, two rice landraces such as *Kuliyadichan* andRajalakshmi exhibited a considerable germination rate at -1.5MPa suggesting that the lower osmotic potential has no impact in the physical process of water uptake (**Table 3**).

Table 2. Phenotypic scoring of landraces under SES, IRRI 1996

Drought tolerant categories	Phenotype scoring of rice landraces at 18 days after sowing	Phenotype scoring of rice landraces at 26 days after sowing
Highly resistant & resistant (score 0 &1)	Kuliyadichan, Chandaikar, Mallikar, Nootripathu, Rajalakshmi,Sahabhagidhan, IR 64 Drt 1, Arubathamkodai, Arikiraavi, Chenkayama, Oheruchitteni, Annada, Mulampunchan, Aathur Kichadi Samba, Sivappumalli, Mattaikar, Keralakandhasala, Kichadi samba, Kothamalli samba, Milagu Samba, KunjuKurju	Kuliyadichan, Chandaikar, Mallikar, Nootripathu, Rajalakshmi, Sahabhagidhan, IR 64 Drt 1, Arubathamkodai, Arikiraavi, Chenkayama, Oheruchitteni
Moderately resistant (score 3)	Adukan, Anjali, Seeragasamba, Akshayaponni, Karuppukavuni, Thuyamalli, Vandhana, Bharathi, Norungan, Varaputha, Virendra,Chenthadi, AanaiKomban, Kattuyanam, Mapillai samba, Muttakaruva, Baskadam, Eluppai poo samba, Meghalaya black rice (MBR), Chemban, Chumala	Adukan, Mulampunchan, Seeragasamba, Sivappumalli, Anjali, Annada, Milagu Samba, Aathur Kichadi Samba, Akshayaponni,Mattaikar, Karuppukavuni, Keralakandhasala, Kichadi samba, Kothamalli samba, Thuyamalli, Vandhana, Bharathi, Norungan, Varaputha, Virendra,KunjuKurju, Chenthadi, AanaiKomban
Moderately susceptible (score 5)	Meikuruvai, Swarna, Uma, Kar samba, Veethirupa, Ohenellu, Molikarumbu, Paalkudaivaalai, Aryan, Kattanoor, Krishnahemavathi, Kullakar, Chembavu, KuruvaiKalanchiyam, Kuruvaikar, Chakhaepoirecton, Chakhaeamubi	Muttakaruva, Baskadam, Eluppai poo samba, Kattuyanam, Mapillai samba, Swarna, Uma, Kar samba, Veethirupa, MBR), Ohenellu, Molikarumbu, Aryan, Chemban, Chumala, Kattanoor, Krishnahemavathi, Kullakar, KuruvaiKalanchiyam, Kuruvaikar
Susceptible (score 7)	Kalinga-3, Karukot, Kottarasamba, Maranellu, Navarai, Pattani, Pokkali, Sadhabhar, Surakuruvai, Chinapunchai, Eravipondi, JaiSreeRam, Kalinga, Karuvalli, Kollam samba, Naatuponni, Thondi, Nochin samba, Sivappukavuni, Thanga samba, ThavalaKannum, Vattan, Chitteni, Chenullu, ChuvannaChitteni, Varakkuranellu, Chunjamkarnellu, Chithiraikar	Kalinga-3, Karukot, Kottarasamba, Maranellu, Navarai, Pattani, Pokkali, Paalkudaivaalai, Sadhabhar, Meikuruvai, Surakuruvai, Chinapunchai, Eravipondi, JaiSreeRam, Kalinga, Karuvalli, Kollam samba, Naatuponni, Nochin samba, Sivappukavuni, Thanga samba, Thondi, Chitteni, Chakhaepoirecton, Chakhaeamubi, Vattan, ThavalaKannum, Chembavu, Chenullu, ChuvannaChitteni, Varakkuranellu, Chunjamkarnellu
Highly susceptible (score 9)	Abya, Jaya,Kadaikannan, Kalaheri, Thamarai, Vanaprabha, Karudansamba, Kavuni, Kayumma, Kichali samba, White sannam, IR64,Kalanamak, Kattu samba, Milagi	Abya, Jaya, Kadaikannan, Chithiraikar, Kalaheri, Thamarai, Vanaprabha, Karudansamba, Kavuni, Kayumma, Kichali samba, White sannam, IR64, Kalanamak, Kattu samba, Milagi

Traditional landraces were italicized.

Growth parameters such as root and shoot length of landraces were significantly reduced by early drought stress as compared to non-stress . More precisely, the susceptible check IR64 showed a sharp reduction in growth parameters. The reason for reduction in growth parameters under PEG-induced moisture stress is attributed by a reduction in turgor pressure which subsequently influenced the cell elongation and expansion (Jaleel *et al*., 2009). Consequently, the R/S ratio was reduced under moisture stress and the differential responses of the landraces to drought were related to their inherent genetic potential. Thus the R/S ratio and vigor index are considered as critical traits for identifying potential drought tolerant genotypes (Mishra and Panda, 2017). However, an increase in root growth under drought condition is a target trait and is considered as an adaptive strategy to increase water uptake (Basu *et al*., 2016). R/S is often found to be increased under harsh environmental conditions and has been reported as an essential trait for drought resilience (Xu *et al*., 2015, Govindaraj *et al*., 2010). Cultivars with higher R/S ratio signifies good source-sink relationship and are the most preferred cultivars to screen for resilience to moisture stress. Accordingly, in the present investigation, *Chenkayama, Oheruchitteni,* Sahabhagidhan, *Kuliyadichan,* Rajalakshmi*, Chandaikar* and *Nootripathu* showed significant R/S ratio when compared to the drought tolerant check IR64 *Drt1* which revealed that this landraces have better source-sink relationship.

Table 3.Per se performanceof traditional rice landraces at osmotic stress (-1.5MPa)

S.no	Genotype	Survival %		root length		Shoot length		R/S		Fresh weight		Dry weight		Turgid weight		RWC		vigour index	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
1	AanaiKomban	19.34	0.79	4.00	0.07	17.66	0.32	0.227	0.001	0.090	0.001	0.018	0.001	0.328	0.004	23.15	0.10	423.56	18.59
2	Aathur Kichadi Samba	51.82	2.11	10.64	0.18	22.68	0.41	0.469	0.002	0.090	0.001	0.020	0.002	0.328	0.004	22.64	0.11	1743.52	76.52
3	Adukan	44.86	1.83	5.47	0.09	14.85	0.27	0.369	0.001	0.090	0.001	0.018	0.001	0.328	0.004	23.15	0.10	921.09	40.42
4	Arubathamkodai	69.61	2.84	6.18	0.10	11.04	0.20	0.560	0.002	0.081	0.001	0.019	0.002	0.319	0.004	20.50	0.11	1209.94	53.10
5	Akshayaponni	47.95	1.96	7.30	0.12	20.87	0.38	0.350	0.001	0.091	0.001	0.023	0.002	0.329	0.004	22.13	0.13	1364.81	59.90
6	Anjali	43.31	1.77	5.98	0.10	8.93	0.16	0.670	0.002	0.063	0.001	0.028	0.002	0.301	0.003	12.69	0.19	651.59	28.60
7	Annada	51.82	2.11	5.67	0.10	12.64	0.23	0.449	0.002	0.090	0.001	0.018	0.001	0.328	0.004	23.15	0.10	958.67	42.07
8	Arikiraavi	71.16	2.90	9.97	0.17	18.86	0.35	0.529	0.002	0.059	0.001	0.018	0.001	0.297	0.003	14.59	0.12	2071.50	90.91
9	Aryan	30.94	1.26	4.76	0.08	27.99	0.51	0.170	0.001	0.085	0.001	0.024	0.002	0.323	0.004	20.24	0.14	1025.18	44.99
10	Baskadam	34.81	1.42	3.55	0.06	17.76	0.32	0.200	0.001	0.039	0.000	0.012	0.001	0.278	0.003	10.22	0.09	750.02	32.92
11	Bharathi	43.31	1.77	3.95	0.07	16.15	0.30	0.245	0.001	0.090	0.001	0.018	0.001	0.328	0.004	23.15	0.10	880.53	38.64
12	Chakhaeamubi	15.47	0.63	6.49	0.11	22.88	0.42	0.284	0.001	0.092	0.001	0.020	0.002	0.330	0.004	23.16	0.11	459.13	20.15
13	Chakhaepoirecton	15.47	0.63	6.69	0.11	23.98	0.44	0.279	0.001	0.089	0.001	0.022	0.002	0.327	0.004	21.86	0.12	479.57	21.05
14	Chandaikar	77.34	3.15	12.67	0.21	19.06	0.35	0.665	0.002	0.090	0.001	0.018	0.001	0.328	0.004	23.15	0.10	2476.48	108.69
15	Chemban	47.95	1.96	6.59	0.11	22.88	0.42	0.288	0.001	0.081	0.001	0.019	0.002	0.319	0.004	20.50	0.11	1428.18	62.68
16	Chembavu	23.20	0.95	6.49	0.11	20.17	0.37	0.322	0.001	0.090	0.001	0.020	0.002	0.328	0.004	22.64	0.11	625.02	27.43
17	Chenkayama	71.16	2.90	17.02	0.29	22.68	0.41	0.751	0.003	0.090	0.003	0.022	0.002	0.301	0.003	24.13	0.66	2849.76	125.07
18	Chenthadi	47.18	1.92	7.50	0.13	19.97	0.37	0.376	0.001	0.090	0.001	0.018	0.001	0.328	0.004	23.15	0.10	1309.23	57.46
19	Chumala	35.58	1.45	5.27	0.09	20.37	0.37	0.259	0.001	0.069	0.001	0.019	0.002	0.308	0.003	17.35	0.12	922.19	40.47
20	Eluppai poo samba	30.94	1.26	7.50	0.13	24.28	0.44	0.309	0.001	0.036	0.000	0.014	0.001	0.275	0.003	8.44	0.11	993.74	43.61
21	Kar Samba	24.75	1.01	3.14	0.05	20.77	0.38	0.151	0.001	0.062	0.001	0.013	0.002	0.300	0.003	13.97	0.15	598.76	26.28
22	Karuppukavuni	47.18	1.92	7.19	0.12	28.90	0.53	0.249	0.001	0.045	0.001	0.015	0.001	0.283	0.003	10.93	0.11	1721.66	75.56
23	Kattanoor	7.73	0.32	4.35	0.07	10.23	0.19	0.425	0.001	0.045	0.001	0.018	0.001	0.283	0.003	10.93	0.11	113.89	5.00
24	Kattuyanam	52.59	2.15	3.45	0.06	16.86	0.31	0.204	0.001	0.090	0.001	0.015	0.001	0.328	0.004	23.15	0.10	1079.90	47.39
25	Keralakandhasala	54.91	2.24	4.36	0.07	21.27	0.39	0.205	0.001	0.046	0.001	0.017	0.001	0.284	0.003	12.28	0.08	1423.38	62.47
26	Kichadi samba	52.59	2.15	6.79	0.11	18.06	0.33	0.376	0.001	0.090	0.001	0.014	0.001	0.328	0.004	23.15	0.10	1320.47	57.95
27	Kothamalli samba	51.05	2.08	7.19	0.12	15.25	0.28	0.472	0.002	0.050	0.001	0.020	0.002	0.288	0.003	10.96	0.14	1157.10	50.78
28	Kuliyadichan	88.95	3.63	16.01	0.27	22.07	0.40	0.725	0.003	0.085	0.002	0.018	0.001	0.270	0.003	28.05	0.49	3417.54	149.99
29	KunjuKurju	63.42	2.59	7.30	0.12	28.49	0.52	0.256	0.001	0.036	0.000	0.023	0.001	0.275	0.003	8.44	0.11	2295.03	100.72
30	Mallikar	64.97	2.65	6.59	0.11	13.04	0.24	0.505	0.002	0.082	0.001	0.018	0.001	0.283	0.003	25.00	0.73	1277.11	63.99
31	Mapillai samba	47.95	1.96	6.49	0.11	26.49	0.48	0.245	0.001	0.046	0.001	0.023	0.001	0.284	0.003	12.28	0.08	1598.78	70.17
32	Mattaikar	51.05	2.08	3.85	0.07	20.17	0.37	0.191	0.001	0.052	0.001	0.018	0.002	0.290	0.003	10.63	0.17	1240.13	54.43
33	MBR	53.37	2.18	6.59	0.11	21.97	0.40	0.300	0.001	0.046	0.001	0.023	0.001	0.284	0.003	12.28	0.08	1540.60	67.61
34	Milagu Samba	60.33	2.46	8.01	0.14	21.97	0.40	0.364	0.001	0.032	0.000	0.012	0.001	0.270	0.003	8.06	0.08	1827.40	80.20
35	Mulam punchan	50.27	2.05	2.43	0.04	21.87	0.40	0.111	0.000	0.040	0.000	0.018	0.001	0.279	0.003	10.57	0.09	1236.67	54.27
36	Muttakaruva	34.03	1.39	6.89	0.12	6.82	0.12	1.011	0.004	0.046	0.001	0.021	0.001	0.284	0.003	12.28	0.08	470.23	20.64
37	Nootripathu	74.25	3.03	5.88	0.10	9.33	0.17	0.630	0.002	0.085	0.001	0.018	0.001	0.283	0.003	25.90	0.21	1130.82	56.72
38	Norungan	47.95	1.96	3.45	0.06	17.66	0.32	0.195	0.001	0.046	0.001	0.021	0.001	0.284	0.003	12.28	0.08	1023.61	44.92
39	Ohenellu	27.07	1.10	3.95	0.07	24.28	0.44	0.163	0.001	0.090	0.001	0.016	0.001	0.328	0.004	23.15	0.10	773.21	33.93
40	Oheruchitteni	75.80	3.09	14.09	0.24	19.26	0.35	0.731	0.003	0.101	0.002	0.025	0.002	0.319	0.004	26.89	0.28	2550.22	111.92
41	Rajalakshmi	78.89	3.22	18.75	0.32	26.09	0.48	0.719	0.003	0.086	0.001	0.018	0.001	0.284	0.003	27.01	0.20	3568.48	156.61
42	Sahbhagidhan	77.34	3.15	11.65	0.20	16.05	0.29	0.726	0.003	0.099	0.000	0.021	0.001	0.328	0.004	25.89	0.33	2162.00	94.88
43	Seeragasamba	42.54	1.74	2.63	0.04	10.64	0.19	0.248	0.001	0.081	0.001	0.013	0.002	0.319	0.004	19.95	0.12	570.77	25.05
44	Sivappumalli	60.33	2.46	4.36	0.07	15.25	0.28	0.286	0.001	0.049	0.001	0.015	0.001	0.287	0.003	12.94	0.09	1195.78	52.48
45	Swarna	27.84	1.14	8.31	0.14	22.07	0.40	0.377	0.001	0.045	0.001	0.018	0.001	0.283	0.003	10.93	0.11	847.11	42.38
46	Thuyamalli	44.86	1.83	4.36	0.07	16.25	0.30	0.268	0.001	0.049	0.001	0.019	0.001	0.287	0.003	12.94	0.09	934.77	41.02
47	Uma	26.30	1.07	11.96	0.20	25.08	0.46	0.477	0.002	0.038	0.000	0.019	0.002	0.277	0.003	7.00	0.16	975.40	48.86
48	Vandhana	36.35	1.48	4.46	0.08	13.55	0.25	0.329	0.001	0.061	0.001	0.019	0.002	0.299	0.003	14.91	0.13	661.42	29.03
49	Varaputha	48.73	1.99	3.65	0.06	26.49	0.48	0.138	0.000	0.046	0.001	0.014	0.002	0.284	0.003	9.91	0.14	1485.89	65.21
50	Veethirupa	29.39	1.20	4.15	0.07	19.46	0.36	0.213	0.001	0.036	0.000	0.025	0.001	0.275	0.003	8.44	0.11	702.06	30.81
51	Virendra	47.95	1.96	8.51	0.14	19.26	0.35	0.442	0.002	0.077	0.001	0.015	0.002	0.315	0.004	19.10	0.12	1345.32	59.04
52	IR 64 Drt 1	77.34	3.15	9.32	0.16	16.05	0.29	0.581	0.002	0.079	0.002	0.030	0.001	0.284	0.003	24.52	0.53	1981.18	86.95

The data represented are mean of three replications (±standard error)

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The range of vigor index under moisture stress was observed from 423.6 to 3568.5 among the landraces. The landraces, Rajalakshmi and *Kuliyadichan* showed maximum vigour index of 3568.5 and 3417.5 respectively, followed by *Chenkayama* (2849.8), *Oheruchitteni* (2550.2), *Chandaikar* (2476.5), Sahabhagidhan(2162.0) and *Arikiraavi* (2071.5) when compared to the drought tolerant check IR 64 *Drt1* (1981.2) at -1.5 MPa. Relative water content significantly varied (p <0.05) under non-stress and moisture stress conditions. Among the selected drought resilient landraces, *Kuliyadichan* (28.05) recorded the highest relative water content, and was on par with Rajalakshmi (27.01), *Oheruchitteni* (26.88), *Nootripathu*(25.89), Sahabhagidhan (25.88), *Mallikar* (24.99), IR 64 *Drt1* (24.52) and *Chenkayama* (24.12). The present investigation revealed that all the selected landraces had a higher RWC compared to the drought susceptible check IR 64 having the lowest relative water content of 10.93 (Table 3). RWC is the measure of dehydration level under PEG-induced moisture stress. The reduced osmotic potential of external micro-environment caused by PEG 6000 reversed the direction of water influx in the cell, thereby resulting in dehydration. In the present study, RWC of rice landraces declined under moisture stress compared with non-stress condition. Few landraces registered higher RWC than the drought-tolerant check, IR64 *Drt1* suggesting a wide spectrum of variation among the landraces for their sensitivity to drought. The data suggested that the traditional landraces possess improved cellular osmotic adjustment mechanisms to preserve membrane damage and sustain turgidity under DS (Swapna and Shyalaraj, 2017). Hence the landraces maintained more water in the cell in comparison to drought-sensitive IR64.

The dispersion of the various parameters recorded for the 52 traditional landraces were checked by graphing frequency distribution trends. From the frequency distribution trends of the morphological parameters recorded for 52 traditional landraces were continuous with the highest frequency occurring between 40-60 in survival percentage, 4-9 in root length, 15-25 in shoot length, 0.2-0.4 in R/S ration, 10-25 in RWC and 5-15 in seed vigour (**Fig. 1**). However, a region of low value in frequency distribution ranging 15-20 was noticed with respect to RWC, suggesting that the particular trait is probably genotype-dependent. Similar results were obtained by (Wei *et al.,* 2007) where the biochemical parameters like phytic acid, total protein, albumin and glutelin contents of 29 *japanica* rice varieties investigated for improved quality showed continuous and normal frequency distribution. The present study revealed that ten landraces namely *Kuliyadichan,* Rajalakshmi*,* Sahabhagidhan*, Mallikar, Nootripathu, Chandaikar, Arubathamkodai, Arikiraavi, Oheruchitteni* and *Chenkayama* had high survival percentage (above 70%) under induced moisture stress.

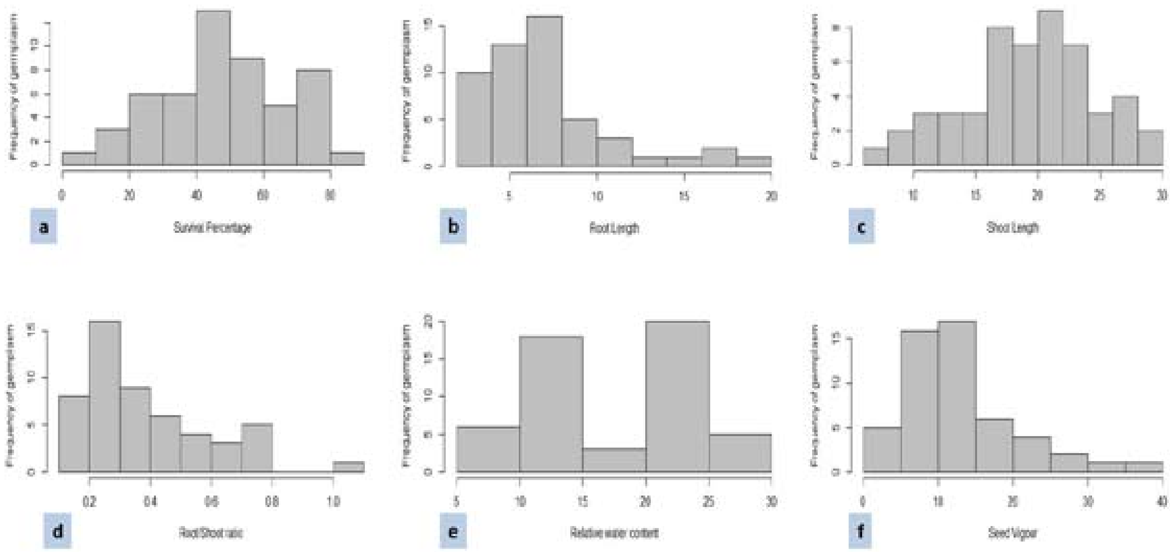

Fig.1. Frequency distribution of six parameters among the traditional landraces under hydroponics at an osmotic potential of (-)1.5Mpa.

(a) Survival Percentage (b) Root Length (c) Shoot Length (d) Root/Shoot ratio (e) Relative water content (f) Seed Vigour

Probability density curve was figured to check the distribution trends of the parameters recorded for 52 rice landraces. The shape of the normal distribution is a function of standard deviation. Distribution trends of 52 traditional rice landraces survival percentage, shoot length and relative water content showed symmetrical normal distribution (**Fig. 2**). The survival percentage of landraces followed the normal distribution with mean of 48.102 and standard deviation of about 18.750 whereas the root length with mean of 6.996 and standard deviation of about 3.655. Dispersion of relative water content of the screened rice landraces showed bimodal distribution with the mean of 17.589 and standard deviation of about 6.384. The two peaks separated the data into two different groups. The morphological parameters like root length, root/shoot ratio and seed vigour showed slightly positive skewness (**Fig. 2**). This asymmetric distribution denoted that more landraces were clustered around the left tail leaving the right tail longer. The distribution of data skewed to right is also a type of non-normal data that follows Poisson's distribution, independent of the sample size. The data following normal distribution can be used in parametric methods for data analysis. Similarly, the frequency distribution of panicle heading dates and flowering dates of individual spikelet on a panicle observed in two rice cultivars were fitted to Poisson and normal distribution function by Nguyen *et al.,*2014. Based on the normal distribution study for survival per cent and per cent reduction in growth, 10 rice genotypes had been categorized as susceptible, moderately tolerant and tolerant genotypes (Vijayalakshmi *et al.,* 2015).

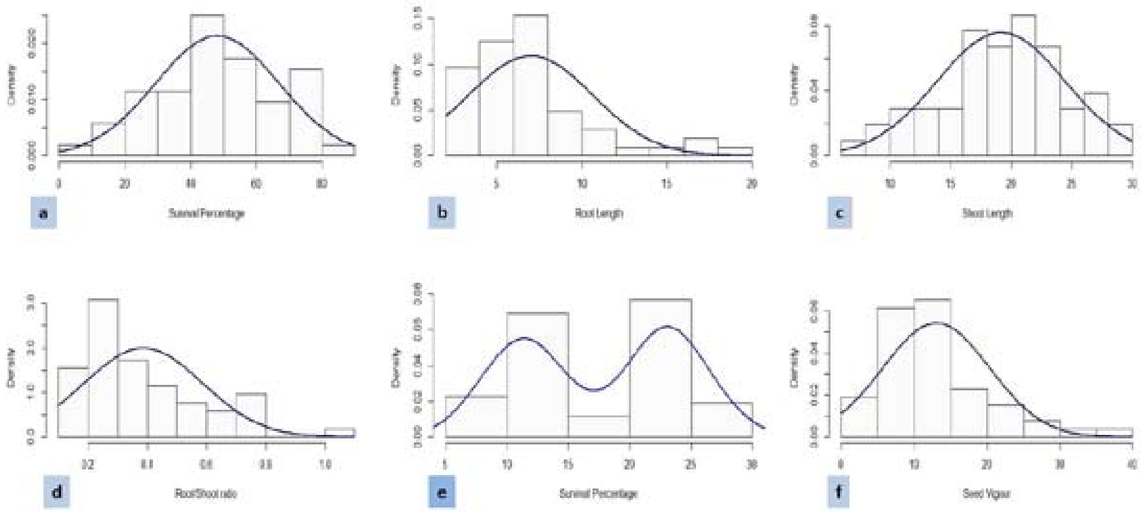

Fig.2. Normal distribution curve with probability density of six parameters among traditional rice landraces under hydroponics at an osmotic potential of (-)1.5Mpa.

(a) Survival Percentage (b) Root Length (c) Shoot Length (d) Root/Shoot ratio (e) Relative water content (f) Seed Vigour

Quantile-Quantile plot (Q-Q plot) helps in deep understanding of the frequency distribution of observed data visually (Ghasemi and Zahediasl, 2012). The germplasm along the default normal line indicates that their distribution trend fitted better to the expected theoretical normal distribution. Thus the present investigation showed that the distribution trends of morphological parameters like survival percent and shoot length showed better fit to the expected symmetric normal distribution with some deviated germplasm forming light thin tails on both the ends. For relative water content, the distribution trend showed a bimodal distribution explaining sinusoidal data (**Fig. 3**). Parameter such as root length, root/shoot ratio and seed vigour were upwardly curved showing that they were positively skewed. In the present study, most of the landraces dispersed along the left tail. Normality of eight quantitative traits for 18 rice in bred were checked using probability density function by Cantila *et al.,* 2017. The study concluded that 6 landraces viz., *Kuliyadichan,* Rajalakshmi, Sahabhagidhan*, Nootripathu, Chandaikar* and *Mallikar*, are potentially drought tolerant among 100 traditional rice germplasm from the different agro-climatic regions of Tamil Nadu. The traits investigated such as RWC, R/S ratio, and seed vigour under moisture stress environment is genetically dependent. Hence the landraces screened in this study can be used as potential donors for rice hybridization and development of climate-resilient rice genotypes.

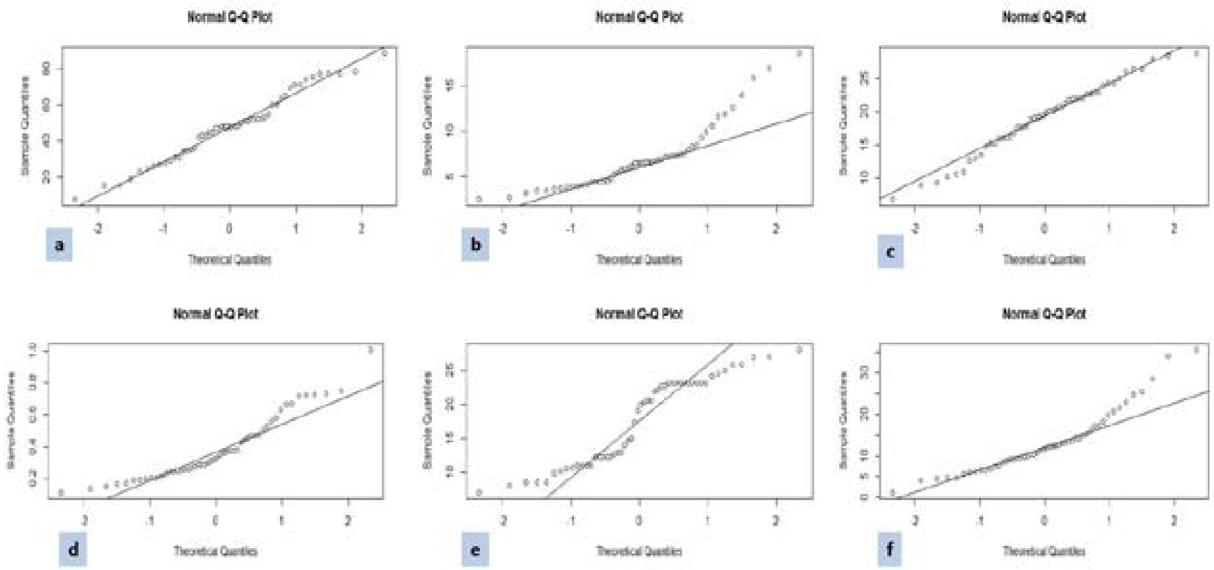

Fig.3. Q-Q plot of six parameters among traditional rice landraces under hydroponics at an osmotic potential of (-)1.5Mpa

(a) Survival Percentage (b) Root Length (c) Shoot Length (d) Root/Shoot ratio (e) Relative water content (f) Seed Vigour.

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