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Short Communication

An approach to climate resilient agriculture farming system using rice landraces collected from Tamil Nadu

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Rice (*Oryza sativa* L.) is the foremost important food crop in the world, especially in Asiatic Continent. Asia accounts for 90 per cent and 92 per cent of the world's rice area and production, respectively. Among all the Asian countries, India is the prominent rice-growing country, it occupies 23.3 per cent of gross cropped area and contributes 43 per cent of total food grain production and 46 per cent of total cereal production. India has the world's largest land area for cultivation of rice (44 million ha) and is second in production as per the data of the union agriculture ministry 2020-2021 (102.36 million tonnes) next to China, accounting for 20 per cent of all world's rice production. It continues to play a vital role in the national food grain supply. It is the staple food of nearly half of the world's population. It ranks third after wheat and maize in terms of worldwide production.

Drought is one of the important factors that limit the productivity of rice in the fragile environments of South India. The existing modern varieties of rice do not perform well under drought stress conditions. India is home to wide varieties of rice cultivars, landraces, and many lesser-known varieties that have been under cultivation for ages by farmers as well as local entrepreneurs. Droughts have obvious consequences in terms of yield reductions, especially if droughts occur during key stages in the rice growth cycle in which plant development is particularly sensitive to water requirements. But droughts may also limit the area under cultivation, such as in the case of delayed monsoon onset. In Tamil Nadu, there are many landraces available some of them have highly tolerant to environmental stresses, such as drought and heat, and are used by the people in that area traditionally. Although the yield capacity of traditional varieties is limited this is compensated by other appreciable characteristics such as high nutritional value, good cooking qualities including pleasurable aroma, and sufficient volume of a cooked meal with less quantity of raw rice. On-farm and in-market management responsiveness of landraces and high-yielding traditional varieties is about 30–35 % more than modern varieties. The seed of traditional varieties costs 2.5 times lesser than that of modern varieties. Therefore, improvement of the heritage of traditional varieties of rice and rice landraces could well be the foundation for future research endeavors in especially agricultural disciplines for authenticated results to future food needs. These rice landraces should be identified before they disappear. Knowing their existence and significance through ancient literature could pave way for a fruitful venture in the collection and characterization of these traditional rice varieties. There is a future need to expand the genetic base of the rice crop by introgressing genes from diverse sources. Thus, it is a need to collect, exploit and evaluate the untapped germplasm. With this background, the current study was conducted with a hypothesis that the screening and selection of rice landraces tolerant to drought stress based on the physiological and biochemical mechanisms may pave the way to develop the elite lines tolerant to drought stress.

Table 1. Detail of studied genotypes with their origin and special character

Sl. No.	Variety	Origin	Specific note
1	Rascadam	Tamil Nadu, India	Landrace, Maturity duration (120-125days)#
2	Kothamallisambha	Tamil Nadu, India	Landrace, Maturity duration (130-135 days)**
3	Kattusambha	Tamil Nadu, India	Landrace, Maturity duration (120-125 days)***
4	Kallundai	Tamil Nadu, India	Landrace, Maturity duration 120 days#
5	Kuliyadichan	Tamil Nadu, India	Landrace, drought-tolerant, Maturity duration (120 days)##
6	Milagusambha	Tamil Nadu, India	Landrace, Maturity duration (150 days)***
7	N 22	Eastern India	Short duration of maturity (80-95 days), deep-rooted, drought and heat tolerant aus rice cultivar*
8	IR 64	IRRI, Philippines	Maturity duration (115 days), hybrid variety with high yield, rainfed lowland areas, semi dwarf, susceptible to abiotic stress*.

*Vikram*et al.* (2016), #Vishnu Varthini *et al.* (2015), ##Vanniarajan *et al.* (2015), **Keerthivarman*et al.* (2019), ***Asish *et al.* (2020)

The field experiment was conducted at the farm of Bagadudurai block (Field No.NF2/3) of Agricultural Research Station (ARS), Tamil Nadu Agricultural University (TNAU), Bhavanisagar, Erode district, (11.29° N latitude and 77.80° E longitude). The field was ploughed to fine tilth and puddle. Uniform-sized plots (3.7x1.7 m) were prepared. Basal application of fertilizers applied before transplanting of 21 days seedlings. Three replications per treatment per genotype were maintained and watered up to the flowering stage of drought imposition (Table 2). Rewatering was also done after 30 days after drought at the reproductive stage. The crop was applied with a recommended dose of fertilizers and other cultivation operations including plant protection measures were carried out as per recommended package of practices for rice. In this study, a separate set of plots with three replications were maintained. Reproductive stage drought was imposed on the 75th day after sowing. Soil moisture content was monitored using a moisture meter (Delta-T Soil moisture kit - Model: SM150, Delta-T Devices, Cambridge) periodically and re-watering was done when the soil moisture reached below 20 per cent and leaves were completely rolled and started drying at tips and margins.

Table 2. Soil moisture (% mineral) content measured during drought under field condition

Genotypes	Vegetative stage stress			Reproductive stage stress		
	Before stress	10 DAS	Before re-watering (25 DAS)	Before stress	12 DAS	Before re-watering (30 DAS)
Rascadam	55	30	15	52	28	17
Kothamalli samba	56	30	16	53	29	17
Kaattu samba	56	29	15	53	29	16
Kallundai	57	32	17	55	27	17
Kuliyadichan	55	27	15	53	26	18
Milagu samba	56	30	16	53	26	18
N22	57	29	15	53	27	18
IR64	56	26	16	53	29	19

DAS: Days after stress

The photosynthetic rate was measured using a portable photosynthesis system (LI-6400 XT; LI-COR Inc. Lincoln, Nebraska, USA). The photosynthetic rate was measured at a light intensity of 1500 µmol m^{-2} s^{-1} PAR, a leaf temperature of 32° C and a constant CO_2 concentration of 390 µmol CO_2 mol^{-1} in a chamber provided with buffer volume. The measurements at specified growth stages were recorded on the top most fully expanded leaf from three plants between 9.30 am to 11.00 am to avoid the effects of photo-inhibition. The average values were computed and expressed as µmol CO_2 m^{-2} s^{-1}. Transpiration rate was measured using Portable Photosynthesis System (LI-6400XT, LicorInc, Nebraska, USA) and expressed as mmol H_2O m^{-2}s^{-1}. Stomatal conductance was measured using Portable Photosynthesis System (LI- 6400XT, LicorInc, Nebraska, USA) and expressed as mol H_2O m^{-2}s^{-1}. Chlorophyll fluorescence was measured using a chlorophyll fluorescence meter (opti-sciences OS1p). The key fluorescence parameters *Fo* (Initial fluorescence), *Fm* (Maximum fluorescence), *Fv* (Variable fluorescence), and the ratio of *Fv/Fm* were automatically calculated. *Fv/Fm* ratio has been proportional to quantum yield and shows a high degree of relationship with photosynthesis.

Crop plants' ability to acclimatize to varied environments is linked to their ability to adjust at the level of photosynthesis, which impacts biochemical and physiological processes and, as a result, the overall development and production of the plant (Chandra and Pental, 2003). Decreasing photosynthetic rate (Pn) is a common response of plants to water deficit stress. This response could be attributed to either stomatal closure or metabolic impairment (França *et al*., 2000). Drought stress decreases the rate of photosynthesis (Kawamitsu *et al*., 2000). Alterations in various photosynthetic attributes are good indicators of a plant's drought tolerance as they show correlations with growth. In this study, under drought conditions, kuliyadichan recorded a higher photosynthetic rate of 29.36 and 30.21 µmol CO_2 m^{-2} s^{-1} at vegetative and reproductive stages, respectively compared to other rice landraces (Table 3). The lesser reduction in the photosynthetic rate was observed in rascadam (7.06, 7.04 %) at both the stages, respectively compared to other genotypes over their respective control due to drought. This reduction in photosynthetic rate might be attributed to lower stomatal conductance to conserve water under drought conditions and consequently, CO_2 fixation is reduced and photosynthetic rate decreases, resulting in less assimilate production for growth and yield of plants. Under drought, diffuse resistance of the stomata to CO_2 entry is most likely the principal factor limiting photosynthesis (Boyer, 1970). The results obtained in this investigation for transpiration rate and stomatal conductance are consistent with Boyer's observations (Boyer, 1970).

Table 3. Impact of drought stress on photosynthetic rate (µmol CO_2 m^{-2} s^{-1})in rice genotypes under field condition

Genotypes	**Vegetative stage stress**			**Reproductive stage stress**		
	Control	**Stress**	**Mean**	**Control**	**Stress**	**Mean**
Rascadam	31.14	28.94	30.04	32.40	30.12	31.26
Kothamallisambha	25.84	22.14	23.99	28.41	21.03	24.72
Kattusambha	23.41	17.58	20.50	27.24	19.56	23.40
Kallundai	28.41	25.36	26.89	32.34	29.41	30.88
Kuliyadichan	32.04	29.36	30.70	32.84	30.21	31.53
Milagusambha	30.12	27.52	28.82	28.64	24.53	26.59
N22	28.56	25.01	26.79	30.84	26.95	28.90
IR64	27.14	15.42	21.28	28.45	17.42	22.94
Mean	28.33	23.92	26.12	30.15	24.90	27.52
	G	T	G x T	G	T	G x T
SEd	0.99	0.49	1.39	1.05	0.52	1.48
CD (0.05)	2.01	1.01	2.85	2.14	1.07	3.02

Closing the stomata to limit transpiration causes an increase in leaf temperature, which leads to an increase in the differential in water vapor pressure between the plant and the air, which reduces transpiration efficiency. Plant respiration may also be increased as a result of this. As a result, increasing water efficiency through stomatal closure is a net positive (Lawlor, 2002). Water stress can also be mitigated by increasing the amount of water available to the plant by reducing transpiration through partial stomatal closure (Alves and Setter, 2000).

The process of water loss from a plant in the form of water vapor from leaves and other aerial components is known as transpiration. As a response to drought stimuli, transpiration is known to decrease under water stress (de Souza *et al*., 2005). Concerning transpiration rate in the present study, a substantial decrease (Table 4) was observed under drought across the landraces. Even though a sharp decline in transpiration rate, the kuliyadichan recorded a lesser reduction in transpiration rate at vegetative state (4.57 %) under drought over its control and it was 40.43, 55.96 per cent in tolerant check N 22 and susceptible check IR 64, respectively. But at reproductive stage drought, the recovery from the water stress was quick in milagusambha which recorded a lesser reduction (6.63 %) in transpiration rate compared to other genotypes. Drought stress in maize resulted in significant decreases in net photosynthesis (33.2 %), transpiration rate (37.8 %), stomatal conductance (25.5 %), water use efficiency (50.8 %), intrinsic water use efficiency (11.5 %), and intercellular CO_2 (5.8 %) when compared to irrigated conditions, according to Anjum *et al.* (2011).

Table 4. Impact of drought stress on transpiration rate (mmol H_2O m^{-2} s^{-1}) in rice genotypes under field condition

Genotypes	Vegetative stage stress			Reproductive stage stress		
	Control	Stress	Mean	Control	Stress	Mean
Rascadam	12.32	10.43	11.38	14.21	12.31	13.26
Kothamallisambha	12.73	8.52	10.63	12.24	6.73	9.49
Kattusambha	11.55	6.63	9.09	12.82	7.57	10.20
Kallundai	12.85	11.86	12.36	13.68	12.70	13.19
Kuliyadichan	13.14	12.54	12.84	14.26	13.06	13.66
Milagusambha	12.93	12.02	12.48	13.58	12.68	13.13
N22	11.87	7.07	9.47	12.64	6.51	9.58
IR64	12.15	5.35	8.75	13.76	3.45	8.61
Mean	12.44	9.30	10.87	13.40	9.38	11.39
	G	T	G x T	G	T	G x T
SEd	0.42	0.21	0.60	0.45	0.23	0.64
CD (0.05)	0.87	0.43	1.23	0.92	0.46	1.31

In the present study, irrespective of the genotypes and stages, drought stress caused a decrease in stomatal conductance up to 31.75 %. The landrace kuliyadichan recorded higher values (1.07 mol H_2O m^{-2} s^{-1}) for stomatal conductance followed by rascadam (1.06 mol H_2O m^{-2} s^{-1}) and kallundai (0.88 mol H_2O m^{-2} s^{-1}) at the reproductive stage (Table 5). Leaf water potential and stomatal conductance (gs) are correlated under drought, largely as a result of an attempt to conserve available water. Lower Pn can also be attributed to cumulative, non-stomatal, and biochemical effects of stress.

When photosystem II efficiency was assessed in terms of chlorophyll fluorescence, it was discovered that water stress induced during the reproductive stage had a significant impact on PS II efficiency, as evidenced by a decrease in the Fv/Fm ratio in all rice genotypes. Photosystem II (PSII), the photosynthetic apparatus, is important in the response of leaf photosynthesis to environmental stressors, particularly drought stress. The impacts of water stress on the photochemical system were evident in the late stages of stress by considerable declines in PSII's maximum quantum yield coupled with increases in minimum fluorescence levels. These changes could indicate a problem with PSII (Osmond, 1994). Crop photosynthesis is directly reflected in the dynamic changes in chlorophyll fluorescence (Maxwell and Johnson, 2000). In the present study, kuliyadichan was found to be associated with higher PSII efficiency as it had shown a lesser reduction of 6.25 and 13.58 % over control in vegetative and reproductive stages, respectively (Table 6) tolerant check N 22 (17.33, 20.51 %) and susceptible check IR 64 (36.84, 34.62 %). This finding in kuliyadichan is confirmed by prior research by Shangguan *et al.* (2000), which found that PSII is somewhat robust to water shortages, being unaffected (or) only affected under extreme drought conditions (Saccardy *et al.*, 1998). Also, according to Havaux (1992), Photosystem II is more resistant to drought stress than heat stress.

Table 5. Impact of drought stress on stomatal conductance (mol H_2O m^{-2} s^{-1})in rice genotypesunder field condition

Genotypes	Vegetative stage stress			Reproductive stage stress		
	Control	**Stress**	**Mean**	**Control**	**Stress**	**Mean**
Rascadam	0.73	0.69	0.71	1.13	1.06	1.10
Kothamallisambha	0.72	0.58	0.65	0.88	0.75	0.82
Kattusambha	0.57	0.45	0.51	0.72	0.58	0.65
Kallundai	0.70	0.67	0.69	0.95	0.88	0.92
Kuliyadichan	0.76	0.72	0.74	1.14	1.07	1.11
Milagusambha	0.68	0.65	0.67	0.88	0.82	0.85
N22	0.62	0.51	0.57	0.79	0.64	0.72
IR64	0.63	0.43	0.53	0.73	0.56	0.65
Mean	0.68	0.59	0.63	0.90	0.80	0.85
	G	T	G x T	G	T	G x T
SEd	0.02	0.01	0.03	0.03	0.02	0.05
CD (0.05)	0.05	0.02	0.07	0.07	0.03	0.09

Table 6. Impact of drought stress on Fv/Fm in rice genotypes under field condition

Genotypes	Vegetative stage stress			Reproductive stage stress		
	Control	**Stress**	**Mean**	**Control**	**Stress**	**Mean**
Rascadam	0.81	0.70	0.76	0.81	0.67	0.74
Kothamallisambha	0.74	0.53	0.64	0.78	0.56	0.67
Kattusambha	0.72	0.55	0.64	0.76	0.52	0.64
Kallundai	0.77	0.69	0.73	0.80	0.67	0.74
Kuliyadichan	0.80	0.75	0.78	0.81	0.70	0.76
Milagusambha	0.79	0.70	0.75	0.80	0.68	0.74
N22	0.75	0.62	0.69	0.78	0.62	0.70
IR64	0.76	0.48	0.62	0.78	0.51	0.65
Mean	0.77	0.63	0.70	0.79	0.62	0.70
	G	T	G x T	G	T	G x T
SEd	0.03	0.01	0.04	0.03	0.01	0.04
CD (0.05)	0.05	0.03	0.08	0.05	0.03	0.08

Considering the above results of this experiment, it is concluded that rice landraces, being adapted to harsh environments, have the inherent ability to withstand drought situations. And Kuliyadichan, Rascadam, and Milagusamba performed better in terms of physiological parameters like photosynthetic rate, stomatal conductance, transpiration rate, and Fv/Fm ratio which ultimately contributed to better tolerance compared to other landraces and check varieties taken for this study. Hence, the traits which are conferring better tolerance in these landraces may be studied further to unravel the actual mechanisms responsible for drought tolerance and to exploit these traits for the crop improvement program.

Author contributions

All the authors contributed to the article and approved the submitted version.

Compliance with ethical standards

Yes

Conflict of interests

No commercial or financial relationships that could be construed as a potential conflict of interest.

References

1. Alves AAC and TL Setter. 2000. Response of cassava to water deficit: leaf area growth and abscisic acid. *Crop Science* **40**(1):131-137.
2. Anjum SA, M Farooq, LC Wang, LL Xue, SG Wang, L Wang, S Zhang and M Chen. 2011. Gas exchange and chlorophyll synthesis of maize cultivars are enhanced by exogenously-applied glycinebetaine under drought conditions. *Plant Soil Environ* **57**:326-331.
3. Boyer JS. 1970. Differing sensitivity of photosynthesis to low leaf water potentials in corn and soybean. *Plant Physiology* **46**(2):236-239.
4. Chandra A and D Pental. 2003. Regeneration and genetic transformation of grain legumes: An overview. *Current Science* **84**(3):381-387.
5. Costa França MG, AT Pham Thi , C Pimentel, RO Pereyra Rossiello, Y Zuily-Fodil and D Laffray. 2000. Differences in growth and water relations among Phaseolus vulgaris cultivars in response to induced drought stress. *Environmental and Experimental Botany* **43**(3):227-237.
6. Havaux M. 1992. Stress tolerance of photosystem II in vivo: antagonistic effects of water, heat, and photoinhibition stresses. *Plant Physiology* **100**(1):424-432.
7. Kawamitsu Y, T Driscoll and SJ Boyer. 2000. Photosynthesis during desiccation in an intertidal alga and a land plant. *Plant and Cell Physiology* **41**(3):344-353.
8. Lawlor DW. 2002. Limitation to photosynthesis in water-stressed leaves: stomata vs. metabolism and the role of ATP. *Annals of Botany* **89**(7):871-885.
9. Maxwell K and Johnson GN. 2000. Chlorophyll fluorescence–a practical guide. *Journal of Experimental Botany* **51**(345):659-668.
10. Osmond CB. 1994. What is photoinhibition? Some insights from comparisons of shade and sun plants. Bios Scientific Publication, Oxford.
11. Saccardy K, B Pineau, O Roche and G Cornic. 1998. Photochemical efficiency of photosystem II and xanthophyll cycle components in *Zea mays* leaves exposed to water stress and high light. *Photosynthesis Research* **56**(1):57-66.
12. Shangguan ZP, MA Shao, and J Dyckmans. 2000. Nitrogen nutrition and water stress effects on leaf photosynthetic gas exchange and water use efficiency in winter wheat. *Environmental and Experimental Botany* **44**(2):141-149.
13. de Souza P , RV Ribeiro, EC Machado, RF de Oliveira, and JAG da Silveira. 2005. Photosynthetic responses of young cashew plants to varying environmental conditions. *Pesquisa Agropecuária Brasileira* **40**:735-744.