Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2021; 10(1): 2328-2330
Received: 04-11-2020
Accepted: 06-12-2020

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Changes in the physiological and biochemical activities of traditional rice landraces affected by water stress during reproductive stage under field condition

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Abstract
A field experiment was conducted to determine the physiological performance of traditional rice landraces under water stress given at reproductive stage. Drought is one of the serious threats on rice productivity. Traditional rice landraces shows substantial adaptability to drought so Six popular rice land races, namely Rascadam, Kothamalli samba, Kaattu samba, Kallundai, Kuliyadichan and Milagu samba from Tamilnadu, India and two popular rice check varieties, namely IR64 (susceptible check), N22 (tolerant check) were used to study the physiological performance for drought tolerance. These genotypes were subjected to drought under field condition at Agricultural Research Station, Bhavanisagar, TNAU, Coimbatore. The crops were imposed with drought during reproductive stage by withholding irrigation till the soil moisture reaches below 20 per cent. The experimental design for the trial was factorial randomized block design (FRBD). Chlorophyll Index (CSI), Soluble protein, Catalase activity and Nitrate reductase activity were measured.

Keywords: traditional rice, chlorophyll index, soluble protein, catalase, NRASE

Introduction
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 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 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 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 the 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, land races and many lesser known varieties that have been under cultivation since 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 of which 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 characters such as high nutritional value, good cooking qualities including pleasurable aroma, and sufficient volume of 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 endeavours 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 fruitful venture in collection and characterization of these traditional rice varieties.

There is 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 mechanism may pave the way to develop the elite lines tolerant to drought stress.

Material and Methods

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). 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. Re-watering was also done after 30 days after drought at reproductive stage. Crop was applied with 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, separate set of plots with three replications were maintained. Reproductive stage drought was imposed at 75th day after sowing. Soil moisture content was monitored using 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.

Soluble protein content of the leaf was estimated by following the procedure described by Lowry *et al.* (1950) [4] and expressed as mg g^{-1} of fresh weight. Catalase was estimated according to Teranishi *et al.* (1974) [7] and expressed as µg of H_2O_2 reduced min^{-1} g^{-1} fresh weight. Nitrate reductase activity in young leaves was estimated as per the method described by Nicholas *et al.* (1976) [6] and the enzyme activity was expressed as µg NO_2 g^{-1} h^{-1}. Chlorophyll index in leaves was measured using chlorophyll content meter (CCM-200 plus, Opti-Sciences)

Results and Discussion

A significant difference in soluble protein content was observed within the treatments and also among the genotypes. Drought imposition was found to impact the soluble protein content under drought stress. Among the genotypes, G1, G4, G5, G6 recorded the highest soluble protein content followed by G2, G6 under reproductive stage stress. The soluble protein content of G7, G8 was the least under drought stress. For interaction effect, G4, G5 genotypes at drought stress recorded higher soluble protein content (Table 02). This result was in accordance with the findings of Jha and Singh (1997) reported that the tolerant rice varieties possessed higher soluble protein content than the susceptible ones under water stress condition.

Drought stress reduced the Nitrate reductase activity under reproductive stage drought stress. With regard to Nitrate reductase activity, the genotypes G1, G4, G5 recorded higher Nitrate reductase activity compared to other genotypes and which was followed by G 6 (Table 03). The NRase enzyme is highly sensitive towards oxidative stress and decreased activity might be due to breakdown of proteins under water stress conditions (Kalarani and Jeyakumar, 1998) [2].

After given of drought stress, decrease the activity of catalase enzyme to irrespective of the genotypes was observed. The highest catalase enzymes activity was observed in G2, G3 when both control and drought stressed plants followed by G8 genotype (Table 04). Lum *et al.* (2014) [5] observed an increased catalase activity in the moisture stressed plants than the control plants. Also, drought tolerant varieties showed relatively higher activities of CAT, SOD and POD when compared to the susceptible one, suggesting that antioxidant system plays an important role in tolerance against environmental stress. This result was in accordance with present study.

The reproductive stage drought in rice reflected a negative impact on SPAD value. Among the genotypes, G1, G4, G5, G6, G7 recorded the highest SPAD value when stress coincided with reproductive stage. G2 and G3 recorded the lowest SPAD value under drought at reproductive stages (Table 05). Leaf thickness is one of the factors that determine chlorophyll index under different conditions (Yamamoto *et al.*, 2002) [8]. It has been demonstrated that reflectance increases with an increase in leaf transmittance (Knapp *et al.*, 1998) [3].

Table 1: Detail of studied genotypes

	Variety	Origin
G1	Rascadam	Tamil Nadu, India
G2	Kothamalli Sambha	Tamil Nadu, India
G3	Kaattu Sambha	Tamil Nadu, India
G4	Kallundai	Tamil Nadu, India
G5	Kuliyadichan	Tamil Nadu, India
G6	Milagu Sambha	Tamil Nadu, India
G7	N22	Eastern India
G8	IR64	IRRI, Philippines

Table 2: Impact of drought stress on soluble protein content (mgg^{-1}) in rice genotypes under field condition

Genotypes	Reproductive stage		
	Control	Drought	Mean
Rascadam	13.72	11.64	12.68
Kothamalli Sambha	13.03	10.41	11.72
Kaattu Sambha	12.39	9.67	11.03
Kallundai	13.53	12.48	13.01
Kuliyadichan	13.36	12.46	12.91
Milagu Sambha	13.13	11.98	12.56
N22	11.05	9.22	10.14
IR64	12.25	7.93	10.09
Mean	12.81	10.72	11.76
	G	T	G x T
SEd	0.45	0.23	0.64
CD (0.05)	0.93	0.47	1.31

Table 3: Impact of drought stress on nitrate reductase activity (µg $no_2g^{-1}h^{-1}$) in rice genotypes under field condition

Genotypes	Reproductive stage		
	Control	Drought	Mean
Rascadam	23.88	22.37	23.12
Kothamalli Sambha	18.05	14.37	16.21
Kaattu Sambha	18.65	14.91	16.78
Kallundai	23.20	21.98	22.59
Kuliyadichan	23.37	21.96	22.66
Milagu Sambha	22.04	20.57	21.31
N22	19.37	18.02	18.70
IR64	20.38	15.84	18.11
Mean	21.11	18.75	19.93
	G	T	G x T
SEd	0.77	0.38	1.09
CD (0.05)	1.57	0.78	2.22

Table 4: Impact of drought stress on catalase activity (µgh_2o_2 reduced $min^{-1}g^{-1}$) in rice genotypes under field condition

Genotypes	Reproductive stage		
	Control	Drought	Mean
Rascadam	5.68	8.34	7.01
Kothamalli Sambha	4.68	5.79	5.23
Kaattu Sambha	4.34	5.63	4.99
Kallundai	6.58	8.81	7.70
Kuliyadichan	6.66	8.31	7.49
Milagu Sambha	5.62	8.17	6.89
N22	6.00	7.91	6.95
IR64	6.53	6.86	6.70
Mean	5.76	7.48	6.62
	G	T	G x T
SEd	0.27	0.14	0.39
CD (0.05)	0.54	0.28	0.79

Table 5: Impact of drought stress on chlorophyll index (SPAD) in rice genotypes under field condition

Genotypes	Reproductive stage		
	Control	Drought	Mean
Rascadam	42.47	40.46	41.46
Kothamalli sambha	36.12	29.01	32.56
Kaattu sambha	38.21	30.63	34.42
Kallundai	41.13	38.37	39.75
Kuliyadichan	42.69	40.21	41.45
Milagu sambha	40.49	37.08	38.78
N22	42.03	38.36	40.19
IR64	42.04	33.03	37.53
Mean	40.65	35.89	38.27
	G	T	G x T
SEd	1.44	0.72	2.04
CD (0.05)	2.94	1.47	4.16

Conclusion

Considering the above results of this experiment, it is concluded that rice landraces, being adapted to harsh environments, have inherent ability to withstand drought situation. And Rascadam (G1), Kallundai (G5), Kuliyadichan (G5), Milagusamba (G6) performed better interms of physiological parameters like Soluble protein content, Chlorophyll index, catalase activity and NRase content which ultimately contributed for 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 crop improvement programme.

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