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# UNRAVELING THE GENETIC POTENTIAL OF RICE LANDRACES FOR VEGETATIVE STAGE DROUGHT TOLERANCE

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**Abstract**

The experiment was conducted under normal irrigated and managed stress conditions for morphological and physiological traits to study the genetic potential of 15 rice landraces at vegetative stage for drought tolerance. The highest shoot length was recorded in Mappillai samba at both normal irrigated (58.07 cm) and managed drought stress condition (54.40 cm). The highest leaf length was observed in Nootripathu at normal irrigated (37.60 cm) and managed drought stress (37.03 cm) conditions. More number of tillers was recorded in Norungan both at normal irrigated situation (6.00) as well as drought condition (5.30). Norungan exhibited highest root length in normal irrigated condition (19.00 cm) whereas Kallurundaikar possess lengthy roots at managed stress condition (25.13 cm). Kallurundaikar showed better leaf rolling score (3) and Chithiraikar showed delayed drying symptom than other landraces. Chithiraikar and Norungan have shown higher rate of relative water content (77.0 and 75.3%, respectively) and maximum proline accumulation in Norungan both in normal irrigated (782.3μg/g FW) and managed stress condition (2366.0μg/g FW). Based on the overall performance, the rice landraces Norungan, Kallurundaikar and Chithiraikar can be selected for further breeding programme to obtain new recombinant types for drought tolerance.

## Introduction

Rice (*Oryza sativa* L.) is a fundamental staple crop, nourishing over half of the global population. Across Asia, Africa and Latin America, rice was cultivated in a range of ecosystems, including irrigated fields, rainfed lowlands and uplands. In 2025, global rice production reached approximately 540 million metric tons, with India contributing about 150 million metric ton of this yield (USDA 2025). However, rice cultivation faced significant challenges from abiotic stresses, particularly drought. Drought is one of the major limiting factors in rainfed rice production. In Asia alone, nearly 23 million hectares of rainfed rice cultivating area is drought-prone and affecting more than 50% of rice yield (Rahman and Zhang 2016). With erratic rainfall patterns and constant climatic anomaly exhibited in India, especially in Tamil Nadu, the identification of more stable and drought tolerant rice genotypes are of high importance. Drought affect germination ability, plant height, biomass, tiller number, roots and leaves growth. Physiologically, drought reduced photosynthesis, transpiration, stomatal conductivity, water use efficiency, relative water content, photosynthesis II activity, membrane stability, change in carbon isotope, and abscisic acid content (Wardoyo *et al*. 2017). All of these factors are responsible for a reduction in grain yield under drought conditions.

Southern Tamil Nadu is the treasure home for large number of traditional rice landraces and majority is untapped. In general, landraces are less productive than commercial cultivars, but in recent years, they have gained significance as sources of genetic diversity in the hunt for genes that can be used to tolerate or resist biotic and abiotic conditions that are essential in agriculture. Farmers have conserved these landraces for their medicinal, nutritional, culinary and cultural values (Muthuramu and Ragavan 2020).

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Rice is the most susceptible to drought stress at both the vegetative and reproductive stages. The phenology, particularly at the reproductive stage, is a major determinant of grain yield in rainfed lowland rice, and any attempt to screen for drought resistance needs to consider variation at the reproductive stage (Pantuwan *et al.* 2001). However, the vegetative stage is another critical determinant of the growth and maturation of rice. Hence selecting rice cultivars that confer drought resistance from different cultivars with contrasting drought tolerance at the vegetative or reproductive stages will bring new insights for the breeding of rice.

Responses to environmental stress in plants are complex and multigenic, and the functions of many induced genes are still a matter of conjuncture. Because of this complexity, selection and breeding of drought tolerant genotypes are extremely difficult (Tirado and Cotter 2010). Therefore, for easy selection of rice genotypes under drought stress, it is necessary to do a proper drought screening, which clearly distinguishes drought-susceptible genotypes from drought-tolerant genotypes (Swamy *et al.* 2017). There is a lack of phenotypic knowledge of indigenous rice landraces of Tamil Nadu with respect to drought tolerance. Thus, the present investigation is aimed to characterize the rice landraces available in Southern Tamil Nadu under moisture stress and to select the best drought resistant donor for the future drought tolerance breeding programme.

**Materials and Methods**

The experimental material comprised of 15 rice landraces acquired from varied origin *viz.*, Tamil Nadu Rice Research Institute-Aduthurai (Mappillai samba, Kichili samba and Kullakar), Agricultural Research Station-Paramakudi (Chithiraikar, Mattaikar, Nootripathu, Norungan, Kuzhiyadichan, Varappukudanchan, Poongar and Kallurundaikar) and Agricultural College and Research Institute-Madurai (Navarai, Seeraga samba, Karunguruvai and Chinnar). Rice landraces were evaluated for morphological and physiological traits under normal irrigated conditions and managed stress conditions in a randomized complete block design (RCBD) with three replications at Agricultural Research Station, Tamil Nadu Agricultural University, Paramakudi during Rabi season of 2025-26. The experimental site is located at 9” 21’ N latitude, 78” 22’ E longitude and an altitude of 42 m above mean sea level with average annual rainfall of 840 mm. This site has clay loam soil texture with soil pH 8.0. Each genotype was raised in 15 m x 10 m plot keeping 15 cm x 10 cm spacing. The recommended agronomic practices were followed and the data on root length shoot length leaf length number of leaves, number of tillers per plant, leaf rolling, leaf drying, relative water content and proline content were recorded on vegetative stage by randomly selecting ten plants from each replication.

The drought score (leaf rolling and drying) of the plants subjected to drought stress was compared with that of the control plants under normal irrigation during the same period using standard criteria proposed by a standard evaluation system for rice (IRRI 2013). A visual score was assigned for the degree of leaf death found on the sample leaf using a scale ranging from 0 to 9 (0 indicating no symptoms and 9 indicating apparent death). The relative leaf water contents were also measured based on the method described by Turner (1981). The proline content in the leaves was estimated based on the method described by Bates *et al.* (1973). The results were exported to the Statistical Package for Social Sciences (SPSS) software, and analysis of variance (ANOVA). The means of the various results were tested for level of significance by Duncan’s multiple range test (DMRT). Statistical significance was accepted at $p < 0.05$.

## Results and Discussion

The analysis of variance for various quantitative characters among 15 rice landraces grown under normal and managed stress conditions revealed that the genotypes differed for all the characters implied that the materials selected for the studies might be of diverse origin (Table 1).

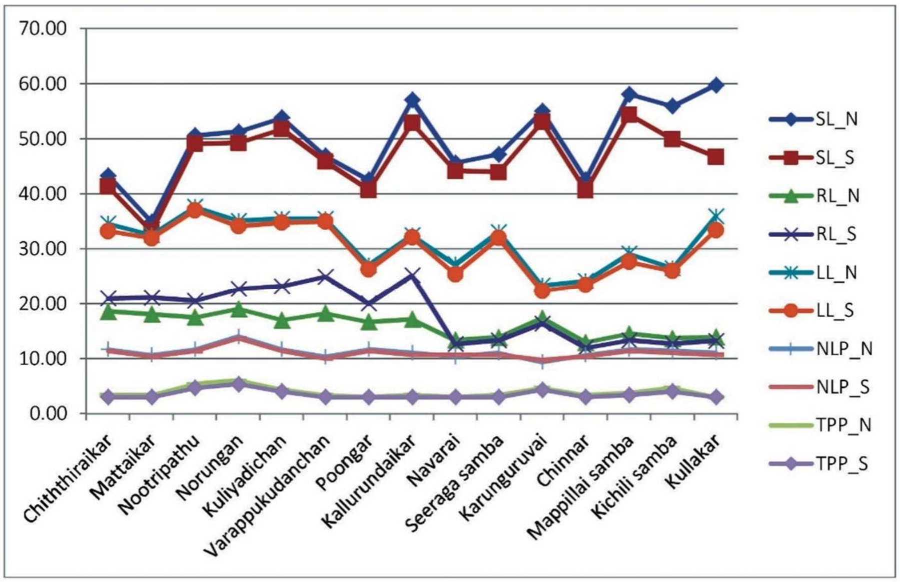
**Table 1. ANOVA for various quantitative traits in 15 rice landraces.**

| Serial No. | Traits | Env. | Replication MSS | Treatment MSS | Error MSS | S.Ed | C.D. (5%) |
|---|---|---|---|---|---|---|---|
| 1 | Shoot length (cm) | N | 2.36 | 150.71** | 3.06 | 1.43 | 2.93 |
| | | S | 3.77 | 103.67** | 3.24 | 1.47 | 3.01 |
| 2 | Root length (cm) | N | 0.57 | 13.89** | 0.11 | 0.27 | 0.56 |
| | | S | 1.18 | 45.62** | 1.47 | 0.99 | 2.03 |
| 3 | Leaf length (cm) | N | 0.22 | 65.28** | 0.74 | 0.70 | 1.44 |
| | | S | 0.29 | 65.38** | 1.01 | 0.82 | 1.68 |
| 4 | No. of leaves / Plant | N | 1.87 | 3.13** | 0.49 | 0.57 | 1.17 |
| | | S | 1.16 | 2.52** | 0.30 | 0.45 | 0.91 |
| 5 | No. of tillers / Plant | N | 0.09 | 2.61** | 0.33 | 0.47 | 0.96 |
| | | S | 0.16 | 1.76** | 0.16 | 0.32 | 0.66 |
| 6 | Leaf rolling | N | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | S | 0.09 | 0.73** | 0.95 | 0.79 | 1.63 |
| 7 | Leaf drying | N | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | S | 0.09 | 2.99** | 0.66 | 0.66 | 1.36 |
| 8 | Relative water content (%) | N | 21.62 | 43.95** | 5.93 | 1.99 | 4.08 |
| | | S | 58.40 | 47.01** | 6.21 | 2.03 | 4.17 |
| 9 | Proline content(μg/g FW) | N | 1235.29 | 27522.17** | 426.57 | 16.86 | 34.57 |
| | | S | 14920.69 | 242134.61** | 11901.09 | 89.07 | 182.60 |

*, ** : Significant at 1 and 5% level , respectively, N: Normal, S: Stress.

Rice yield significantly declined due to drought stress, with reductions ranging from 21 to 50.6 % during the vegetative growth stage. Drought during the seedling phase resulted poor seed germination, stunted growth, reduced seedling height, and lower dry matter accumulation, all of which can impair the plant's subsequent development. Response of selected rice landraces for shoot length, root length, leaf length, number of leaves and tillers both in normal irrigated and managed drought stress condition at vegetative stage are shown in Fig. 1. The highest shoot length was recorded in Mappillai samba at normal irrigated (58.07 cm) and managed drought stress condition (54.40). Overall reduction in shoot length was noticed due to drought in all the landraces studied. The same strategy was observed also for leaf length and number of tillers per plant. The highest leaf length was observed in Nootripathu at both normal irrigated (37.60 cm) and managed drought stress (37.03 cm) conditions. More number of tillers was recorded in Norungan in normal irrigated situation (6.00) as well as drought condition (5.30). Therewere not much variation in leaf number invariably in all rice landraces. In terms of morphology, plants under water stress exhibited decrease cell growth and elongation due to low or insufficient water flow onto the xylem or neighboring cell (Dash *et al*. 2018).

Norungan exhibited the highest root length in normal irrigated condition (19.00 cm) whereas Kallurundaikar possess lengthy roots at managed stress condition (25.13 cm). Rice root length can both increase and decrease during water stress, depending on the specific conditions, the rice variety, and the plant's adaptive response. Xie *et al*. (2021) stated that some studies showed a reduction in total root length, while others report an increase in length, often due to hormonal changes like the rise in abscisic acid. In the present investigation, some land races such as Chithiraikar, Mattaikar, Nootripathu, Norungan, Kuzhiyadichan, Varappukudanchan, Poongar and Kallurundaikar) showed increase and some land races (Navarai, Seeraga samba, Karunguruvai, Chinnar, Mappillai samba, Kichili samba and Kullakar) exhibited decrease in root length when they were exposed to stress condition (Fig. 1).




SL: Shoot length, RL: Root length, LL: Leaf length, NLP: No. of leaves per plant, TPP: Tillers per plant, N: Normal, S: Stress

Fig. 1. Mean performance of 15 rice landraces for morphological traits.

In this experiment, genotypes showed no response at normal irrigated condition. Among the rice landraces of this trial, Kuzhiyadichan, Varappukudanchan and Kallurundaikar showed better leaf rolling score (score 3) when compared to others (Fig. 2). Chithiraikar, Mattaikar and Poongar showed delayed drying symptom than other genotypes. Generally plant responded to the givendrought condition gradually by leaf rolling and drying during as the drought duration is increasing (Susanto *et al.* 2022).

The relative leaf water content (RWC) of all the rice landraces was compared in both normal irrigated and stress situations. During the normal irrigated condition, no significant differences were found in the RWC among the genotypes when compared to managed stress condition. There is a significant reduction of RWC in all the rice landraces when they were grown under drought. The RWC was reduced to 64.3% in Seeraga samba and 64.7% in Mappillai samba and Kichili samba (Fig. 3).Chithiraikar and Norungan have shown higher rate of RWC (77.0% and 75.3%, respectively) when compared to other rice landraces. The RWC is the important parameter to determine the ability of plants to withstand drought. The present study indicated that various rice landraces can resist drought differently. Nguyen *et al.* (1997) stated that drought-tolerant cultivars can maintain the water status in their leaves, which demonstrates their ability to cope with drought stress.

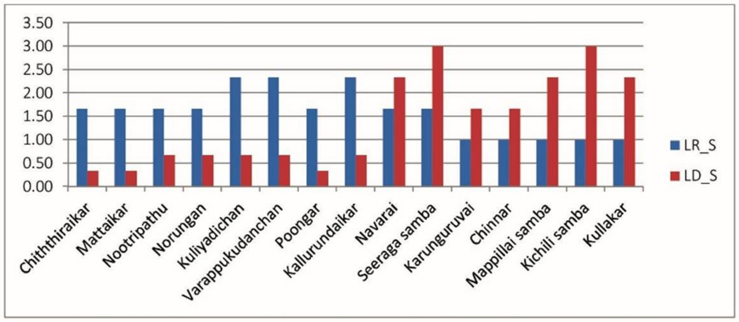



Fig. 2. Response of 15 rice landraces for drought sensitivity during vegetative stage.
LR: Leaf rolling, LD: Leaf drying, N: Normal, S: Stress

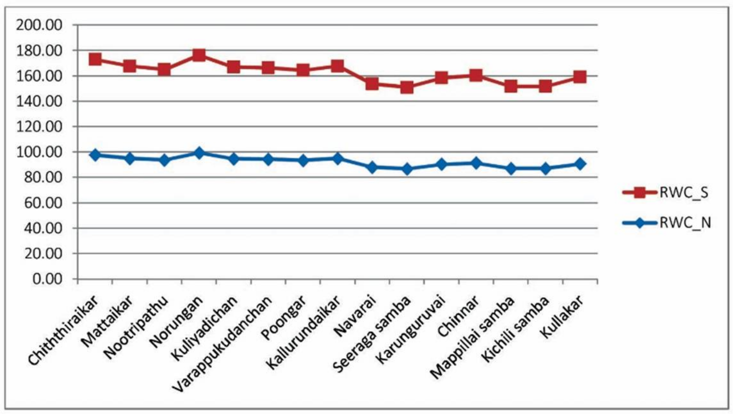



Fig 3. Response of 15 rice landraces for relative water content (%) during vegetative stage.

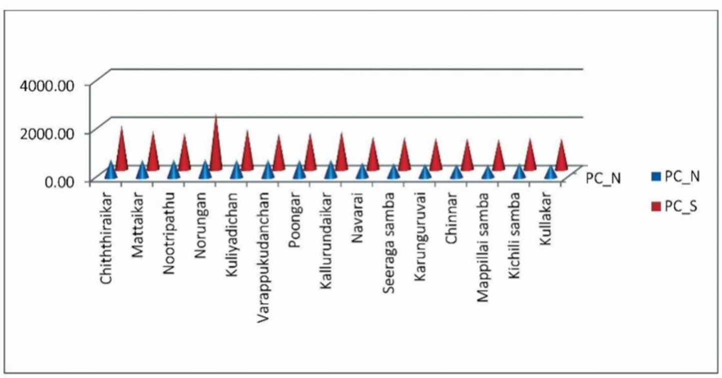



Fig. 4. Response of 15 rice landraces for proline content during vegetative stage.

Proline content of different rice landraces under normal irrigated field condition as well as managed stress condition are depicted in Fig. 4 and they were significantly different. In the present study, rice landraces tended to increasingly accumulate proline under managed drought stress. Themaximum proline accumulation was observed in Norungan both in normal irrigated (782.3μg/g FW) and managed stress condition (2366.0μg/g FW). Proline is a vital osmoprotectant that helps rice plants to withstand drought stress. Research has shown that proline accumulation during drought periods is linked to increased drought tolerance in rice. Proline helps rice plants cope with drought by reducing oxidative stress, alleviating osmotic stress, and enhancing nutrient uptake, ultimately improving plant growth, biomass, and productivity (Semida *et al*. 2019). Proline levels can serve as a biochemical marker for plant drought tolerance (Mishra *et al*. 2019).

The studied rice landraces displayed different abilities to resist drought. Based on the present study, the rice landraces Norungan, Kallurundaikar and Chithiraikar were adjudged as highly drought tolerant landraces as they showed high performance in all the morphological and physiological traits. These can be selected for future breeding programme to obtain new recombinant types for drought tolerance in the arid region.

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