Effect of rice varieties on physiological parameters under flood irrigation and alternate wetting and drying (AWD) irrigation practices

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Abstract
Field experiment were carried out in the experimental research farm, Agricultural College and Research Institute, Coimbatore during Sirambu season in the year 2018-2019 to study the physiological parameters of rice varieties under flooding irrigation and alternate wetting and drying (AWD) irrigation practices. The experiment was laid out in a split plot design with three replication. The treatments comprised of two irrigation management viz., (M1) Flood irrigation and (M2) Alternate wetting drying respectively in main plot and Subplot eight varieties viz., (S1) Kallanamak, (S2) Jeeragasamba, (S3) Kavuni, (S4) MappilaiSamba, (S5) Improved TNAU White ponni, (S6) Bhavani, (S7) CO 51 and (S8) CO 52. The results of this study showed that the positive impact of higher photosynthetic rate and specific leaf weight; lower transpiration rate and proline content of leaves were observed with AWD irrigation management with SRI practice.

Keywords: Physiological parameter, varieties, AWD, flood irrigation

Introduction
Rice is the dominant staple food crop of 2.7 billion people and is critically important for the food security of the world. Of the world rice production 476 million tonnes, India is the largest cereal crop grown in about 43 million hectares and 112 million tons of production with a productivity of 2568 kg ha⁻¹. With a total production of 6.34 million tons and average productivity of 3467 kg ha⁻¹, it is grown on 1.84 million hectares in Tamil Nadu (India stat, 2019) [9]. Water resources, both surface and underground are shrinking and water has become a limiting factor in rice production (Farooq et al., 2009) [16]. Rice is one of the greatest water users among cereal crops, consuming about 80% of the total irrigated freshwater resources in Asia. In Asia, with relatively more suitable growing conditions for rice, production has declined due to increasing water stress (Tao et al., 2004) [22]. Therefore, it is important to cut down the water supply for rice cultivation but without affecting rice yield. The Food and Agricultural Organization (FAO) estimates that rice crop consumes about 4000-5000 liters of water per kg of grain production. So there is an imperative need to find ways to reduce water use while maintaining high yields in rice cultivation. Since water for rice production has become increasingly scarce water saving is the main issue in maintaining the sustainability of rice production when water resources are becoming scarce (Arif et al., 2012) [1]. There are several alternatives to continuous flooding of rice. One approach that can be used is intermittent irrigation or alternate wetting and drying (AWD). Instead of keeping rice fields continuously flooded resulting in enormous wastage of water and lower water use efficiency, the adoption of AWD methods means that irrigation water is applied to fields to restore flooded conditions on an intermittent basis, only after a certain number of days have passed since the disappearance of ponded (standing) water (Zhang et al., 2009) [28]. If rice is grown under traditional conditions, farmers resort to continuous submergence irrigation. Hence, it becomes essential to develop and adopt strategies and practices for more efficient use of water in rice cultivation.

The reduction of relative water content in leaves under water stress conditions, nevertheless soil water status at saturated or more did not affect relative water content (Kato, 2004) [10]. Water stress affects photosynthesis (Pn) rate, which supports to a reduction of Pn rate in plants grown under AWD conditions but saturated or above water conditions did not affect Pn rate, transpiration rate (Okuma, 2011) [17].
In the other case, the photosynthetic rate of flag leaf was significantly higher in plants growing at wider spacing than in the more closely spaced plants (Thakur et al., 2010a) [23]. SRI had a significantly higher chlorophyll index (SPAD) (41.50), net photosynthetic rate (23.15 µmol m⁻² s⁻¹) than is recommended management practices (12.23 µmol m⁻² s⁻¹) (Thakur et al., 2010b) [24]. Hence, the present investigation was taken up to study the effect of agronomic management and irrigation practices on physiological parameters of rice varieties.

Materials and Methods
A Field experiment was conducted during the Samba season of 2018-2019 at Research Farm, Agricultural College and Research Institute, Coimbatore, Tamil Nadu. The experimental site is geographically located in the Western Agro Climatic Zone of Tamil Nadu at 11°N latitude, 77°E longitude with an altitude of 426.7 m above mean sea level. The soil of the experimental site was clay loam in texture having alkaline pH (8.10) and medium organic carbon (0.62%). With regard nutrient status, the soil was low in available nitrogen (215.7 kg ha⁻¹), medium in phosphorus (15.8 kg ha⁻¹) and high in potassium (568.1 kg ha⁻¹), respectively. The experiment was laid out in a split plot design with three replication.

The treatments comprised of two methods of irrigation viz., (M₁) flood irrigation practice of continuous submergence of 2.5 cm throughout the crop period and (M₂) alternate wetting and drying at 15 cm depletion of ponded water and submergence at flowering and irrigation on the day of the disappearance of ponded water. respectively in the main plot and Subplot eight varieties viz., (S₁) Kalanamak, (S₂) Jeeragasamba, (S₃) Kavuni, (S₄) Mappilaissanmba, (S₅) Improved TNAU White ponni, (S₆) Bhavani, (S₇) CO 51 and (S₈) CO 52, To evaluate the effect of different irrigation management practices and different varieties on relative water content and proline content, the data were statistically analyzed using "Analysis of variance test". The critical difference at 5% level of significance was calculated to find out the significance of different treatments over each other (Gomez and Gomez, 1984) [8]. The physiological parameters of specific leaf weight, relative water content, leaf gas exchange parameters and proline in leaves were calculated as per the standard procedure.

Specific Leaf Weight (SLW)
The SLW was arrived at by employing the formula suggested by (Garnier et al., 2001) [7] and expressed in g cm⁻² at the panicle initiation stage.

\[
\text{SLW} = \frac{\text{Leaf dry weight (g)}}{\text{Total leaf area (cm}²\text{)}}
\]

Relative Water Content (RWC)
The RWC was estimated at the panicle initiation stage by the formula given by (Barrs and Weatherley, 1962) [3] and expressed in per cent.

\[
\text{Relative Water Content (º)} = \frac{\text{Fresh weight (g)} - \text{Dry weight (g)}}{\text{Turgid weight (g)} - \text{Dry weight (g)}} \times 100
\]

Leaf Gas Exchange parameters
Leaf gas exchange measurements were performed using the Portable Photosynthetic System (PPS) (Model LI-6400 of Licor inc., Lincoln, Nebraska, USA) equipped with a halogen lamp (6400-02B LED) positioned on the cuvette. Totally three measurements were taken in the same leaf at the panicle initiation stage. Leaves were inserted in a 3 cm² leaf chamber and PPFD 1200 µmol photons m⁻² s⁻¹ and relative humidity were set at 50-55%. The following gas exchange parameters were recorded viz., Photosynthetic rate (µmol CO₂ m⁻² s⁻¹), Stomatal conductance (mol H₂O m⁻² s⁻¹), Transpiration rate (mmol H₂O m⁻² s⁻¹) and Leaf temperature (°C).

Proline in leaves
The method for the estimation of proline content was adopted from (Bates et al., 1973) [1] with slight modifications. Samples were collected at the panicle initiation stage and the collected leaves (1 g) were homogenized with 10 ml of 3 % sulphosalicylic acid and centrifuged at 3000 rpm for 10 minutes. Two ml of the supernatant was taken and 2 ml of glacial acetic acid and 2 ml of acid ninhydrin mixture were added. The contents were allowed to react at 100 °C for 1 hr and then it is incubated on ice for 10 minutes to terminate the reaction. The reaction mixture was mixed vigorously with 4 ml toluene for 15-20 seconds. The chromophore containing toluene aspirated from the aqueous phase, warmed to room temperature and optical density was read at 520 nm. The proline content was determined from the standard graph prepared using a commercially available proline in the concentration range of 20-100 µg.

Results and Discussion
Specific Leaf Weight
Data on specific leaf weight (SLW) shows a clear variation among different transplanting methods and irrigation management practices (Table 1). Among irrigation practices and different varieties, AWD with SRI management record higher specific leaf weight of 4.87 g cm⁻² on CO 52 variety and lower value recorded in conventional transplanting method with flooded irrigation on Kalanamak aromatic rice (3.12g cm⁻²). The higher SLW in AWD with SRI management plants indicated thicker leaves as compared to the leaves grown under conventional and also this may be the reason for AWD with SRI management have received a higher photosynthetic rate. These results in line with the findings of (Tao et al., 2004) [22].

Leaf Gas Exchange parameters
There were significant differences in flag leaf photosynthesis, stomatal conductance, transpiration rate and leaf temperature were observed with a different method of irrigation management practices at the panicle initiation stage (Table 1 & Table 2). Among different method of irrigation and varieties, AWD with SRI recorded higher photosynthetic rate of 29.60 µmol CO₂ m⁻² s⁻¹ was received CO 52 and lower transpiration rate (8.60 mmol H₂O m⁻² s⁻¹), stomatal conductance (0.68 mol H₂O m⁻² s⁻¹) and leaf temperature (28.03 °C) were observed Kalanamak aromatic rice.

This may be due to wider spacing in SRI management and AWD irrigation indicates that they were used water and nutrient sources more efficiently than conventionally managed continuously flooded rice. The photosynthetic rate of flag leaf was significantly higher in plants growing at wider spacing than in the more closely spaced plants. A similar result has been already reported by (Thakur et al., 2010a) [23] and (Wahlang et al., 2015) [26].

Relative Water Content
Relative water content (RWC) represents the ability of the crop to retain tissue water status under water stress and this is
one of the most important indicators of plant water stress. RWC of leaves significantly differ with irrigation management practices but not significantly varied with different transplanting methods (Fig. 1). Among various irrigation management practices, higher RWC recorded with continuous flooding (97.0%) was observed in Bhavani rice variety. Whereas, lower RWC (84.50%) was observed in CO52 rice variety with AWD with field water tube irrigation management practice. These results suggest the reduction of relative water content in leaves under such water stress conditions, nevertheless soil water status at saturated or more did not affect relative water content. This is the reason the higher RWC treatment have lower leaf temperature. Similar findings were also observed by Khairi et al. (2015) [11].

Proline content in leaves

There was a clear variation of tissue proline content in different methods of water management treatments (Fig. 1). Among different methods of irrigation and varieties, higher proline content was recorded with AWD with SRI management (1.67 µmol g⁻¹) CO 52 rice and lower proline content were found with continuous flooded irrigation (1.48 µmol g⁻¹) kalanamk. There were increases in the proline content in all AWD treatments, and the level of proline even increased with increasing the length of the period of suspension of irrigation. Accumulation of free proline in the plant cells in response to the onset of stresses is one of such mechanisms (Vendruscolo et al., 2007) [23] & (Cattivelli et al., 2008) [8]. Mostajeran and Rahimi-Eichi (2009) [12] also observed a higher amount of plant proline content in non-submerged rice and a positive correlation between free proline accumulation and drought tolerance. Singh et al. (2000) [18] mentioned that proline is a non-protein amino acid that forms in plant tissues when subjected to water stress and rapidly metabolized upon recovery from drought. This indicates the specific role of accumulated free proline in plant tissues acts as an osmolyte produced under water stress and plays a significant role in drought adaptation of plants.

Table 1: Effect of flood irrigation and alternate wetting drying in rice varieties on Specific leaf weight (g cm⁻²) and Net photosynthetic rate (µmol CO₂ m⁻² s⁻¹)

| Treatment          | Specific leaf weight | Net photosynthetic rate |
|--------------------|----------------------|-------------------------|
|                    | M₁ | M₂ | Mean | M₁ | M₂ | Mean |
| Aromatic rice      |    |    |      |    |    |      |
| S₁ : Kalanamk      | 3.12 | 4.00 | 3.56 | 21.2 | 25.0 |    |
| S₂ : Jeeragasamba  | 3.77 | 4.64 | 4.21 | 22.1 | 27.9 | 25.0 |
| Mean               | 3.45 | 4.33 | 3.88 | 23.7 | 26.5 | 24.1 |
| Land races         |    |    |      |    |    |      |
| S₃ : Kavuni        | 3.79 | 4.65 | 4.22 | 22.3 | 28.5 | 25.4 |
| S₄ : Mappilaisamba | 3.80 | 4.68 | 4.24 | 21.5 | 25.4 | 23.5 |
| Mean               | 3.80 | 4.67 | 4.23 | 21.9 | 27.0 | 24.4 |
| Popular cultivar   |    |    |      |    |    |      |
| S₅ : Improved W P  | 3.94 | 4.82 | 4.38 | 23.5 | 29.0 | 26.3 |
| S₆ : Bhavani       | 3.72 | 4.60 | 4.16 | 22.9 | 27.5 | 25.2 |
| Mean               | 3.83 | 4.71 | 4.27 | 23.2 | 28.3 | 25.7 |
| Recent released varieties |    |    |      |    |    |      |
| S₇ : CO 51         | 3.92 | 4.80 | 4.36 | 23.1 | 28.8 | 26.0 |
| S₈ : CO 52         | 3.99 | 4.87 | 4.43 | 24.3 | 29.6 | 26.9 |
| Mean               | 3.96 | 4.84 | 4.40 | 23.7 | 29.2 | 26.4 |
| Mean               | 3.76 | 4.63 | 4.19 | 22.6 | 27.7 | 25.2 |
| SEd                | 0.10 | 0.21 | 0.30 | 0.30 | 0.12 | 0.23 |
| CD (p=0.05)        | 0.42 | 0.43 | 0.68 | 0.61 | 0.50 | 0.46 |
| M₁: Flood irrigation | M₂: Alternate wetting drying monitored by field tube |

Table 2: Effect of flood irrigation and alternate wetting drying in rice varieties on Transpiration rate (mmol H₂O m⁻² s⁻¹), Stomatal conductance (mol H₂O m⁻² s⁻¹) and Leaf Temperature (°C)

| Treatment          | Transpiration rate | Stomatal conductance | Leaf Temperature |
|--------------------|--------------------|----------------------|-----------------|
|                    | M₁ | M₂ | Mean | M₁ | M₂ | Mean | M₁ | M₂ | Mean |
| Aromatic rice      |    |    |      |    |    |      |    |    |      |
| S₁ : Kalanamk      | 10.60 | 8.60 | 9.60 | 0.82 | 0.68 | 0.75 | 28.03 | 30.85 | 29.44 |
| S₂ : Jeeragasamba  | 10.90 | 8.90 | 9.90 | 0.82 | 0.75 | 0.79 | 28.20 | 31.00 | 29.60 |
| Mean               | 10.75 | 8.75 | 9.75 | 0.82 | 0.72 | 0.77 | 28.12 | 30.93 | 29.52 |
| Land races         |    |    |      |    |    |      |    |    |      |
| S₃ : Kavuni        | 10.92 | 8.92 | 9.92 | 0.83 | 0.73 | 0.78 | 29.10 | 34.00 | 31.55 |
| S₄ : Mappilaisamba | 10.88 | 8.88 | 9.88 | 0.82 | 0.73 | 0.78 | 29.87 | 35.60 | 32.74 |
| Mean               | 10.90 | 8.90 | 9.90 | 0.83 | 0.73 | 0.78 | 29.49 | 34.80 | 32.14 |
| Popular cultivar   |    |    |      |    |    |      |    |    |      |
| S₅ : Improved W P  | 11.34 | 9.34 | 10.34 | 0.85 | 0.76 | 0.81 | 29.04 | 33.02 | 31.03 |
| S₆ : Bhavani       | 10.98 | 8.98 | 9.98 | 0.85 | 0.75 | 0.80 | 28.60 | 33.00 | 30.80 |
| Mean               | 11.16 | 9.16 | 10.16 | 0.85 | 0.76 | 0.80 | 28.82 | 33.01 | 30.92 |
| Recent released varieties |    |    |      |    |    |      |    |    |      |
| S₇ : CO 51         | 11.02 | 9.02 | 10.02 | 0.83 | 0.75 | 0.79 | 29.00 | 32.10 | 30.55 |
| S₈ : CO 52         | 11.45 | 9.45 | 10.45 | 0.85 | 0.78 | 0.82 | 29.05 | 34.06 | 31.56 |
| Mean               | 11.24 | 9.24 | 10.24 | 0.84 | 0.77 | 0.80 | 29.03 | 33.08 | 31.05 |
| Mean               | 11.35 | 9.69 | 10.52 | 0.83 | 0.74 | 0.79 | 28.86 | 32.95 | 30.91 |
| SEd                | 0.22 | 0.45 | 0.64 | 0.64 | 0.02 | 0.04 | 0.05 | 0.05 | 0.77 |
| CD (p=0.05)        | 0.94 | 0.92 | 1.47 | 1.31 | 0.08 | 0.07 | 0.12 | 0.11 | 3.33 |
| M₁: Flood irrigation | M₂: Alternate wetting drying monitored by field tube |
的效果和特定叶面积的较高光合作用速率和特定叶面积的较低蒸腾速率与脯氨酸含量的观察与不同的水稻品种与适合的灌溉管理实践。这些发现对于改进水稻通过选择适合的灌溉管理实践和不同品种与适合的灌溉管理实践和不同品种与适合的灌溉管理实践的水稻的生产性是有用的。

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