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

P Kunjammal, Subbalakshmi Lokanadhan, S Murali Krishnasamy, D Jawahar and K Ganesamurthy

P Kunjammal
Ph.D., Scholar (s), Department of Agronomy, Tamil Nadu Agricultural University Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Subbalakshmi Lokanadhan
Professor, Department of Agronomy, Tamil Nadu Agricultural University Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

S Murali Krishnasamy
Department of Agronomy, Tamil Nadu Agricultural University Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

D Jawahar
Department of Agronomy, Tamil Nadu Agricultural University Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

K Ganesamurthy
Department of Agronomy, Tamil Nadu Agricultural University Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Corresponding Author:
P Kunjammal
Ph.D., Scholar (s), Department of Agronomy, Tamil Nadu Agricultural University Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Abstract
Field experiment were carried out in the experimental research farm, Agricultural College and Research Institute, Coimbatore during *Samba* 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*., (M_1) Flood irrigation and (M_2) Alternate wetting drying respectively in main plot and Subplot eight varieties *viz*., (S_1) *Kalanamak*, (S_2) *Jeeragasamba*, (S_3) *Kavuni*, (S_4) *Mappilaisamba*, (S_5) Improved TNAU White ponni, (S_6) Bhavani, (S_7) CO 51 and (S_8) 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) [6]. 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*., (M_1) flood irrigation practice of continuous submergence of 2.5 cm throughout the crop period and (M_2) 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*., (S_1) *Kalanamak,* (S_2) *Jeeragasamba,* (S_3) *Kavuni*, (S_4) *Mappilaisamba,* (S_5) Improved TNAU White ponni, (S_6) Bhavani, (S_7) CO 51 and (S_8) 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.

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

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.

$$\text{Relative Water Content (\%)} = \frac{\text{Fresh weight (g)} - \text{Dry weight (g)}}{\text{Turgid weight (g)} - \text{Dry weight (g)}} \times 100$$

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 cm^2 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 CO_2 m^{-2} s^{-1}), Stomatal conductance (mol H_2O m^{-2} s^{-1}), Transpiration rate (mmol H_2O 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) [4] 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 ºC 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 aspired 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 CO_2 m^{-2} s^{-1} was received CO 52 and lower transpiration rate (8.60 mmol H_2O m^{-2} s^{-1}), stomatal conductance (0.68 mol H_2O m^{-2} s^{-1}) and leaf temperature (28.03 °C) were observed *Kalalanamk* 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 varies 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) [25] & (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 CO_2 m^{-2} s^{-1})

Treatment		Specific leaf weight				Net photosynthetic rate		
		M_1	M_2		Mean	M_1	M_2	Mean
Aromatic rice								
S_1 : *Kalanamak*		3.12	4.00		3.56	21.2	25.0	
S_2 :*Jeeragasamba*		3.77	4.64		4.21	22.1	27.9	25.0
Mean		3.45	4.32		3.88	21.7	26.5	24.1
Land races								
S_3 : *Kavuni*		3.79	4.65		4.22	22.3	28.5	25.4
S_4 : *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								
S_5 : Improved W.P		3.94	4.82		4.38	23.5	29.0	26.3
S_6 : 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								
S_7 : CO 51		3.92	4.80		4.36	23.1	28.8	26.0
S_8 : 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
	M	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**
SEd	0.10	0.21	0.30	0.30	0.12	0.23	0.32	0.32
CD (p=0.05)	0.42	0.43	0.68	0.61	0.50	0.46	0.75	0.66

M_1: Flood irrigation & **M_2**: Alternate wetting drying monitored by field tube

Table 2: Effect of flood irrigation and alternate wetting drying in rice varieties on Transpiration rate (mmol H_2O m^{-2} s^{-1}), Stomatal conductance (mol H_2O m^{-2} s^{-1}) and Leaf Temperature (°C)

Treatment	Transpiration rate			Stomatal conductance			Leaf Temperature					
	M_1	M_2	Mean	M_1	M_2	Mean	M_1		M_2		Mean	
Aromatic rice												
S_1 : *Kalanamak*	10.60	8.60	9.60	0.82	0.68	0.75	28.03		30.85		29.44	
S_2 :*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												
S_3 : *Kavuni*	10.92	8.92	9.92	0.83	0.73	0.78	29.10		34.00		31.55	
S_4 : *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												
S_5 : Improved W.P	11.34	9.34	10.34	0.85	0.76	0.81	29.04		33.02		31.03	
S_6 : 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												
S_7 : CO 51	11.02	9.02	10.02	0.83	0.75	0.79	29.00		32.10		30.55	
S_8 : 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	
	M	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**	**M**	**S**	**M at S**	**S at M**

SEd	0.22	0.45	0.64	0.64	0.02	0.04	0.05	0.05	0.77	1.37	1.98	0.22
CD (p=0.05)	0.94	0.92	1.47	1.31	0.08	0.07	0.12	0.11	3.33	2.82	4.73	0.94

M_1: Flood irrigation & **M_2:** Alternate wetting drying monitored by field tube

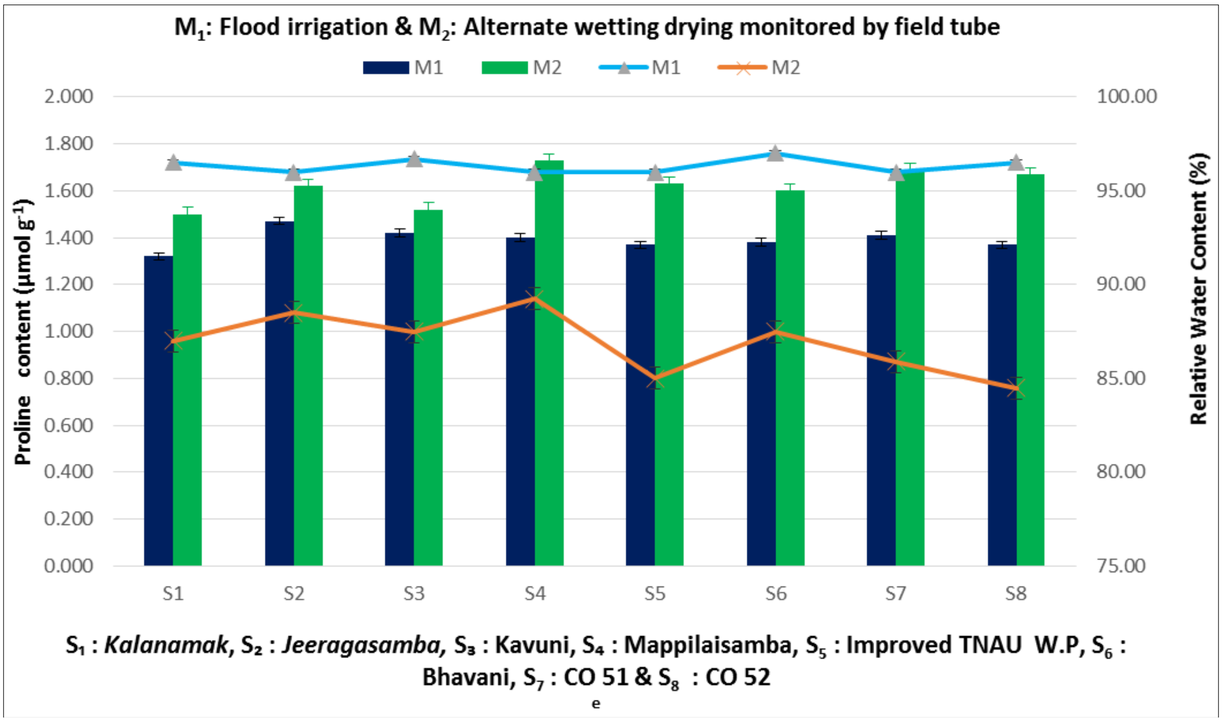

Fig 1: Effect of flood irrigation and alternate wetting drying in rice varieties on Relative Water Content (%) and Proline content (μmol g^{-1})

Conclusion

The results of the experiment shown that the positive impact of higher photosynthetic rate and specific leaf weight; lower transpiration rate and proline content were observed with alternate wetting drying with agronomic management practice. These findings are useful for improving the productivity of rice through the selection of a suitable method of irrigation practice and different varieties with suitable based on resource availability.

References

1. Arif C, Setiawan BI, Mizoguchi M, Doi R. Estimation of water balance components in paddy fields under non-flooded irrigation regimes by using excel solver. J Agron. 2012; 11(2):53-59.
2. Aslam M, Hussain S, Ramzan M, Akhter M. Effect of different stand establishment techniques on rice yields and their attributes. J Anim. Pl. Sci. 2008; 18(2-3):80-82.
3. Barrs HD, Weatherley PE. A re-examination of relative turgidity for estimating water deficits in leaves. Aust. J Biol. Sci., 1962; 15:413-428.
4. Bates LS, Waldren RP, Teare ID. Rapid determination of proline for water stress studies. Plant Soil. 1973; 39:205-207.
5. Cattivelli L, Rizza F, Badeck FW, Mazzucotelli E, Mastrangelo AM, Francia E. Drought tolerance improvement in crop plants: an integrated view from breeding to genomics. Field Crops Res. 2008; 10:1-14.
6. Farooq M, Kobayashi N, Wahid A, Shadhzad MA, Basra. Strategies for producing more rice with less water. Advances in Agronomy. 2009; 101:351-388.
7. Garnier E, Shipley B, Roumet C, Laurent G. A standardized protocol for the determination of specific leaf area and leaf dry matter content. Functional Ecol. 2001; 15:688-695.
8. Gomez KA, Gomez AA. Statistical procedures for agricultural research. (2nd Ed.), Wiley India Pvt Ltd., India, 1984.
9. INDIASTAT. Indian Agriculture Statistical information, 2019. (http://www.indiastat.com/)
10. Kato Y, Satoshi H, Akiniko K, Abe J, Urasaki K, Yamagishi J. Enhancing grain yield of rice (*Oryza sativa* L.) under upland conditions in Japan. 4th International Crop Science Congress, Brisbane, Australia, 2004.
11. Khairi M, Nozulaidi M, Afifah MA, Jahan S. Effect of various water regimes on rice production in lowland irrigation. Aus. J Crop Sci. 2015; 9(2):153-159.
12. Mostajeran A, Rahimi-Eichi V. Effects of drought stress ongrowth and yield of rice (*Oryza sativa* L.) cultivars andaccumulation of proline and soluble sugars in sheath and blades of their different ages leaves. Am. Eurasian J. Agric. Environ. Sci. 2009; 5:264-272.
17. Okuma E, Jahan MS, Munemasa S, Ogawa K, Watanabe-Sugimoto M, Nakamura Y *et al*. Negative regulation of abscisic acid-induced stomatal closure by glutathione in Arabidopsis. J Plant Physiol. 2011; 168:2048-2055.
18. Singh DK, Sale PWG, Charles KP, Vijaya S. Role of prolineand leaf expansion rate in the recovery of stressed white clover Leaves with increased phosphorus concentration. New Phytol. 2000; 146:261-269.
21. Singh G, Singh RG, Singh OP, Kumar T, Mehta RK, Kumar V *et al*. Effect of weed management practices on direct seeded rice *(Oryza sativa)* under puddled low lands. Indian J Agron. 2005; 50(1):35-37.
22. Tao FM, Yokozawa Z, Zhang Y, Hayashi HG, Fu C. Variability in climatology and agricultural production in China in association with the East Asia summer monsoon and El Niño South Oscillation. Climate Res. 2004; 28:23-30.

23. Thakur AK, Rath S, Roychowdhury S, Uphoff N. Comparative Performance of Rice with System of Rice Intensification (SRI) and Conventional Management using Different Plant Spacings. J Agron. & Crop Sci. 2010a; 196:146-159.
24. Thakur AK, Uphoff N, Antony E. An assessment of physiological effects of system of rice intensification (SRI) practices compared with recommended rice cultivation practices in India. Expl. Agric. 2010b; 46(1):77-98.
25. Vendruscolo ECG, Schuster I, Pileggi M, Scapim CA, Molinari HBC, Marur CJ. Stress-induced synthesis of proline confers tolerance to water deficit in transgenic wheat. J Plant. Physiol. 2007; 164:1367-1376.
26. Wahlang B, Das A, Layek J, Munda GC, Ramkrushna GI, Panwar AS. Effect of establishment methods and nutrient management on physiological attributes and water-use efficiency of rice (*Oryza sativa*) in a sub-tropical climate. Indian J Agron. 2015; 60(4):157-163.
27. Yadav SK, Singh DK, Rani M. Interaction effect of weed management practices, brown manuring and nitrogen levels on yield of direct seeded rice and growth of weeds. Green Farming. 2014; 5(1):46-50.
28. Zhang H, Xue Y, Wang Z, Yang J, Zhang J. An alternate wetting and moderate soil drying regime improves root and shoot growth in rice. Crop Sci. 2009; 49:2246-2.