

Effect of Irrigation Practices on Water Use Its Efficiency and Economic Yield in Rice Varieties

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was carried out at the Agricultural College & Research Institute, Coimbatore in research farm during samba season 2018-2019 to assess the water use and its efficiency in different rice varieties comprising aromatic rice, land races, popular cultivars and recent released variety under modified irrigation practices. The experimental design was a split plot with three replications. The main plots with continuous flooding and modified irrigation practices and sub plots with eight varieties as treatments viz., (S1) Kalanamak, (S2) Jeeragasamba, (S3) Kavuni, (S4) Mappilaisamba, (S5) Improved TNAU White ponni, (S6) Bhavani, (S7) CO 51 and (S8) CO 52. Irrigation practice of alternate wetting and drying, monitoring with field tube registered lower consumption of water (900 mm) with less number of irrigation(14), higher water use efficiency (7.3 kg ha⁻¹mm⁻¹) and water productivity (1682 lit.kg⁻¹) in rice, compared to flood irrigation practices. In Sub plot with different rice varieties viz.,

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aromatic, landraces, popular cultivar and recently released rice variety among these varieties the recent released variety CO52 recorded higher grain yield (6.6 t ha⁻¹), compared to other varieties.

Keywords: Irrigation practices; water use efficiency; water productivity.

1. INTRODUCTION

Rice is one of India's Chief Grains. Moreover, as it is one of the main food crops, this country has the largest area under rice cultivation. The world rice production is 476 million tonnes, India rice crop is 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 [1].

Rice is one of the high water user crop among cereals, consuming about 80% of the total irrigated freshwater resources in Asia. In Asia, with relatively more suitable growing conditions for rice, production at present has declined due to increasing water stress (Tao et al., 2004). Therefore, it is important to cut down the water supply for rice cultivation without affecting rice yield. So there is a need to find ways to reduce water use while maintaining constant high yields in rice cultivation. At present, the growing water scarcity and water related crisis have already shown a reduction in irrigated rice area and shift towards less water demanding cropping activities. To sustain present food self-sufficiency and to meet future food requirements, India has to realize an annual growth in rice productivity of at least 3 per cent. Considering the future food requirements, competition from non-agricultural use for freshwater, and the large amounts of water currently used in cropping, new methods of rice cultivation must be identified aiming at higher water and crop productivity. AWD, a new form of rice irrigation is gaining importance to achieve higher productivity since the factors of production devoted to rice such as land, labour, capital and water are utilized effectively. There are several alternatives to conventional method of irrigation practices of rice (continuous flooding). In its place of protection rice fields continuously flooded, the adoption of AWD methods means that irrigation water is applied to fields to restore flooded conditions on an alternate basis, only after a certain number of days have passed since the disappearance of ponded (standing) water [2].

The practice of safe AWD by using field tube as water saving technology entails irrigation when water depth falls to a threshold depth of below the soil surface. The recommended water management for "safe" (no yield loss) AWD involves, irrigating (to the depth of around 5 cm) when the floating water table falls to 15 cm below the soil surface [3]. Several studies have shown that safe AWD reduces water input significantly without reducing grain yield [4]. AWD is safe to limit the water use up to 25 % without a reduction in rice yield reported by Kulkarni [5]. Thirty percentage of irrigation water saved by safe AWD irrigation practices, compared to continuous flooding [6]. Hence, the present investigation was taken up to study the effect of irrigation practices on water production and yield of rice varieties.

2. MATERIALS AND METHODS

A Field experiment was conducted during the *Samba* season of 2018-2019 at the 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 to 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 two method of irrigation viz., Flood irrigation practice of continuous submergence of 2.5 cm throughout the crop period (M₁) and alternate wetting and drying at 15 cm depletion of ponded water and submergence at flowering and irrigation on the day of disappearance of ponded water (M₂) respectively in main plots and subplots consisted of eight rice varieties viz., (S₁)*Kalanamak*, (S₂)*Jeeragasamba*, (S₃)*Kavuni*, (S₄)*Mappilaisamba*, (S₅)*Improved TNAU White ponni*, (S₆)*Bhavani*, (S₇)*CO51* and (S₈)*CO52*. To evaluate the effect

of agronomic management with irrigation practices on water use efficiency (WUE), water productivity and yield, the data were statistically analyzed using "ANOVA". The critical difference at 5% level of significance was calculated to find out the significance of different treatments with each other [7].

2.1 Water Use Efficiency

Water use efficiency (WUE) was computed using the equation of Viets [8] and expressed as $\text{kg ha}^{-1} \text{mm}^{-1}$.

$$\text{WUE} = \frac{\text{Grain yield (kg ha}^{-1}\text{)}}{\text{Total water consumed in (mm)}}$$

2.2 Water Productivity

Water productivity is the function of the total water used and grain yield obtained in the crop and expressed in lit. kg^{-1} .

$$\text{Water Productivity} = \frac{\text{Volume of water used (lit.)}}{\text{Grain yield (kg ha}^{-1}\text{)}}$$

3. RESULTS AND DISCUSSION

3.1 Effect Due to Field Irrigation Practices

The higher water use efficiency (WUE) and water productivity (WP) can be increased either by increasing yield or by maintaining the yield level with reduced quantity of water as input (Table 1). Among the irrigation practices higher WUE and WP obtained in AWD practices, lower WUE and WP found with flood irrigation practices. Reduction in consumptive water use under field water tube irrigation at 15 cm drop of water table coupled with the maintenance of yield at an optimum level increased the WUE and WP. Among the varieties, CO 52 recorded higher WUE of $7.3 \text{ kg ha}^{-1} \text{mm}^{-1}$, WP of $1682 \text{ lit. kg}^{-1}$ under AWD practices while, lower WUE of $2.1 \text{ kg ha}^{-1} \text{mm}^{-1}$ and WP of $4835 \text{ lit. kg}^{-1}$ was observed under flood irrigation which is conventional method of irrigation. The increased water use efficiency obtained in AWD irrigation practices could be attributed to the optimum need based irrigation using the monitoring device i.e. field water tube coupled with increased grain

Table 1. Effect of flood irrigation and alternate wetting drying in rice varieties on water use efficiency ($\text{kg ha}^{-1} \text{mm}^{-1}$) and Water Productivity (lit. kg^{-1})

| Treatment | Water use efficiency | | | Water productivity | | | | |
|----------------------------------|----------------------|----------------|---------------|--------------------|----------------|----------|---------------|---------------|
| | M ₁ | M ₂ | Mean | M ₁ | M ₂ | Mean | | |
| Aromatic rice | | | | | | | | |
| S ₁ : Kalanamak | 2.4 | 3.1 | 2.7 | 4238 | 3253 | 3745 | | |
| S ₂ : Jeeragasamba | 3.0 | 4.0 | 3.5 | 3339 | 2524 | 2931 | | |
| Mean | 2.7 | 3.5 | 3.1 | 3788 | 2888 | 3338 | | |
| Land races | | | | | | | | |
| S ₃ : Kavuni | 3.6 | 4.6 | 4.1 | 2800 | 2173 | 2486 | | |
| S ₄ : Mappilaisamba | 2.1 | 2.6 | 2.3 | 4835 | 3875 | 4355 | | |
| Mean | 2.8 | 3.6 | 3.2 | 3818 | 3024 | 3421 | | |
| Popular cultivar | | | | | | | | |
| S ₅ : Improved W.P | 4.7 | 6.6 | 5.6 | 2146 | 1509 | 1828 | | |
| S ₆ : Bhavani | 4.0 | 6.0 | 5.0 | 2484 | 1666 | 2075 | | |
| Mean | 4.3 | 6.3 | 5.3 | 2315 | 1587 | 1951 | | |
| Recent released varieties | | | | | | | | |
| S ₇ : CO 51 | 4.6 | 6.6 | 5.6 | 2181 | 1512 | 1847 | | |
| S ₈ : CO 52 | 5.0 | 7.3 | 6.2 | 2002 | 1361 | 1682 | | |
| Mean | 4.8 | 7.0 | 5.9 | 2092 | 1437 | 1764 | | |
| Mean | 3.7 | 5.1 | 4.4 | 3003 | 2234 | 2619 | | |
| | M | S | M at S | S at M | M | S | M at S | S at M |
| SEd | 0.11 | 0.11 | 0.22 | 0.32 | 0.32 | 67.6 | 122.2 | 175.2 |
| CD (p=0.05) | 0.48 | 0.48 | 0.46 | 0.74 | 0.65 | 290.7 | 250.3 | 417.6 |

M₁: Flood irrigation & M₂: Alternate wetting drying

Table 2. Effect of flood irrigation and alternate wetting drying in rice varieties on yield (kg ha⁻¹)

| Treatment | Grain yield (kg ha ⁻¹) | | | Straw yield (kg ha ⁻¹) | | | | |
|----------------------------------|------------------------------------|----------------|---------------|------------------------------------|----------------|----------|---------------|---------------|
| | M ₁ | M ₂ | Mean | M ₁ | M ₂ | Mean | | |
| Aromatic rice | | | | | | | | |
| S ₁ : Kalanamak | 2655 | 2840 | 2748 | 6671 | 6817 | 6744 | | |
| S ₂ : Jeeragasamba | 3369 | 3646 | 3508 | 7412 | 7656 | 7534 | | |
| Mean | 3012 | 3243 | 3128 | 7042 | 7237 | 7139 | | |
| Land races | | | | | | | | |
| S ₃ : Kavuni | 4071 | 4257 | 4165 | 7429 | 7663 | 7546 | | |
| S ₄ : Mappilaisamba | 2440 | 2581 | 2511 | 7565 | 8259 | 7912 | | |
| Mean | 3256 | 3419 | 3338 | 7497 | 7961 | 7729 | | |
| Popular cultivar | | | | | | | | |
| S ₅ : Improved W.P | 5382 | 6003 | 5693 | 6808 | 7004 | 6906 | | |
| S ₆ : Bhavani | 4589 | 5536 | 5062 | 6507 | 6791 | 6649 | | |
| Mean | 4985 | 5770 | 5377 | 6657 | 6897 | 6777 | | |
| Recent released varieties | | | | | | | | |
| S ₇ : CO 51 | 5382 | 6003 | 5693 | 6789 | 6900 | 6844 | | |
| S ₈ : CO 52 | 4589 | 5536 | 5062 | 7377 | 7645 | 7511 | | |
| Mean | 4985 | 5770 | 5377 | 7083 | 7272 | 7177 | | |
| Mean | 4232 | 4683 | 4457 | 7070 | 7342 | 7206 | | |
| | M | S | M at S | S at M | M | S | M at S | S at M |
| SEd | 106 | 180 | 261 | 257 | 153 | 286 | 408 | 404 |
| CD (p=0.05) | 457 | 370 | 632 | 527 | 660 | 585 | 965 | 827 |

M₁: Flood irrigation & M₂: Alternate wetting drying

yield levels. The higher consumptive use with more frequent irrigations without corresponding increase in grain yields could have lead to decreased WUE under farmers' practice of irrigation practice. The results of this study are in agreement which is the conventional type with the findings of Bouman et al. [3].

The field water use depends mostly on irrigation frequency and the quantity of water used by the crop. Water usage was higher in flood irrigation, with total water usage of 118 cm and lowest water use efficiency of 2.7kg ha⁻¹mm⁻¹, higher water productivity of 3745 lit.kg⁻¹ recorded with continuous submergence of water.

3.2 Rice Varieties

Irrigation management practices in rice varieties had a profound influence on the grain and straw yield of rice as shown in Table 2. Irrigation management practices greatly influenced rice grain yield. Statistically, significant P (0.05) and wide variations in the grain yield of the varieties were recorded. Aromatic rice varieties in flood irrigation mean yield was 3.0 t ha⁻¹ and in AWD irrigation the mean yield was 3.2 t ha⁻¹. Rice land races in flood irrigation and AWD irrigation mean yield was 3.3 t ha⁻¹ and 3.4 t ha⁻¹. The mean yield of Popular cultivar varieties in flood

irrigation was 4.9 t ha⁻¹ and in 5.7 t ha⁻¹AWD irrigation. Recent released rice varieties under in flood irrigation was 5.5 t ha⁻¹ and in 6.3 t ha⁻¹ AWD irrigation. The increased yield under SRI with AWD method of irrigation might be due to favorable growing with good environment and nutrition supply and increased uptake of nutrients as recorded in SRI with AWD method of irrigation, which lead the plants to superior growth and favorable growth traits which enhanced the yield attributing characters, higher source to sink conversion, which in turn resulted in higher grain and straw yield. This is in line with the findings of [9] and Sureshkumar and Pandian (2017). Need based water management practice of field water tube irrigation at 15 cm drop of water table also reduced irrigation, which recorded an increased level of grain. The result was supports the findings of Bouman et al. [3] and Oliver et al. [10].

4. CONCLUSION

Modified irrigation practices of Alternate Wetting and Drying (AWD) method in rice cultivation enhanced the water use efficiency and water productivity. Also, produced higher grain yields indicated that the physico-chemical environment prevailed under these treatment combinations produced favourable growth and yield attributes,

which in turn reflected on grain and straw yields. AWD practice also had a profound influence on the grain and straw yield of rice varieties viz., Aromatic rice (Jeergasamba), land races (kavuni), popular cultivar (TNAU improved white ponni) and recently released varieties (CO52).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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