



Research Article

Yield maximization of direct sown rice (*Oryza sativa L.*) under water constraint situation

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Abstract

More efficient water management practices need to be adopted for better sustainable rice production grown under traditional areas due to increased water scarcity. Among the different water management practices, efficient new generation water-saving chemicals and organic products were used to conserve water under field condition. An experiment was conducted to evaluate the yield maximization in direct sown CO51 rice (*Oryza sativa L.*) under water constraint situation. The main plot treatments comprised of three levels of irrigation *viz.*, Conventional irrigation (M_1), Tensiometer based irrigation (M_2) and Deficit irrigation (M_3), respectively and were tested with four different water conservation practices in sub-plots *viz.*, soil application of water-saving crystals (WSC) @ 5 kg ha⁻¹ (S_1), foliar application of drought shield @ 3 litres ha⁻¹ (S_2), soil application of humic granules @ 2.5 kg ha⁻¹ (S_3) and soil application of FYM @ 12.5 t ha⁻¹ (S_4). Experimental results indicated that Tensiometer based irrigation with soil application humic granules @ 2.5 kg ha⁻¹ (M_2S_3) recorded higher number of panicles m⁻² (411) and number of filled grains panicle⁻¹ (108.16) in direct-sown rice. However, M_2S_3 recorded significantly maximum grain yield (6352 kg ha⁻¹) and minimum (3940 kg ha⁻¹) in (M_3S_4) deficit irrigation applied with FYM @12.5 t ha⁻¹ in the year 2018 *Sornavari season*, respectively. Thus the Tensiometer based irrigation with soil application of humic granules @ 2.5 kg ha⁻¹ can be a feasible approach for increasing grain yield and conserve water in north eastern region of Tamil Nadu, by promoting water use efficiency method in direct rice cultivation areas.

Keywords: Direct-sown rice, Irrigation, Water conservation, Yield parameters

INTRODUCTION

For millions of people in the world, particularly in Asian countries, rice is the staple food. Cultivation of rice possesses immense importance in the food security of Asia, where more than 90% of the global rice is produced and consumed. Nowadays the availability of water for irrigation is getting scarce and it is important to look into a water-efficient agriculture. (Kurrey *et al.*

2018). Food demand gets on increasing while the water resources are declining and are becoming challenges for food security. With diminishing water availability, increased frequency of extreme drought and high temperature events are a serious threat to the farmers, resulting in crop losses (Korres *et al.*, 2017). Hence, rice production had to be switched towards a smart irrigation method, which involves increased rice productivity with increased water use efficiency (WUE).

Water saving crystals in other terms, agricultural hydrogels are synthetic polymers that absorb as many times as their weight in water, which can be distributed in dry areas to improve the soil ability to absorb water (Neethu *et al.*, 2018).

Tensiometer is a simple device which measures the amount of energy required by the plant to pull soil water at the current moisture level and thereby guides the farmers when to irrigate the crop (Kamal *et al.*, 2018). Studies of Bhatt *et al.* (2016) tensiometer based irrigation application in rice would save 14-15% of water. The application of FYM resulted in improved crop growth by supplying plant nutrients, including micronutrients, which improved soil properties, thereby favouring maximum yield (Dejene and Lemlem, 2012). Drought shield protects plants from heat, water loss, drying winds, sunburn and make them stable under drought-prone condition. According to Perumal Palanivel *et al.* (2015), the application of humic substance in rice resulted in increased plant growth and yield characteristics significantly.

Hence a field investigation was carried out to study the effect of water conservation practices in conjunction with different levels of irrigation on the grain yield of rice (CO51) under direct-sown condition with the objective to study the influence of different levels of irrigation and water conservation practices on the yield and yield characters of direct-sown rice (CO51).

MATERIALS AND METHODS

The experiment was carried out at the Experimental Farm, Department of Agronomy, Annamalai University, to study the agronomic practices for yield maximization of direct-sown rice under water constraint situation during February to May 2018 ("Sornavari" season). Rice variety CO51 obtained from Tamilnadu Agricultural University, Coimbatore, was chosen for the study and a spacing of 15 x 10 cm was adopted. The recommended dose of fertilizer RDF for rice (CO51) variety 120:40:40 kg of NPK ha⁻¹ was practised.

Three replication in a Split plot design was carried out for the research. The main plot treatments were composed of three irrigation viz., M₁-Conventional irrigation, M₂-Tensiometer-based irrigation, and M₃-Deficit irrigation. The sub-plot treatments comprised of different water conservation practices viz., S₁-Soil application of water-saving crystals (WSC) @ 5 kg ha⁻¹, S₂-Foliar application of drought shield @ 3 litres ha⁻¹, S₃-Soil application of humic granules @ 2.5 kg ha⁻¹ and S₄-Soil application of FYM @ 12.5 t ha⁻¹. The average water requirement for direct-sown rice in the experimental area is 920 mm. Under conventional irrigation, the crop was irrigated with 5 cm of water each time 3 days after the disappearance of applied water throughout the crop duration. In Tensiometer based irrigation, the crop

was irrigated upto the field capacity (tensiometer value of 0.7) and in deficit irrigation, the crop was irrigated to a medium level of Available soil moisture (ASM) with a tensiometer value of 0.5. Irrigation was scheduled at the vegetative phase, reproductive phase, ripening phase. The number of irrigations given under the main plots was scheduled as follows: Conventional irrigation – 23, Tensiometer based irrigation – 17 and Deficit irrigation – 12, respectively. Observations on the number of panicles m⁻², number of filled grains panicle⁻¹, Grain yield and straw yield were recorded.

The data obtained from various observations were statistically analyzed as the split-plot design procedure using the standard techniques of Analysis of Variance (ANOVA) as suggested by Gomez and Gomez (1984). The critical difference at 5% level of probability was calculated for testing the significance of the difference between any two means wherever 'F' test was found significant. Wherever the calculated 'F-value' exceeded the tabulated value, the difference between the treatments was significant.

RESULTS AND DISCUSSION

Effects of irrigation and water conservation practices on yield parameters:

Number of panicles m⁻² and filled grains panicle⁻¹:

Among the irrigation practices adopted, Tensiometer based irrigation - M₂, recorded the maximum number of panicles m⁻² (368) and number of filled grains panicle⁻¹ (96.06). Availability of adequate water to the crop and enough aeration at critical growth stages of direct sown rice resulted in maximum yield components (Table 1).

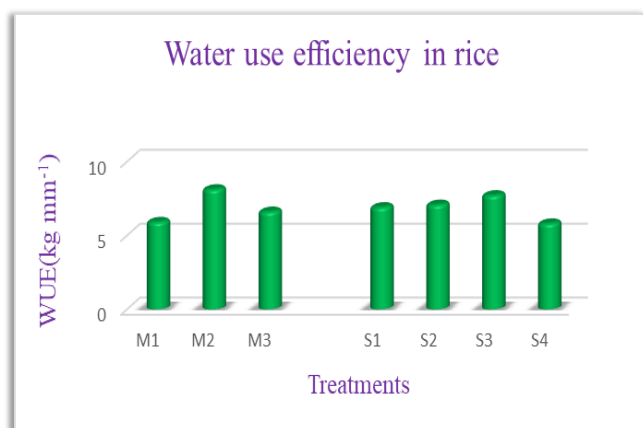
Among the water conservation practices scheduled, soil application of humic granules @ 2.5 kg ha⁻¹ on 30 and 45 DAS had recorded the maximum number of panicles m⁻² (382) and number of filled grains panicle⁻¹ (100.05) in direct-sown rice. This might be due to higher nutrient uptake, particularly phosphorous, which might have enhanced the grain filling in direct sown rice. Similar higher results were obtained in the studies of Saha *et al.* (2013) by incorporating Humic acid (HA) @ 6Lha-1 in T. aman rice cv. BRR1 dhan 39. The treatment combination M₃S₄ (Deficit irrigation applied with FYM @ 12.5 t ha⁻¹) recorded the minimum yield components which might be due to water stress in plants at grain filling stage.

Yield

Water management practices played a major role in influencing the grain and straw yield of direct sown rice. M₂-Tensiometer based irrigation recorded the maximum grain yield (5524 kg ha⁻¹) and straw yield (6849 kg ha⁻¹). The increased yield might be due to the effective utilization of water throughout the crop growth, especially at critical growth stages (Fig. 1). Similarly, Kumar

Table 1. Effects of different levels of irrigation and water conservation practices on yield and yield parameters ha⁻¹ of direct-sown CO 51 rice .

Treatments	Number of panicles m ⁻² (nos.)	Number of filled grains panicle ⁻¹ (nos.)	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Harvest index
M ₁ – Conventional irrigation	364	95.74	5438	6765	44.53
M ₂ – Tensiometer based irrigation	368	96.06	5524	6849	44.52
M ₃ – Deficit irrigation	318	82.09	4497	5895	43.23
S. Ed	2.53	0.66	38.90	47.02	NS
C.D (p=0.05)	7.03	1.85	108.02	130.55	NS
S ₁ – Soil application of water saving crys-	352	91.83	5158	6553	43.98
S ₂ – Foliar application of drought shield@ 3	354	92.54	5290	6604	44.42
S ₃ – Soil application of humic granules @ 2.5 kg ha ⁻¹	382	100.05	5779	7111	44.76
S ₃ – Soil application of FYM @ 12.5 t ha ⁻¹	312	80.76	4385	5743	43.24
S. Ed	4.19	1.09	63.66	78.38	NS
C.D (p=0.05)	8.82	2.31	133.76	164.68	NS

**Fig 1.** Water use efficiency in different levels of irrigation and water conservation practices in M – as main plots and S – as sub-plot treatments.

et al. (2017) reported in four rice varieties (Apo, Anna-da, Satabdi and Naveen) that improved grain yield has happened due to the adoption of water deficit irrigation strategy with an appropriate irrigation threshold can save water and increase water productivity.

Among the water conservation practices, S₃- Humic granule @ 2.5 kg ha⁻¹ on 30 and 45 DAS recorded the maximum grain yield of 5779 kg ha⁻¹ and straw yield of 7111 kg ha⁻¹. This might be due to increased uptake of nutrients, improved aeration and water holding capacity of soil in the humic acid applied treatment. Enhanced uptake of nutrients was evident in the present study could have exerted beneficial effects on growth and yield components of direct-sown rice. Similar findings were observed by Saha *et al.* (2013) in BRR1 dhan 39 with HA 6 L ha⁻¹ and El-Gohary *et al.* (2010) in rice plants with foliar application of humic @ 5 g/L in Giza, Egypt. This was followed by foliar application of drought

shield @ 3 liters ha⁻¹ (S₂) with a value of 5290 kg ha⁻¹. Mitali *et al.* (2017) reported that grain yield was highest at Tensiometer based irrigation at 35 cm depth with 50 kPa tension and lowest at 20 cm depth with 20 kPa tension in 2013-14 and grain yield was highest at Tensiometer at 35 cm depth with 50 kPa tension in 2014-15.

In the present study, the interaction between different levels of irrigation and water conservation practices influenced the grain yield of direct-sown rice. The maximum grain yield was recorded in the treatment combination (M₂S₃) Tensiometer based irrigation along with soil application of humic granules @ 2.5 kg ha⁻¹ on 30 and 45 DAS. The increased yield might be due to the availability of adequate nutrients and soil moisture during the physiological growth stages, thereby providing favourable conditions for the crop to express its maximum yield potentiality.

Conclusion

We found that Tensiometer based irrigation with soil application of humic granules was highly responsive to direct-sown rice (CO51). This unique treatment has resulted in higher number of panicles m⁻², number of filled grains panicle⁻¹, grain yield and straw yield than conventional and deficit irrigation with other subplot treatments. Since the conventional and deficit irrigation with other subplot treatments offered no significant yield advantages over the Tensiometer based irrigation, we recommend the tensiometer meter + HA granules @ 2.5 kgha⁻¹ in the soil to hasten the direct-sown rice productivity. These results indicated that Tensiometer based irrigation with soil application of humic gran-

ules was a feasible and practical means of increasing grain yield under water constraint situations and water use efficiency of direct sown rice (CO51) in north eastern regions of Tamil Nadu.

Conflict of interest

The authors declare that they have no conflict of interest.

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