

**PERFORMANCE OF RICE VARIETIES WITH VARYING IRRIGATION REGIMES
UNDER AEROBIC CONDITION**

Abstract:

The field experiment was conducted at the Regional Research Technology and Transfer Station (RRTTS), Chiplima, Sambalpur, Odisha during *summer* season of 2019 & 2020 to see performance of medium duration rice varieties with varying irrigation regimes under aerobic condition. The experiment was laid out in split plot design with 3 replications and consisted of four irrigation regimes (I_1 = Irrigation at IW/CPE = 1.0, I_2 = Irrigation at IW/CPE = 1.5, I_3 = Irrigation at IW/CPE = 2.0, and I_4 = Irrigation at IW/CPE = 2.5) in main plot treatments and four varieties (V_1 = Naveen, V_2 = MTU-1010, V_3 = CR Dhan-201 and V_4 = CR Dhan-204 in subplot treatments. The result of pooled mean of both the years showed that highest grain yield was recorded at IW/CPE = 2.5 i.e 4.07 t/ha, which was at par with IW/CPE = 2.0 (3.90 t/ha) and significantly superior to rest of other irrigation regimes. But in case of cultivars, highest grain yield was obtained with variety CR-Dhan 201(3.54 t/ha) which was at par with variety Naveen (3.30t/ha) and significantly superior to rest of other cultivars. The interaction of irrigation at IW/CPE 2.0 with variety CR Dhan 201 gave the highest grain yield (4.39t/ha) which was at par with irrigation at IW/CPE 2.5 with variety CR Dhan 201 (4.30 t/ha) and significantly superior to rest of other interactions. The interaction of irrigation regime at IW/CPE 1.5 with Naveen variety produced the highest field water use efficiency (44.05 kg ha⁻¹) but it was at par with all irrigation regimes except at IW/CPE 2.5 with variety CR Dhan 201. Hence, it may be concluded that variety like CR Dhan 201 needs to be irrigated at IW/CPE 2.0 produced economically optimum yield and field water use efficiency on sandy loam soils of western region of Odisha under aerobic condition.

Key words: Aerobic rice, Irrigation regimes, Water use efficiency, Cultivars, IW/CPE ratio

Introduction

Rice (*Oryza sativa* L.) is the staple food for billions of people all over the world. Scarcity of freshwater resources in the world's leading rice-producing countries like China and India are limiting the production of the flooded rice crop. In Asia, it was estimated that by 2025, 17 million hectare of irrigated areas may experience “physical water scarcity” and 22 million areas may have “economic water scarcity” (Tuong & Bouman, 2005). Traditional rice cultivation is having standing water for most of the crop stages and it requires 3000 - 5000 litres of water to produce one kg rice (IRRI, 2001) depending on the variety and rice cultivation methods. Increasing scarcity of water has threatened the traditional rice cultivation practices all over the world (Tuong & Bouman, 2003). Conventional puddle transplanted rice cultivation consumes more water, which threatens the sustainability of rice production. Puddling of rice fields repeatedly destroys soil aggregates, reduces permeability in subsurface layers and creates hard pans at shallow depths. Thus, there is a need to find out the alternate means of rice cultivation to save water and other inputs.

Aerobic rice culture is an alternative emerging technology and revolutionary way of growing rice (coined by IRRI) where, the direct seeded rice varieties with aerobic environment are grown in well drained unpuddled and non saturated soil (aerobic soil) in order to increase the water use efficiency. This concept is mainly target for irrigated low lands where, water is not sufficient for rice cultivation and suitable uplands, where facility for supplemental irrigation was available (Bleeder *et al.* 2005). This method is unique in its characteristics to withstand both flooding and dry soil conditions. Hence, ecology of aerobic rice is intermediate between upland and favorable shallow low land. In this method of growing rice saves water by eliminating continuous seepage and percolation, reducing evaporation and eliminating wet land preparation (Castaneda *et al.* 2007).

The rice varieties suitable for aerobic must system possess the combined drought resistance and high-yielding characters (Prasad 2011). Identification of medium duration varieties that contributing to superior yield performances under aerobic condition will be useful in developing rice varieties suitable for aerobic cultivation. Research is under way to develop special aerobic and nutrient-responsive varieties across the rice growing countries. However, reliable information on vital agro-techniques for successful aerobic rice culture in this region is absolutely lacking. Therefore, present study was taken in order to know the performances of medium duration selected rice varieties like Naveen, MTU-1010, CR Dhan-201 and CR Dhan-204 with varying irrigation regimes under aerobic condition.

Materials And Methods

The field experiment was conducted at the Regional Research Technology and Transfer Station (RRTTS), Chiplima, Sambalpur, Odisha during *Summer* Season of 2019 & 2020 to see performance of medium duration rice varieties with varying irrigation regimes under aerobic condition. The acidic (pH 5.45) soil of the experimental field was sandy loam soil, low in organic carbon (0.38%) and available N, P, K content are 187, 15.4 and 172 kg/ha, respectively. The moisture content at field capacity and permanent wilting point was 19.6 and 8.6 per cent, respectively. The experiment was laid out in split plot design with 3 replications and consisted of four irrigation regimes (I_1 = Irrigation at IW/CPE = 1.0, I_2 = Irrigation at

IW/CPE = 1.5, I₃ = Irrigation at IW/CPE = 2.0, and I₄ = Irrigation at IW/CPE = 2.5) in main plot treatments and four varieties (V₁ = Naveen, V₂ = MTU-1010, V₃ = CR Dhan-201 and V₄ = CR Dhan-204 in subplot treatments). The experimental field was ploughed three times in dry unploughed conditions. The first ploughing was done in order to remove all weeds and other plant residues of previous crop from the field. The second ploughing was done 15 days after first ploughing and light irrigation was applied to the field to enhance the germination of weed seeds and seeds of previous crop in the field. The third ploughing was done three days before sowing to destroy the weed and previous crop in the field. Then, leveled the field with leveler in order to prepare good seed bed for smooth germination of rice seeds. Seeds of cultivars were manually sown (hand dibbled) in 2-3 cm depth @ 45 kg/ha in furrows made by trench hoe at 20 cm × 10 cm spacing. Thinning and gap filling was done at seedling 20 days after sowing so as to maintain optimum and uniform plant population in all the plots.

Recommended dose fertilizers (80 kg N, 40 kg P₂O₅ and 40 kg K₂O) applied in the field. Full dose of phosphorus in the form of DAP and half dose of potash in the form of MOP were applied as basal in the rows about 4-5 cm deep before seeding and remaining half dose of potash was top dressed at 60 days after sowing (DAS). The nitrogen in the form of urea was top dressed in three splits i.e.; half dose of nitrogen at 20 DAS and remaining half dose of nitrogen was applied in two equal splits each at 40 DAS and 60 DAS. All the other cultural operations were carried out as per recommendation. The volume of irrigation water in each plot was calculated by multiplying the depth of irrigation and area of the plot. Then, irrigation water was measured on the basis discharge rate (l/s) of water entering to the experimental field. The time of irrigation for every plot was computed by using given depth of irrigation, area of the plot and discharge rate. The initial two common irrigations were applied to all the treatments after sowing for proper establishment of the plants till 20 DAS and thereafter, irrigation was applied as per treatment details.

The observations on grain and straw yield were recorded on the net plot basis. Water requirement was calculated by adding effective rainfall during crop growth period and irrigation applied to the field. Field water use efficiency (kg/ha-cm) was calculated as the ratio of grain yield and the amount of water applied to the field plots. The experimental data recorded for various parameters under study were subjected to statistically analyzed ANOVA given by Gomez and Gomez (1984) to draw a valid conclusion. The variation in the treatments mean was tested by using critical difference (CD) values at 5% level of significance.

Results And Discussion

Grain yield

The result showed that grain yield of rice increased significantly with increase in IW/CPE up to 2.0 and further increase IW/CPE did not prove beneficial during both individual years and its pooled mean (Table-1). The highest grain yield of 4.09, 4.06 and 4.07 t/ha were produced with irrigation regime at IW/CPE = 2.5 in first year, second year and pooled mean, respectively. The increase in grain yield owing to irrigation at IW/CPE = 2.5 over at IW/CPE = 2.0, IW/CPE = 1.5 and IW/CPE = 1.0 were 4.1, 38.2 and 85.9 % in first year, 5.2, 46.6 and 80.4 % in second year and 4.4, 42.3 and 82.5 % in pooled mean, respectively. The highest grain yield was produced with increase in irrigation frequency might be due to higher growth

and yield attributes as well as conducive situation for efficient water and nutrient uptake which boost their growth and yield attributes through supply of more photosynthates towards the reproductive sink. This result was in corroboration with the findings of Maheswari *et al.* (2008) and Shekara *et al.* (2010).

Among the cultivars, the rice variety CR Dhan 201 performed better in grain yield than the other varieties during individual years and its pooled mean. In first year as well as pooled mean, the rice variety CR Dhan 201 recorded the highest grain yield of 3.60 and 3.54 t/ha, respectively and significantly superior to rest of the varieties. Whereas in second year, the grain yield of rice variety CR Dhan 201 was at par with Naveen variety and significantly superior to rest of the varieties. The increase in grain yield owing to rice variety CR Dhan 201 over Naveen, CR Dhan 204 and MTU-1010 were 8.1, 13.2 and 17.6 % in first year, 6.11, 11.57 and 12.3 % in second year and 7.3, 12.7 and 14.9 % in pooled mean, respectively. The probable reasons assigned for rice variety CR Dhan 201 produced significantly higher grain yield than all other varieties due to enhanced stature of growth and yield attribute and finally increased grain yield. This was in accordance with the findings of Duary *et al.* (2017).

The interaction between different irrigation regimes and cultivars on grain yield was found to be significant in pooled value of both years under study (Table 2). The interaction of irrigation at IW/CPE 2.0 with variety CR Dhan 201 gave the highest grain yield (4.39 t/ha) which was at par with irrigation at IW/CPE 2.5 with variety CR Dhan 201 (4.30 t/ha) and significantly superior to other interaction of irrigation regimes with cultivars. Hence, interaction between irrigation regime at IW/CPE 2.0 with variety CR Dhan 201 might be economic optimum to realize maximum yield under aerobic rice cultivation. The results are in conformity with the findings of Maheswari *et al.*, (2008) and Mandal *et al.*, (2013).

Field water use efficiency (FWUE)

Water requirement (average of two years) of different irrigation interval varied from 55.23 to 120.23 cm (Table 3). The highest water requirement of 120.23 cm was observed with irrigation at IW/CPE 2.5 whereas, lowest value of 55.23 cm was observed with irrigation at IW/CPE 1.0 among different irrigation regimes. During first year, the highest mean FWUE of 42.04 kg/ha-cm was observed with treatment that received irrigation at IW/CPE 1.5 which was at par with irrigation at IW/CPE 2.0 and IW/CPE 1 and significantly superior to irrigation regime at IW/CPE 2.5. Similar trend was observed in pooled value of both the years under study. But during the second year, the irrigation regimes at IW/CPE 1.0 irrigation regime registered highest mean FWUE of 40.80 kg/ha-cm which was at par with irrigation regimes at IW/CPE 1.5 and IW/CPE 2.0 and significantly superior to irrigation regimes at IW/CPE 2.5 (33.78 kg/ha-cm). The irrigation regimes at IW/CPE 2.5 gave lower water use efficiency though grain yield was higher. This is due to consumption of more quantity of water. Similar findings have also been reported by Shekara *et al.* (2010).

The highest value of FWUE (kg/ha-cm) was observed with variety CR Dhan 201 whereas, lowest value was observed with variety MTU 1010 among different cultivars. During pooled mean of both the years under study, the highest mean FWUE of 41.60 kg/ha-cm was observed with variety CR Dhan 201 which was at par with variety Naveen (39.25 kg/ha-cm).

and significantly superior to rest of the other varieties. Similar trend was observed in pooled value of both the years under study.

The interaction effect of irrigation regimes and cultivars on field water use efficiency was found to be significant as per the pooled of both the years under study (Table 4). The interaction of irrigation regime at IW/CPE 1.5 with Naveen variety produced the highest field water use efficiency (44.05 kg ha-cm⁻¹) but it was at par with all irrigation regimes except at IW/CPE 2.5 with variety CR Dhan 201.

Conclusion:

From the present investigations, it may be concluded that variety like CR Dhan 201 needs to be irrigated at IW/CPE 2.0 produced economically optimum yield and field water use efficiency on sandy loam soils of western region of Odisha under aerobic condition

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Table 1 : Effect of irrigation regimes and cultivars on grain and straw yield of rice in aerobic condition									
Treatments	Grain yield (t/ha)			Straw yield (t/ha)			Harvest index (%)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Irrigation Regimes									
I ₁ : IW/CPE =1.0	2.20	2.25	2.23	2.83	2.88	2.85	43.80	43.82	43.82
I ₂ : IW/CPE =1.5	2.96	2.77	2.86	3.74	3.45	3.60	44.05	44.37	44.21
I ₃ : IW/CPE =2.0	3.93	3.86	3.90	4.90	4.81	4.85	44.27	44.46	44.36
I ₄ : IW/CPE =2.5	4.09	4.06	4.07	5.20	5.15	5.17	44.00	44.07	44.03
SE _m (±)	0.08	0.08	0.06	0.10	0.10	0.07	0.74	0.50	0.45
CD(0.05)	0.29	0.27	0.18	0.33	0.34	0.21	NS	NS	NS
Cultivars									
V ₁ : Naveen	3.33	3.27	3.30	4.16	4.07	4.11	44.30	44.53	44.47
V ₂ : MTU-1010	3.06	3.09	3.08	4.00	3.95	3.98	42.88	43.53	44.06
V ₃ : CR Dhan 201	3.60	3.47	3.54	4.41	4.30	4.36	44.83	44.63	44.68
V ₄ : CR Dhan 204	3.18	3.11	3.14	4.09	3.97	4.03	44.10	44.02	43.21
SE _m (±)	0.07	0.08	0.06	0.10	0.10	0.07	0.64	0.46	0.40
CD(0.05)	0.21	0.24	0.16	NS	NS	0.20	NS	NS	NS

Table -2 Interaction effect of irrigation regimes and cultivars on grain yield of rice under aerobic condition				
Irrigation regimes	Grain yield (t ha⁻¹)			
	Pooled			
	Cultivars			
	Naveen	MTU-1010	CR Dhan 201	CR Dhan 204
I ₁ : IW/CPE = 1.0	2.32	2.04	2.37	2.18
I ₂ : IW/CPE =1.5	3.09	2.72	3.08	2.53
I ₃ : IW/CPE = 2.0	3.72	3.44	4.39	4.03
I ₄ : IW/CPE = 2.5	4.07	4.11	4.30	3.82
	I within V		V within I	
SEm (±)	0.110		0.109	
CD (P=0.05)	0.34		0.31	

Table 3 : Effect of irrigation regimes and cultivars on water requirement and water use efficiency of rice in aerobic condition						
Treatments	Irrigation Applied (IA)(cm)	Effective Rainfall (ER) (cm)	WR (cm) = IA+ER	FWUE (kg ha-cm ⁻¹)		
				2019	2020	Pooled
Average of both years						
Irrigation Regimes						
I ₁ : IW/CPE = 1.0	50	5.23	55.23	39.90	40.80	40.35
I ₂ : IW/CPE = 1.5	65	5.23	70.23	42.04	39.37	40.71
I ₃ : IW/CPE = 2.0	95	5.23	100.23	39.20	38.54	38.87
I ₄ : IW/CPE = 2.5	115	5.23	120.23	34.00	33.78	33.89
SE_m(±)	-	-	-	0.86	1.19	0.73
CD(0.05)	-	-	-	2.97	4.12	2.26
Cultivars						
V ₁ : Naveen	81	5.23	86.23	39.16	39.33	39.25
V ₂ : MTU-1010	81	5.23	86.23	36.26	35.86	36.06
V ₃ : CR Dhan 201	81	5.23	86.23	42.28	40.91	41.60
V ₄ : CR Dhan 204	81	5.23	86.23	37.44	36.38	36.91
SE_m(±)	-	-	-	0.94	0.99	0.68
CD(0.05)	-	-	-	2.73	2.90	1.94
Average Evaporation=4mm/day Irrigation applied = 12 days,9 days,6 days and 5 days No. of irrigation required=10,13,19 and 23						

Table- 4 Interaction Effect of irrigation regimes and cultivars on water use efficiency of rice in aerobic condition				
Irrigation regimes	WUE (kg ha-cm⁻¹)			
	Pooled			
	Cultivars			
	Naveen	MTU-1010	CR Dhan 201	CR Dhan 204
	I₁ : IW/CPE = 1.0	42.00	36.96	42.94
I₂ : IW/CPE =1.5	44.05	38.76	43.92	36.09
I₃ : IW/CPE = 2.0	37.11	34.36	43.76	40.25
I₄ : IW/CPE = 2.5	33.81	34.17	35.76	31.80
	I within V		V within I	
SEm (±)	1.39		1.37	
CD (P=0.05)	4.29		3.88	