Original Research Article

Effect of varying irrigation regimes and cultivars on growth, yield, water use efficiency and economics of rice (*Oryza sativa*) under aerobic conditions

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 growth and yield attributes effect significantly in regards to different irrigation regimes and cultivars. The maximum plant height (69.0 cm) and filled grains per panicle (80.98) leaf area index (LAI) at 75DAS (3.940,dry matter accumulation of the shoot at 90 DAS (927 g m^{-2}), number of effective panicles m^{-2} (287) and test weight (22.27 g) were maximum at irrigation regime IW/CPE = 2.5.Whereas, which was at par with irrigation regime at IW/CPE = 2.0. The maximum plant height(67.1cm), filled grains per panicle (74.47), leaf area index (LAI) at 75DAS (3.52), dry matter accumulation of the shoot at 90 DAS (901 g m^{-2}) and number of effective panicles m^{-2} (286) were recorded with CR Dhan 201 which was significantly higher as compare to other cultivars. 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 highest mean FWUE of 40.71kg/ ha-cm was observed with irrigation at IW/CPE 1.5 which was at par with other irrigation regimes except IW/CPE 2.5 whereas, highest B: C ratio (1.74) was observed with irrigation at IW/CPE 2.0 which was at par with IW/CPE 2.5 (1.73) and significantly superior to other irrigation regimes. But in case of cultivars, highest mean FWUE of 41.60kg/ ha-cm and B: C ratio (1.62) was observed with variety CR Dhan 201 and significantly superior to rest of other cultivars. 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, Water use efficiency, IW/CPE ratio, Yield attributes, Growth parameter, BC ratio

Introduction

Rice (Oryza sativa L.) is the staple food for about 50% of the world population. The theme "Rice is life" is quite appropriate for India as this crop plays an important role in our national food security and is a source of livelihood for a millions of rural household Recently, there is an increasing scarcity of fresh water for agriculture particularly for rice cultivation due to decline in water levels in one hand and the demand of water for industries and other sectors on the other hand which threatens the sustainability of the irrigated rice ecosystem. 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). Increasing scarcity of water has threatened the traditional rice cultivation practices all over the world (Tuong & Bouman, 2003). Hence, by shifting gradually from traditional rice production to aerobic rice production system can mitigate the occurrence of water related problems. Aerobic rice culture is an emerging technology and revolutionary way of growing rice where the direct-seeded rice varieties with aerobic environment are grown in well drained, un-puddled and non-saturated soils (aerobic soils). Aerobic rice assumes greater importance in water scarcity area and increasing demand for rice.

The rice vanities 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. As aerobic rice culture is a new system, there is need to evaluate the different varieties that are sustainable to particular location and management practices under scarcity condition. Odisha is having substantial area under rainfed/semidry dry rice and has a vast scope of growing rice under aerobic conditions. However, reliable information on vital agro techniques for successful aerobic rice cultivation in this region is absolutely lacking. In this back drop, the present study was undertaken for standardization of irrigation interval and performances of medium duration selected rice varieties under aerobic condition in west central table land zone of odisha.

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, 15.4and 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, 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 experimental field was ploughed three times in dry unpuddled 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, levelled the field with leveller 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 ×10cm 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 (80kgN, 40kg $P_2O_5$and 40kgK_2O) 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 60days 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 40DAS and 60DAS.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 20DAS and thereafter, irrigation was applied at 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. Economics was worked out on the basis of prevailing market price of the produce and inputs used in the experiment. The experimental data recorded for various parameters under study were subjected to statistically analysed 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

Growth parameters

The result showed that growth and yield attributes of rice increased significantly with increase in IW/CPE up to 2.0 and further increase IW/CPE did not prove beneficial during pooled mean of both the years (Table-1) except plant height and filled grains per panicle. The maximum plant height (69.0 cm) and filled grains per panicle (80.98) were recorded with irrigation regime at IW/CPE = 2.5 which was significantly higher as compare to other irrigation regimes. Whereas, laef area index (LAI) at 75DAS (3.940,dry matter accumulation of the shoot at 90 DAS (927 g m^{-2}) , number of effective panicles m^{-2} (287) and test weight (22.27 g) were maximum at irrigation regime IW/CPE = 2.5 which was at par with irrigation regime at IW/CPE = 2.0 and significantly higher as compare to other irrigation regimes. The reduction of growth and yield attributes due to water scarcity resulted in low leaf water potentials and reductions in photosynthesis; photosynthetic activity declines because of decreased stomata opening and the inhibition of chloroplast activity; this reduced the length of the

internodes, decreased functional leaf area and enhanced leaf senescence, reduced the number of tillers m^{-2},dry matter production and nutrient uptake. The results are in conformity with the findings of Shekara *et al*. (2011); Nayak (2015) and Duary (2017).

The result showed that growth and yield attributes of rice significantly effect with cultivars. The maximum plant height(67.1cm) , filled grains per panicle (74.47), laef area index (LAI) at 75DAS(3.52),dry matter accumulation of the shoot at 90 DAS ((901 g m^{-2}) and number of effective panicles m^{-2} ((286)) were recorded with CR Dhan 201 which was significantly higher as compare to other cultivars. Whereas, the maximum test weight was recorded with variety CR Dhan 201 (21.60 g) which was at par with Naveen (20.97g) and significantly superior to other verities. This result was in corroborates with the findings of Maheswari *et al*. (2008); Sekhara et al. (2010); Mandal *et al*. (2013) and Duary (2017). Mukherjee *et. al*. (2017).

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 supplyof more photosynthates towards the reproductive sink.This resultwas in corroborates 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 3.54t/ha, respectively and significantly superior to rest of the varieties. Whereas in second year, the grain yield of rice variety CR Dhan201 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).

Field water use efficiency (FWUE)

Water requirement (average of two years) of different irrigation interval varied from 55.23to 120.23cm .The highest water requirement of 120.23cm was observed with irrigation at IW/CPE 2.5 whereas, lowest value of 55.23cm was observed with irrigation at IW/CPE 1.0 among different irrigation regimes.

The pooled mean result of both the years under study (Table 2), the highest mean FWUE of 40.71kg/ 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 findings have also been reported by Shekara *et al.* (2010).

Among the cultivars, the result of pooled mean of both the years under study showed that highest mean FWUE of 41.60kg/ ha-cm was observed with variety CR Dhan 201 which was at par with variety Naveen (39.25kg/ ha-cm) and significantly superior to rest of the other varieties.

Economics:

The maximum net return (Rs 35781/ha) and benefit: cost ratio (1.74) were obtained (Table 2) from the crop irrigated at IW/CPE 2.5 which was at par with irrigation at IW/CPE 2.0 and significantly superior to those of other irrigation regimes . It might be due to higher grain yield with higher irrigation levels. Similar findings obtained Shekara *et al.,* (2010). The maximum net return (Rs 28367/ha) and benefit: cost ratio (1.62) was obtained with variety CR Dhan 201 .It was significantly superior to that of other cultivars. It might be due to higher grain yield. Similar findings obtained Reddy *et al.,* (2012) and Pradhan *et al.,* (2014).

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 growth and yield attributes under aerobic condition (Pooled data)						
Treatments	**Plant height**	**Leaf area index(LAI) at 75DAS**	**Dry matter accumulation (DMA)(g/m^2) 90DAS**	**Effective panicles (Nos/m^2)**	**Filled grains (Nos/Panicle)**	**Test weight(g)**
Irrigation Regimes						
I_1: IW/CPE =1.0	59.6	2.33	805	244	59.05	19.16
I_2: IW/CPE =1.5	63.6	3.07	859	264	67.14	20.30
I_3 : IW/CPE =2.0	65.0	3.82	901	279	75.83	21.51
I_4 : IW/CPE =2.5	69.0	3.94	927	287	80.98	22.27
SE_m(±)	0.7	0.05	6.6	4.9	1.05	0.28
CD(0.05)	2.1	0.17	29.7	15.2	3.23	0.88
Cultivars						
V_1: Naveen	64.6	3.30	885	272	71.27	20.97
V_2: MTU-1010	62.0	3.14	845	255	68.13	20.00
V_3 : CR Dhan 201	67.1	3.52	901	286	74.47	21.60
V_4 : CR Dhan 204	63.4	3.21	864	260	69.13	20.66
SE_m(±)	0.6	0.06	9.0	4.9	1.01	0.31
CD(0.05)	1.6	0.17	25.8	13.9	2.88	0.88

Table-2: Effect of irrigation regimes and cultivars on yield ,water use efficiency and economics under aerobic condition (Pooled data)

Treatments	Grain yield (t/ha)			WUE(kg/ha-cm)	Net Return(Rs/ha)	B:C ratio
	2019	2020	Pooled			
Irrigation Regimes						
I_1: IW/CPE =1.0	2.20	2.25	2.23	40.35	5337	1.13
I_2: IW/CPE =1.5	2.96	2.77	2.86	40.71	16496	1.39
I_3 : IW/CPE =2.0	3.93	3.86	3.90	38.87	34274	1.74
I_4 : IW/CPE =2.5	4.09	4.06	4.07	33.89	35781	1.73
$SE_m(\pm)$	0.08	0.08	0.06	0.73	1103	0.02
CD(0.05)	0.29	0.27	0.18	2.26	3400	0.08
Cultivars						
V_1: Naveen	3.33	3.27	3.30	39.25	23602	1.52
V_2: MTU-1010	3.06	3.09	3.08	36.06	19426	1.42
V_3 : CR Dhan 201	3.60	3.47	3.54	41.60	28367	1.62
V_4 : CR Dhan 204	3.18	3.11	3.14	36.91	20492	1.44
$SE_m(\pm)$	0.07	0.08	0.06	0.68	1073	0.02
CD(0.05)	0.21	0.24	0.16	1.94	3051	0.07