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Response of Rice Varieties to Different Levels of Irrigation Under Aerobic Condition

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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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Short Research Article

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ABSTRACT

The field experiment was conducted West Central Table Zone, Odisha during *summer* season of 2019 & 2020 to evaluate the effect of medium duration rice varieties with varying irrigation regimes under aerobic condition. The experiment was laid out in split plot design having four irrigation regimes (Irrigation at IW/CPE = 1.0, 1.5, 2.0, 2.5) in main plot treatments and four varieties (Naveen, MTU-1010, CR Dhan-201 and CR Dhan-204) in subplot treatments. The result showed that higher grain yield was recorded at IW/CPE = 2.5 (4.07 t/ha) ,which was significantly superior to rest of other irrigation regimes except IW/CPE = 2.0 (3.90 t/ha) that was at par with IW/CPE = 2.5 .Whereas, in case of cultivars, higher grain yield was obtained with CR-Dhan 201(3.54 t/ha) which was significantly to rest of other cultivars except Naveen (3.30t/ha) which was at par with

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CR-Dhan 201.The FWUE at IW/CPE 1.5 (40.71kg/ ha-cm) was recorded higher which was at par with other irrigation regimes except IW/CPE 2.5. The higer B: C ratio (1.74) was observed at IW/CPE 2.0 and at par with IW/CPE 2.5 (1.73) and significantly to rest other irrigation regimes. Whereas in cultivars, FWUE of 41.60kg/ ha-cm and B:C ratio (1.62) were observed with CR Dhan 201 but it was significantly to rest of other cultivars. It may be concluded that rice grown under aerobic culture, variety 'CR Dhan 201' was found optimum as it has resulted in highest growth of aerobic rice and realizing higher productivity besides enhancing economically profitability at irrigation regimes at IW/CPE 2.0 in West Central Table Land Zone of Odisha under aerobic condition.

Keywords: Aerobic rice; water use efficiency; IW/CPE ratio; yield attributes; growth parameter; B:C ratio.

1. INTRODUCTION

"Rice (*Oryza sativa L*.) is the staple food for billions of people all over the world. "Rice is life" is quite appropriate for India as this crop plays a pivotal role in our national food security. World rice production has continuously increased in the past three decades beginning with the green revolution but the productivity has not increased significantly. Rice demand was projected to increase by 25% from 2001 to 2025 to keep pace with population growth. To fulfill the increased rice demand with shrinking resources, it is necessary to increase yield per unit area with less water. The traditional rice cultivation needs standing water for most of the crop stages and it requires 3000 - 5000 litres of water to produce one kilogram of rice depending on the variety as well as rice cultivation methods" (Tuong & Bouman, 2003; Bouman et al., 2006). "It is revealed that the increasing scarcity of water has threatened not only the traditional rice cultivation practices all over the world but also threatens sustainability of irrigated rice ecosystem. The transplanted rice cultivation consumes more water that threatens the sustainability of rice production. Thus, there is a need to find out the alternate means of rice cultivation to save water and other inputs. Nowadays, aerobic rice culture is an alternative emerging technology and revolutionary way of growing rice. The new concept of aerobic rice entails the use of nutrient-responsive cultivars that are adapted to aerobic culture aiming at yields of 70-80% of high input flooded rice" (Prasad, 2011; Patel et al., 2010). "The target environments are irrigated lowlands, where water is insufficient to keep lowland (rainfed or irrigated) paddy fields flooded and favorable uplands with access to supplementary irrigation. In this aerobic culture, the direct seeded rice varieties with aerobic environment are grown in well drained un-puddled and un-saturated soil in order to increase the water use efficiency. These rice varieties have withstand both flooding as well as dry soil conditions. Aerobic rice is a projected sustainable rice production methodology for immediate future to address water scarcity and environmental safety in the scenario of global warming. Western region of Odisha is having substantial area under rainfed/semi-dry rice and has a vast scope of growing rice under aerobic conditions" (Tuong & Bouman, 2003; Filzah et al., 2014; Xiaoguang et al., 2005). However, reliable information on the vital agro-techniques for successful aerobic rice culture in this region is absolutely lacking. In this backdrop, the present study was undertaken with the objective to identify the suitable medium duration selected rice varieties and to formulate the optimum irrigation regimes for maximum productivity of rice under aerobic culture.

2. MATERIALS AND METHODS

The field experiment on response of rice varieties to different levels of irrigation under aerobic condition was undertaken during Summer Season of 2019 & 2020 at the Regional Research Technology and Transfer Station (RRTTS), Chiplima, Odisha. The soil of the experimental field was sandy loam with acidic reaction (pH 5.9). The organic carbon content was 0.8 % and available N,P and K content were 187,15.4 and 172 kg ha $^{-1}$, respectively. The moisture content at field capacity and permanent wilting point was 19.4 an 8.4 percent, respectively. The experiment was designed with split plot having four irrigation regimes (Irrigation at IW/CPE = 1.0, 1.5, 2.0, and 2.5) in main plots and four varieties (Naveen, `MTU-1010, CR Dhan-201 and CR Dhan-204 in subplots. Seeds of selected cultivars were manually sown (hand dibbled) in well ploughed leveled field in 2-3 cm depth@ 45 kg/ha in furrows made by trench hoe at 20 cm ×10cm spacing. In order to maintain optimum and uniform plant population in all the plots, thinning and gap filling operations were done, when seedlings were at 20 days after sowing. Cultural operations were carried out as per recommended practices. In each plot, volume of irrigation water was calculated by multiplying the depth of irrigation and area of the plot. The time of irrigation was calculated by using given depth of irrigation, area of the each plot and discharge rate. Then, irrigation was applied as per treatment details except initial two common irrigations were applied to all treatments after sowing till 20 DAS for proper establishment of the plant. The observations on yield were recorded on the net plot basis. On the basis of prevailing market price of the produce and inputs used, economics was worked out. As per standard statistical analysis of variance procedure suggested by Panse and Sukhatme (1985**)**, data recorded on various growth and yield parameters of rice crop were analyzed.

3. RESULTS AND DISCUSSION

3.1 Growth Attributes

As regards to irrigations, the results (Table 1) showed that the maximum dry matter accumulation of the shoot at 90 DAS (927 g m^{-2}), leaf area index at 75 DAS (3.94), crop growth rate at 60-75 DAS (27.41 g $m^{-2}day^{-1}$), chlorophyll content at 45 DAS (3.19 mg g^{-1}) and root volume (17.24 cc) at 75 DAS were recorded at IW/CPE = 2.5, which was at par with irrigation regime at IW/CPE = 2.0 and also significantly higher than other irrigation regimes. But in case of root length, maximum was observed at IW/CPE = 1.0, which was at par with irrigation regime at IW/CPE = 1.5 and also higher than other irrigation regimes. It might be due to the improved uptake of nutrients under higher moisture availability condition, resulting in more number of leaf and higher leaf area coupled with more number of tillers. The result is in conformity with the finding of Maheswari *et al*., (2008). As regards to cultivars, the results (Table 1) indicated that maximum dry matter accumulation of the shoot at 90 DAS (901 g m^{-2}), leaf area index at 75 DAS (3.52) and crop growth rate at 60-75 DAS (26.56 g $m^{-2}day^{-1}$) were recorded in variety CR Dhan 201, which was at par with Naveen and also significantly higher than other varieties. But in chlorophyll content at 45 DAS (3.24mg g^{-1}) was recorded maximum in variety CR Dhan 201 which was significantly higher than other varieties. In statistically there was no difference among the varieties in respect of the root length and volume. Similar results were also reported by Reddy *et al.* (2012).

3.2 Yield Attributes

As regards to irrigations, the results (Table 2) that, the maximum number of effective panicles m^{-2} was recorded at IW/CPE = 2.5 (287) but at par with IW/CPE = 2.0 (279). Both the above irrigation regimes produced significantly superior to rest of the irrigation regimes. The maximum number of filled grains panicle^{-1} (80.98) was recorded with irrigation regime at IW/CPE = 2.5, which was significantly higher than rest irrigation regimes. The test weight was recorded maximum at IW/CPE = 2.5 (22.27 g) which was significantly higher than rest of the irrigation regimes except at IW/CPE = 2.0 (21.51 g). It might be due to enhanced the supply of photosynthates from source to sink. This was in accordance with findings of Shekara *et al., (*2010) and Duray (2017). As regards to cultivars, the results showed that, maximum number of effective panicles m^{-2}(286) and filled grains panicle^{-1} (74.47) were recorded with variety CR-Dhan 201 which was significantly higher than other varieties. But in test weight was recorded maximum with variety CR Dhan 201 (21.60 g) but it was significantly superior to other verities except Naveen (20.97g). This was in accordance with the findings of Duray (2017).

3.3 Grain Yield

The result revealed that (Table 2) grain yield of rice increased significantly with increase in IW/CPE up to 2.0 and did not prove beneficial for further increase of IW/CPE. The irrigation regime at IW/CPE =2.5 recorded the highest grain yield of 4.07 t/ha but significantly superior to rest other irrigation regimes except IW/CPE =2.0. 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 4.4, 42.3 and 82.5 %, respectively. It might be due to more photosynthates towards the reproductive sink. This result was in corroborates with the findings of Maheswari *et al.* (2008) and Shekara *et al.* (2010). Among the cultivars, the result indicated that (Table 2), CR Dhan 201 gave higher grain yield (3.54t/ha) which was significantly superior to rest of the varieties. The increase in grain yield by CR Dhan 201 over Naveen, CR Dhan 204 and MTU-1010 were 7.3, 12.7 and 14.9 %, respectively. The significantly higher grain yield produced by CR Dhan 201 than all other varieties due to enhanced stature of yield attribute. Similar findings was in accordance with Duray (2017).

Table 1. Effect of Irrigation Regimes and Cultivars on Growth Attributes Under Aerobic Condition (Pooled data)

Treatments	DMA(g/m^2) At 90DAS	CGR (g m^{-2} day^{-1}) at 60-75DAS	LAI at 75DAS	Chlorophyll content (mg g^{-1} of fresh leaf) at 45 DAS	Root Length (cm) at 75 DAS	Root Volume (cc)at 75 DAS
Irrigation Regimes						
IW/CPE =1.0	805	24.07	2.33	2.43	14.11	14.08
IW/CPE =1.5	859	24.97	3.07	2.81	13.53	15.95
IW/CPE =2.0	901	26.80	3.82	3.06	13.14	16.71
IW/CPE =2.5	927	27.41	3.94	3.19	12.07	17.24
$SE_m(\pm)$	6.6	0.27	0.05	0.05	0.23	0.36
CD(0.05)	29.7	0.78	0.17	0.14	0.72	1.10
Cultivars						
Naveen	885	26.35	3.31	2.97	13.3	15.96
MTU-1010	845	24.85	3.14	2.57	12.92	15.64
CR Dhan 201	901	26.56	3.52	3.24	13.55	16.51
CR Dhan 204	864	25.48	3.21	2.70	13.09	15.87
$SE_m(\pm)$	9.0	0.24	0.06	0.04	0.22	0.26
CD(0.05)	25.8	0.67	0.17	0.11	NS	NS

LAI : Leaf Area Index CGR: Crop Growth Rate DMA: Dry Matter Accumulation

Table 2. Effect of Irrigation Regimes and Cultivars on Yield Attributes, Yield,Water Use Efficiency and Economics Under Aerobic Condition (Pooled data)

Treatments	Effective panicles (Nos/m^2)	Filled grains/Panicle (Nos)	Test weight (g)	Grain yield (t/ha)	WUE (kg/ha-cm)	B:C ratio
Irrigation Regimes						
IW/CPE =1.0	244	59.05	19.16	2.23	40.35	1.13
IW/CPE =1.5	264	67.14	20.30	2.86	40.71	1.39
IW/CPE =2.0	279	75.83	21.51	3.90	38.87	1.74
IW/CPE =2.5	287	80.98	22.27	4.07	33.89	1.73
$SE_m(\pm)$	4.9	1.05	0.28	0.06	0.73	0.02
CD(0.05)	15.2	3.23	0.88	0.18	2.26	0.08
Cultivars						
Naveen	272	71.27	20.97	3.30	39.25	1.52
MTU-1010	255	68.13	20.00	3.08	36.06	1.42
CR Dhan 201	286	74.47	21.60	3.54	41.60	1.62
CR Dhan 204	260	69.13	20.66	3.14	36.91	1.44
$SE_m(\pm)$	4.9	1.01	0.31	0.06	0.68	0.02
CD(0.05)	13.9	2.88	0.88	0.16	1.94	0.07

3.4 Field Water Use Efficiency

Water -use efficiency was significantly influenced by different irrigation regimes and varieties. The result indicated that (Table 2), the field water use efficiency (40.71kg/ ha-cm) was recorded maximum with irrigation at IW/CPE 1.5 and it was at par with at IW/CPE =2.0 and IW/CPE= 1 and significantly to IW/CPE 2.5. Similar findings have also been reported by Shekara *et al.* (2010). Among the cultivars, the result revealed that field water use efficiency (41.60kg/ ha-cm) was maximum with CR Dhan 201 which was at par with Naveen (39.25kg/ ha-cm) and significantly to rest other varieties. This was in accordance with the findings of Duray (2017).

3.5 Economics

The benefit- cost ratio of rice under aerobic culture differed significantly with varieties and irrigation regimes (Table 2). The result indicated that at IW/CPE 2.0 benefit: cost ratio (1.74) was maximum (Table 2) that at par with at IW/CPE 2.5. It might be due to higher grain yield with higher irrigation levels. Simillar findings was reported with Shekara *et al.*, (2010). In CR Dhan 201, the maximum benefit: cost ratio (1.62) was obtained and significantly 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). Remunerative economic returns play a key role, to convince the farmers for adoption of any refined version of agro techniques. In the present study, benefit: cost ratio were found to be the highest with CR Dhan 201and irrigation at IW/CPE 2.0. It is obvious that realization of higher returns was the result of higher grain and straw yield with the best treatment.

4. CONCLUSION

Rice production significantly depends on most of the time on amount of irrigation and varieties. From the present investigations, it may be concluded that rice grown under aerobic culture 'CR Dhan 201' was found optimum as it has resulted in highest growth of aerobic rice and realizing higher productivity besides enhancing economically profitability at irrigation regimes at IW/CPE 2.0 and may be the potential technology to cut cost of rice production and facilitate to achieve higher yield.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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