**Yield, Nutrient Uptake and Economics of Aerobic Rice Under Different Irrigation Regimes and Cultivars**

**Abstract:**

The field experiment was conducted West Central Table Zone, Odisha during *summer* season of 2019 & 2020 to study 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 revealed that highest grain yield was recorded at IW/CPE = 2.5 (4.07 t/ha) ,which was significantly superior to rest of other irrigation regimes but at par with IW/CPE = 2.0 ( 3.90 t/ha) .Whereas, in case of cultivars, highest grain yield was obtained with variety CR-Dhan 201( 3.54 t/ha) which was significantly superior to rest of other cultivars but at par with variety Naveen (3.30t/ha) . The highest uptake of N (80.07 kg /ha), P(36.70 kg /ha) and K(124.4 kg /ha ) were produced with irrigation regime at IW/CPE =2.5 but it was significantly superior to rest other irrigation regimes. Whereas, highest uptake of N(65.41 kg /ha), P(30.49 kg /ha) and K(104.8 kg /ha ) were produced with variety CR Dhan 201 but it was significantly superior to rest other varieties. The FWUE of 40.71kg/ ha-cm was recorded higher with irrigation at IW/CPE 1.5 which was at par with other irrigation regimes except IW/CPE 2.5 whereas, 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, FWUE of 41.60kg/ ha-cm and B: C ratio (1.62) were observed with variety CR Dhan 201 and significantly superior to rest of other cultivars.

 ***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 billions of people all over the world. 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 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). of water but also causes environmental degradation and reduces the fertilizer use efficiency. Conventional puddle transplanted rice cultivation consumes more water, which 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. Aerobic rice culture is an alternative 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 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. This method is unique in its characteristics to withstand both flooding and dry soil conditions. Identification of medium duration varieties that contributing to better yield performances under aerobic condition will be useful in developing rice varieties suitable for aerobic cultivation. Therefore, present field experiment was taken in order to know the performances of medium duration selected rice varieties with varying irrigation regimes under aerobic condition

**Materials and Methods**

The field study was conducted at the Regional Research Technology and Transfer Station (RRTTS), Chiplima, Odisha during Summer Season of 2019 & 2020 to study effect 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 experiment was designed with split plot having four irrigation regimes (Irrigation at IW/CPE = 1.0, 1.52.0, and 2.5) in main plot treatments and four varieties (Naveen, MTU-1010, CR Dhan-201 and CR Dhan-204 in subplot treatments. Seeds of 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. When seedling at 20 days after sowing, thinning and gap filling was done so as to maintain optimum and uniform plant population in all the plots. Fertilizer was applied @ 80:40:40 N: P2O5: K2O/ha in all the plots. As per recommendation, all the cultural operations were carried out. In each plot, the volume of irrigation water was calculated by multiplying the depth of irrigation and area of the plot. The irrigation water was measured on the basis discharge rate (l/s) of water entering to the experimental field. In every plot , time of irrigation was computed by using given depth of irrigation, area of the plot and discharge rate. All the treatments, the initial two common irrigations were applied after sowing for proper establishment of the plants till 20DAS .Then , irrigation was applied at as per treatment details. The observations on yield (grain + sraw) were recorded on the net plot basis. Adding effective rainfall during crop growth period and irrigation applied to the field was used to calculate water requirement. The ratio of grain yield and the amount of water applied to the field plots was used to calculate field water use-efficiency (kg/ha-cm). Economics was worked out on the basis of prevailing market price of the produce and inputs used. The experimental data recorded for various parameters and these data were subjected to statistically analyzed ANOVA to draw a valid conclusion.

**Results and Discussion**

***Yield attributes:***

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

***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 4.4, 42.3 and 82.5 % in pooled mean, respectively. The straw yield of rice increased significantly with increase in IW/CPE up to 2.5. It might be due to 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 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 7.3, 12.7 and 14.9 % in pooled mean, respectively. But incase of straw yield, the variety like CR Dhan 201 produced significantly higher grain yield than all other varieties except Naveen. It might be 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 2.0withvariety 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 other interaction of irrigation regimes with cultivars.. Hence, interaction between irrigation regime at IW/CPE 2.0withvariety 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)

***Nutrient Uptake:***

The result showed that nutrient uptake of rice increased significantly with increase in IW/CPE up to 2.5 (Table-3). The highest uptake of N(80.07 kg /ha), P(36.70 kg /ha) and K(124.4 kg /ha ) were produced with irrigation regime at IW/CPE =2.5 but it was significantly superior to rest other irrigation regimes. Similar findings have also been reported by Shekara et al. (2010). Among the cultivars, the result revealed that highest uptake of N(65.41 kg /ha), P(30.49 kg /ha) and K(104.8 kg /ha ) were produced with variety CR Dhan 201 but it was significantly superior to rest other varieties. This was in accordance with the findings of Duary et al. (2017)

***Water Use Efficiency:***

The result indicated that (Table 3), the field water use efficiency (40.71kg/ ha-cm) was recorded maximum 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 higher to irrigation regime at 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 variety CR Dhan 201 which was at par with variety Naveen (39.25kg/ ha-cm) and significantly superior to rest of the other varieties. This was in accordance with the findings of Duary et al. (2017).

***Economics:***

 The result indicated that the maximum net return (Rs35781/ha) and benefit: cost ratio (1.74) were obtained (Table 3) irrigation at IW/CPE 2.5 which was significantly superior to other irrigation regimes and at par with irrigation at IW/CPE 2.0. It might be due to higher grain yield with higher irrigation levels. Similar findings obtained Shekara et al., (2010). The maximum net return (Rs28367/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 CR Dhan 201 variety produced economically optimum yield and field water use efficiency at irrigation regimes at IW/CPE 2.0 in West Central Table Land Zone of Odisha under aerobic condition.

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| **Table1: Effect of Irrigation Regimes and Cultivars on Yield and Attributes and Yield Economics Under Aerobic Condition (Pooled data)** |
| **Treatments** | **Effective Panicles (Nos/m2)** | **Filled Grains/Panicle (Nos)** | **Test Weight****(g)** | **Grain Yield (t/ha)** | **Straw** **Yield (t/ha)** | **Harvest** **Index (%)** |
| **2019** | **2020** | **Pooled** |
| **Irrigation Regimes**  |
| IW/CPE =1.0 | 244 | 59.05 | 19.16 | 2.20 | 2.25 | 2.23 | 2.85 | 43.82 |
| IW/CPE =1.5 | 264 | 67.14 | 20.30 | 2.96 | 2.77 | 2.86 | 3.60 | 44.21 |
| IW/CPE =2.0 | 279 | 75.83 | 21.51 | 3.93 | 3.86 | 3.90 | 4.85 | 44.36 |
|  IW/CPE =2.5 | 287 | 80.98 | 22.27 | 4.09 | 4.06 | 4.07 | 5.17 | 44.03 |
| SEm(±) | 4.9 | 1.05 | 0.28 | 0.08 | 0.08 | 0.06 | 0.07 | 0.45 |
| CD(0.05) | 15.2 | 3.23 | 0.88 | 0.29 | 0.27 | 0.18 | 0.21 | NS |
| **Cultivars** |
|  Naveen | 272 | 71.27 | 20.97 | 3.33 | 3.27 | 3.30 | 4.11 | 44.47 |
|  MTU-1010 | 255 | 68.13 | 20.00 | 3.06 | 3.09 | 3.08 | 3.98 | 44.06 |
| CR Dhan 201 | 286 | 74.47 | 21.60 | 3.60 | 3.47 | 3.54 | 4.36 | 44.68 |
| CR Dhan 204 | 260 | 69.13 | 20.66 | 3.18 | 3.11 | 3.14 | 4.03 | 43.21 |
| SEm(±) | 4.9 | 1.01 | 0.31 | 0.07 | 0.08 | 0.06 | 0.07 | 0.40 |
| CD(0.05) | 13.9 | 2.88 | 0.88 | 0.21 | 0.24 | 0.16 | 0.20 | NS |

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| **Table -2 Interaction effect of irrigation regimes and cultivars on grain yield of rice under aerobic condition** |
| **Irrigation regimes** | **Grain yield (t/ ha)** |
| **Pooled** |
| **Cultivars** |
| Naveen | MTU-1010 | CR Dhan 201 | CR Dhan 204 |
| I1 : IW/CPE = 1.0 | 2.32 | 2.04 | 2.37 | 2.18 |
| I2 : IW/CPE =1.5 | 3.09 | 2.72 | 3.08 | 2.53 |
| I3 : IW/CPE = 2.0 | 3.72 | 3.44 | 4.39 | 4.03 |
| I4 : 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 |

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| **Table-3: Effect of Irrigation Regimes and Cultivars on Nutrient Uptake,Water Use Efficiency and Economics Under Aerobic Condition (Pooled data)** |
| **Treatments** | **Nutrient Uptake (grain+straw)(kg/ha)** | **WUE(kg/ha-cm)** | **Net Return(Rs/ha)** | **B:C ratio** |
| N | P | K |
| **Irrigation Regimes** |
| IW/CPE =1.0 | 28.58 | 14.77 | 51.22 | 2.20 | 2.25 | 2.23 |
| IW/CPE =1.5 | 46.73 | 21.67 | 76.47 | 2.96 | 2.77 | 2.86 |
| IW/CPE =2.0 | 65.00 | 27.99 | 102.32 | 3.93 | 3.86 | 3.90 |
|  IW/CPE =2.5 | 80.07 | 36.70 | 124.39 | 4.09 | 4.06 | 4.07 |
| SEm(±) | 1.00 | 0.49 | 1.81 | 0.08 | 0.08 | 0.06 |
| CD(0.05) | 2.90 | 1.41 | 5.25 | 0.29 | 0.27 | 0.18 |
| **Cultivars** |
|  Naveen | 59.48 | 26.53 | 98.97 | 3.33 | 3.27 | 3.30 |
|  MTU-1010 | 46.00 | 21.09 | 69.25 | 3.06 | 3.09 | 3.08 |
| CR Dhan 201 | 65.41 | 30.49 | 104.79 | 3.60 | 3.47 | 3.54 |
| CR Dhan 204 | 49.50 | 23.02 | 81.39 | 3.18 | 3.11 | 3.14 |
| SEm(±) | 0.81 | 0.45 | 1.42 | 0.07 | 0.08 | 0.06 |
| CD(0.05) | 2.27 | 1.26 | 3.97 | 0.21 | 0.24 | 0.16 |

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