PERFORMANCE OF RICE VARIETIES WITH VARYING IRRIGATION SCHEDULING UNDER AEROBIC CONDITION

Abstract:

A field experiment was conducted at the Regional Research Technology and Transfer Station (RRTTS), Chiplima, Sambalpur, Odisha during *summer* season of 2019& 2020 to evaluate performance of medium duration rice varieties with varying irrigation schedules under aerobic condition. The experiment was laid out in split-plot design with 3 replications and consisted of four irrigation schedules*i.e.*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 *i.e.* V1 = Naveen, V2 = MTU-1010, V3= CR Dhan-201 and V4 = CR Dhan-204 in subplot treatments.

The result of pooled mean of both the years showed that highergrain 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 schedules. But in case of cultivars,highergrain yield was obtained with varietyCR-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 schedulesat IW/CPE 1.5 withNaveen variety produced the highest field water use efficiency (44.05 kg ha-cm^{-1}) but it was at par with all irrigation schedules 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 schedules, 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" (Tuong et al. 2005). 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*et al.*2005)."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 soilaggregates, 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 un puddled and unsaturated 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"(Bleder*et al*.2005). "This method is unique in its characteristics to withstand both flooding and dry soil conditions .Hence,ecologyof 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 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.Rice varieties that are suitable for aerobic environments, exhibit specific characteristics that allow them to grow effectively in conditions with reduced water availability compared to traditional flooded rice paddies. 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 performancesof medium duration selected rice varieties like Naveen, MTU-1010, CR Dhan-201 and CR Dhan-204 with varying irrigation schedules under aerobic condition.

Materials and Methods

A field experiment was conducted at the Regional Research Technology and Transfer Station (RRTTS), Chiplima, Sambalpur,Odisha during *Summer* Season *of* 2019 & 2020 to observe the performance of medium duration rice varieties with varying irrigation schedules under aerobic condition. The soil of the experimental field wasacidic (pH 5.45) sandy loam soil, low in organic carbon (0.38%) and total 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

replicationsand consisted of four irrigation schedules (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-204in subplot treatments .The experimental field was ploughed three times in dry conditions. Three plowings were done to destroy the weeds and previous crops 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 shown at 20 cm x 10 cm spacing, and thinning and gap filling were done 20 days after sowing to maintain an 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 were 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 andstraw 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 ANOVAgiven 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 results of the experiments showed that,grain yield of rice increased significantly with increase inIW/CPE upto2.0and further increase IW/CPE did not prove beneficial during both individual years and itspooled mean (Table-1). The higher grain yield of 4.09, 4.06and 4.07t /hawere produced with irrigation schedulingat 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 highergrain 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 results were 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 201recorded 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 varietyand significantly superior to rest of the varieties. The increase in grain yield owing to rice variety CR Dhan201 overNaveen, CR Dhan204 and MTU-1010were8.1, 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 (2017).

The interaction between different irrigation schedules and cultivars on grain yield was found to be significant in pooled value of both the years under study (Table 2). The interaction of irrigation at IW/CPE 2.0withvariety CRDhan 201 gave the highest grain yield (4.39t/ha) which was at par with irrigationat IW/CPE 2.5 withvariety CR Dhan 201 (4.30 t/ha) and significantly superior to other interaction of irrigation schedules with cultivars. Hence, interaction between irrigation schedulesat 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).

Field water use efficiency (FWUE)

Water requirement (average of two years) of different irrigationinterval varied from 55.23to 120.23cm (Table 3). 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 1.0among different irrigation schedules. During first year, the highest mean FWUE of 42.04kg/ 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 schedules 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 schedules at IW/CPE 1.0irrigation schedulesregistered highest mean FWUEof 40.80kg/ ha-cm which was at par with irrigation schedules at IW/CPE 1.5and IW/CPE 2.0and significantly superior to irrigation schedules at IW/CPE 2.5(33.78kg /ha-cm). The irrigation schedules at IW/CPE 2.5gave lower water use efficiency though grain yield was higher. This is due toconsumption 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 withvariety CR Dhan 201whereas, lowest value was observed with variety MTU 1010 among different cultivars.During both the years of study, the higher pooled mean of FWUE of 41.60kg/ ha-cm was observed withvariety CR Dhan 201which was at par withvariety Naveen (39.25kg/ 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 schedules 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 schedulesat IW/CPE 1.5 withNaveen variety produced the higher field water use efficiency (44.05 kg ha-cm^{-1}) but it was at par with all irrigation schedules except at IW/CPE 2.5 with variety CR Dhan 201.

Conclusion:

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

References

Belder, P., Bouman, B.A.M., Spiertz, J. H. J., Peng, S., Castaneda, A. R. and Visperas, R.M. 2005. Crop performance, nitrogen and water use in flooded and aerobic rice. *Plant and soil.*273:167-182.

Castaneda, A.R., Bouman, B.A.M., Peng, S., Visperas, R.M., Fernandez, L.R., Acosta, J.A., Faronilo, J. E. 2007. Performance of aerobic rice in field experiments in the Philippines. *Journal of Crop Science*. 32(1): 31-35.

Duary, S. 2017. Response of aerobic rice to irrigation and nitrogen management in red and lateritic soil.M.Sc.Thesis.Department of Agronomy, PSB, Visva-Bharati, Sriniketan.

Gomez, K.A.,Gomez, A.A. 1984.Statistical Procedures for Agricultural Research.Wiley, New York.

IRRI.2001.Annual report 2000-2001.: Rice research: The way forward.International Rice Research Institute, Los Banos (Philippines), pp.71-73.

Maheswari, J., Bose, J., Sangeetha, S.P., Sanjutha, S. and SathyaPriya, R. 2008. Irrigation regimes and N levels influence chlorophyll, leaf area index, proline and soluble protein content of aerobic rice. *International Journal of Agricultural Research.*3: 307-309.

Prasad, R.2011. Aerobic rice systems.*Advances in Agronomy.*111:207-47.

Shekara, B.G., Sharnappa and Krishnamurty,N. 2010. Effect of irrigation schedules on growth and yield of aerobic rice (*Oryzasativa*L.) under varied levels of farmyard manure in Cauvery command area.*Indian Journal of Agronomy.*55: 35-39.

Tuong, T.P. and Bouman, B.A.M. (2003) Rice production in water-scarce environments. In: Kijne, J.W., Barker, R. and Molden, D., Ed., Water Productivity in Agriculture: Limits and Opportunities for Improvement, CABI Publishing, Wallingford, 53-67.

Tuong, T.P., Bouman, B.A.M. and Mortimer, M. (2005) More Rice, Less Water-Integrated Approaches for Increasing Water Productivity in Irrigated Rice-BasedSystems in Asia. Plant Production Science, 8, 229-239.

Table 1 : Effect of irrigation schedules and cultivars onharvest index (%)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 Schedules									
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 of irrigation schedules and cultivars on grain yield of rice under aerobic condition				
Irrigation schedules	**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 schedules 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 Schedules						
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
$SE_m(\pm)$	-	-	-	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
$SE_m(\pm)$	-	-	-	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 of irrigation schedules and cultivars on water use efficiency of rice in aerobic condition				
Irrigation schedules	**WUE (kg ha-cm^{-1})**			
	Pooled			
	Cultivars			
	Naveen	MTU-1010	CR Dhan 201	CR Dhan 204
I_1 : IW/CPE = 1.0	42.00	36.96	42.94	39.51
I_2 : IW/CPE =1.5	44.05	38.76	43.92	36.09
I_3 : IW/CPE = 2.0	37.11	34.36	43.76	40.25
I_4 : 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	