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Growth and Yield of Rice (*Oryza sativa* L.) Varieties as Influenced by Nutrient Management Practices under Irrigated-Aerobic Condition

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Abstract: A Field experiments were carried out during *kharif* 2019 and 2020 at Agricultural Research Station, Binjhagiri , Faculty of Agricultural Sciences, IAS, SOADU, Bhubaneswar, Odisha to study the growth and yield of rice (*Oryza sativa* L.) varieties as influenced by nutrient management practices under irrigated-aerobic condition. The experiment was laid out in split plot design and consisted of three varieties (CR Dhan-205, Naveen and- Nirmal-150) in main plot and five practices of nutrient management (F_1 - Control, F_2 – 40-20-20 N-P_2O_5-K_2O kg ha^{-1}, F_3 -80-40-40 N-P_2O_5-K_2O kg ha^{-1}, F_4– 120-60-60 N-P_2O_5.K_2O $kgha^{-1}$and F_5- 160-80-80 N-P_2O_5-K_2O kg ha^{-1}) in subplot. CR Dhan 205, an aerobic rice variety, performed well and produced significantly the highest yield of grain (4.01 tha^{-1}) and straw (5.3 tha^{-1}).The increase in grain yield was associated with a significantly higher number of filled grains/panicle (107.7), Ear bearing tillers/ m^2(288.6), and test weight(23g). Among the nutrient management practices, F_4 -120-60-60 N-P_2O_5-K_2O $kgha^{-1}$recorded highest grain (4.36 tha^{-1}) and straw (5.86 tha^{-1}) yield and it was at par with F_3 -80-40-40 N-P_2O_5-K_2O kg ha^{-1}. The variety Naveen closely followed with CR Dhan 205.

Keywords: Nutrient management practices, Aerobic condition, Rice varieties, Grain yield

The word "food grains or cereals" usually indicates rice in many parts of the world. Owing to its ability of adaptability to a wide range of geo-hydrological situations, rice holds a distinctive place among the field crops. The rice production area in India as of the year 2019-20 is 43.78 million hectares with a production of 118.4 million tonnes (Anonymous 2021). West Bengal ranks first among the different rice growing states of the country having acreage of about 5.46 M ha with total production of 15.57 MT of rice (Anonymous 2021). Rice is the single biggest user of freshwater. Although, the maximum proportion of rice yield is obtained from lowland the cost of ample use of water for transplanting and puddling operations includes maintenance of 5-10 cm of standing water throughout its growing period. India leads the world in total water withdrawal for irrigation, where irrigation withdrawals represent 80 to 90% of all water use in India. With these facts and predictions, the future of our most important staple food crop can be easily presumed. Therefore, to cope up with this water scarcity situation, scientists are now taking on the challenging task of developing rice production systems that require economic water-use. In this scenario, the aerobic rice production technology is a good alternative of the conventional puddling system and is effective with limited water resources. Aerobic rice reported 51% lower total water use (by reducing water use during land preparation, seepage, percolation and evaporation) and 32-88% higher water productivity, expressed as gram of grain per kilogram of water, than flooded rice (Bouman et al 2005). As this system devoid of the practices like nursery preparation, transplanting and puddling, so the labour requirement is also lower than the conventional method of rice establishment. In another perspective, aerobic rice production system can be considered as eco-friendly and environmentally safe since rice is grown here under non-saturated condition and thus reduces the methane gas emission to the atmosphere, whereas lowland conventional rice cultivation is the major source of methane gas (CH_4) emissions, contributing 48% of the total greenhouse gases emitted by agricultural sources. It will be convincing for the farmers if they find the performance of available and popular varieties (mostly suitable for the conventional system) well under this irrigated-aerobic condition. This will reduce their cultivation cost and will encourage adopting this technique. The research-based information on the effect of nutrient management on different varieties (besides aerobic rice variety) grown under irrigated-aerobic system is meagre. In this context, the present research has been framed to evaluate the effect of nutrient management practices on growth and yield of different rice varieties under irrigated-aerobic condition.

MATERIAL AND METHODS

A field experiment was conducted to study the "growth and yield of rice (*Oryza sativa* L.) varieties as influenced by nutrient management practices under irrigated- aerobic condition" at Agricultural Research Station, Binjhagiri, Institute of Agricultural Sciences, SOADU, Odisha, India. The experiment field is situated between 20°26' N latitude and 85°67' E longitude at an altitude of 45 meters above mean sea level. The soil of the experimental plot was sandy loam in texture with acidic in reaction (pH 5.80) and low in organic carbon (0.43%) and available nitrogen (205.24 kg ha^{-1}), high in phosphorous (32.15 kg ha^{-1}) and medium in potassium (142 kg ha^{-1}) content. The experiment was laid out in split plot design with three replications comprising fifteen treatment combinations. Treatments consisted of three varieties (in main plot and five nutrient management practices (Table 1). The rice varieties were transplanted at 21 DAS on dd/mm/year.One third quantity of nitrogen and full amount of phosphorus and potassium were applied in each plot as basal during the final land preparation. Rest two third quantity of N was applied in two splits as top dressing *i.e.* one third of nitrogen was top dressed at active tillering stage and rest one third of nitrogen was top dressed at panicle-initiation stage. The recommended agronomic practices and plant protection measures were adopted to raise the crop. Grain and straw yields along with associated characters such as ear bearing tillers, dry matter accumulation, leaf area index, panicle length, panicle weight and fertile grains per panicle.

RESULTS AND DISCUSSION

Significant variations in plant height observed at harvest during both the years (2019 and 2020). At harvest, the highest plant height (96.9 cm) was recorded with the variety Naveen followed by CR Dhan 205 (90.2 cm) and shortest plant (81.8 cm) was with the variety Nirmal-150 (Table 1). Mahajan et al (2010) reported heights differ due to their genetic makeup and response to different climatic components. Praveen *et al* (2014) observed that the ultimate plant height is highly influenced by the variety and favourable weather. Among the nutrient management practices highest plant height (106.45 cm) was with the application of 160-80-80 N-P_2O_5-K_2O kg ha^{-1} at harvest followed by application of 120-60-60 N- P_2O_5- K_2O kg ha^{-1} (Table 1). The plant heights of treatment F_4 and F_3 were at par with each. Upland rice variety CR Dhan 205 registered significantly highest value of dry matter production m^{-2} and number of tillershill^{-1} at harvest and it was at par with variety Naveen. CR Dhan 205 recorded 7.76% higher number of tillers per hill compared to hybrid variety Nirmal 150 .Ndaeyo et al (2008) reported that significant differences in the number of tillers can be attributed to differences due to their ability to utilize the fertilizer as well as partitioning of dry matter. Among the nutrient management practices, highest number of tillers/hill and dry matter production per/m^2 was recorded in F_4 at harvest and was closely followed by treatment F_3. Lowest no of tillers per hill and dry matter production per m^2 was recorded under control plot at harvest (Table 1). Shekara et al (2010) revealed that application of 125 kg N ha^{-1} recorded significantly higher plant height, a greater number of tillers $hill^{-1}$ and dry matter accumulation over its lower levels.

Yield attributes and yield: Upland rice variety CR Dhan 205 recorded the maximum panicle length, ear bearing tillers/ m^2, panicle weight, thousand grain weights, number of fertile grains panicle^{-1} than other varieties and it was at par with variety Naveen. Hybrid variety Nirmal 150 recorded 11.07 and 9.50% lower number of Ear bearing tillers m^{-2} than variety CR Dhan 205 and Naveen respectively. The number of fertile grains per panicle increased by 22.72% with upland variety CR Dhan 205 in compared to hybrid variety Nirmal 150 (Table 2). Medium duration lowland high yielding variety Naveen

Table 1. Effect of rice varieties and nutrient management practices on growth attributing characters(pooled data of two years)

Variety	Plant height (cm)	Number of tillers per hill	Dry matter production (g m^{-2})
V_1 CR Dhan -205	90.2	11.1	743.68
V_2 Naveen	96.9	10.9	709.01
V_3 Nirmal-150	81.8	10.3	684.68
CD(p= 0.05)	5.16	0.54	39.90
Nutrient management practices			
F_1=Control	68.59	5.93	553.22
F_2=40:20:20 N:P_2O_5:K_2O kg/ha	80.29	9.57	648.74
F_3=80:40:40 N:P_2O_5:K_2O kg/ha	93.95	12.98	798.67
F_4=120:60:60 N:P_2O_5:K_2Okg/ha	98.79	13.38	830.56
F_5=160:80:80 N:P_2O5:K_2O kg/ha	106.45	12.08	730.00
CD (p=0.05)	6.98	1.09	57.07

recorded 18.18% higher number of fertile grains panicle^{-1} than hybrid variety Nirmal in irrigated upland condition. Among the nutrient management practices, panicle length, ear bearing tillers/ m^2,panicle weight, thousand grain weights, number of fertile grains per panicle were recorded in treatment F_4 (120-60-60 N-P_2O_5-K_2O kgha^{-1}) at harvest and it was closely followed by treatment F_3 (80-40-40 N-P_2O_5-K_2O kgha^{-1}) at harvest .Similar findings have been reported by Prakash et al (2014)

An insight into the data clearly highlighted marked effect of all the variables on yield of grain and straw. Among the varieties aerobic rice CR Dhan 205 recorded significantly higher grain and straw yields (4.03 and 5.3 tha^{-1}, respectively) but it was statistically at par with variety Naveen (3.90 and 5.20 tha^{-1}), a medium duration lowland high yielding variety (Table 3). Both of these varieties were recorded significantly 17.61and 14.87% higher grain yield , respectively over the

Table 2. Effect of rice varieties and nutrient management practices on yield attributing characters (pooled data of two years)

Variety	Panicle length (cm)	Panicle weight (g)	EBT per m^2	1000 grain weight (g)	Fertile grains per panicle	Sterile grains per panicle	Sterile (%)
V_1 CR Dhan -205	24.6	2.59	289	23.0	108	27	20.28
V_2 Naveen	23.6	2.46	284	22.1	104	26	20.29
V_3 Nirmal-150	22.4	2.2	257	19.1	88	33	28.0
CD (p= 0.05)	1.53	0.22	22.52	1.31	7.84	3.01	
Nutrient management practices							
F_1=Control	19.11	1.84	170	17.34	63	31	32.67
F_2=40:20:20 N:P_2O_5:K_2O kg/ha	21.91	2.21	226	20.01	76	34	30.68
F_3=80:40:40 N:P_2O_5:K_2O kg/ha	26.07	2.71	333	23.39	123	23	15.99
F_4=120:60:60 N:P_2O_5:K_2Okg/ha	27.16	2.80	353	24.11	128	23	15.19
F_5=160:80:80 N:P_2O5:K_2O kg/ha	23.47	2.44	301	22.14	109	34	23.56
CD (p=0.05)	2.01	0.10	25.22	1.19	5.22	2.04	
Interaction	NS	S	NS	NS	S	NS	
	CD (p=0.05)	CD (p=0.05)	CD (p=0.05)	CD (p=0.05)	CD (p=0.05)	CD (p=0.05)	
V X F	-	0.17	-	-	9.42	-	
F X V	-	0.22	-	-	9.97	-	

Table 3. Effect of rice varieties and nutrient management practices on grain yield, straw yield and harvest Index (pooled data of two years)

Variety	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest Index(%)
V_1-CR Dhan -205	4.03	5.3	43.1
V_2-Naveen	3.90	5.2	42.8
V_3-Nirmal-150	3.32	4.7	41.5
CD (p= 0.05)	0.27	0.22	NS
Nutrient management practices			
F_1=Control	2.85	3.94	42.04
F_2=40:20:20 N:P2O5:K2O kg/ha	3.30	4.51	42.14
F_3=80:40:40 N:P2O5:K2O kg/ha	4.26	5.73	42.58
F_4=120:60:60 N:P2O5:K2O kg/ha	4.38	5.85	42.70
F_5=160:80:80 N:P2O:K2O kg/ha	3.96	5.25	42.93
CD (p= 0.05)	0.18	0.13	NS
Interaction	S	S	NS
	CD	CD	CD
V X F	0.31	0.23	NS
F X V	0.34	0.26	NS

Table 4. Interaction effect of varieties with nutrient management practices on grain yield (t/ha) (pooled data of two years)

Variety	Nutrient management practices Grain yield (t ha^{-1})					
	F_1	F_2	F_3	F_4	F_5	Mean
V_1	3.04	3.56	4.60	4.70	4.25	4.03
V_2	2.85	3.35	4.53	4.63	4.15	3.90
V_3	2.67	3.00	3.64	3.80	3.48	3.32
Mean	2.85	3.30	4.26	4.38	3.96	
	Variety (V)	Nutrient management practices(F)			V XF	FX V
CD (p=0.05)	0.27	0.18			0.31	0.34

variety Nirmal 150, a new hybrid variety that produced 3.32 tha^{-1} of grain yield. Present investigation indicated that hybrid variety could not perform well under aerobic condition. Grain and straw yield varied significantly with different nutrient management practices. Among the nutrient management practices, the treatment F_4 (120-60-60 N-P_2O_5-K_2O kg ha^{-1}) produced the highest grain and straw yield (4.38 and 5.85 t ha^{-1}) followed by treatments F_3 (80-40-40 N-P_2O_5-K_2O $kgha^{-1}$),F_5 (160-80-80 N-P_2O_5-K_2O $kgha^{-1}$) and F_2 (40-20-20 N-P_2O_5-K_2O $kgha^{-1}$). Treatments F_4 and F_3 did not differ among themselves and were at par. Treatment F_4 (120-60-60 N-P_2O_5-K_2O $kgha^{-1}$) recorded 53.68% higher grain yield over control plot. The least value of grain and straw yield (2.85 and 3.94 t ha^{-1}) were recorded under control treatment. Two factors Interaction effect were found significant (Table 4). Variety CR Dhan 205 with application of treatment F_4 recorded the highest grain yield (4.70 tha^{-1}) as against the grain yield of variety Naveen (4.63 t/ha) and Nirmal 150 (3.80 t ha^{-1}) under same management practices. No significant difference in values of harvest index with respect to varieties and nutrient management practices were evident (Table 3). Among the varieties, CR Dhan recorded the highest harvest index (43.10%) followed by Naveen (42.80%) and Nirmal 150 (41.50%). Among different nutrient management practices, F_5 (160-80-80 N- P_2O_5-K_2O kg ha^{-1})recorded highest harvest index (42.93%) followed by treatments F_4(42.70%), F_3(42.58%) and F_2(42.14%).The least value of harvest index was found in control plot (42.04%).

CONCLUSION

The rice variety CR Dhan 205, performed well under aerobic condition. However, the existing high yielding variety Naveen performed equally well. Naveen can be used both as lowland and aerobic rice depending on situation. Hybrid variety Nirmal 150 does not perform well under aerobic condition. Application of 120-60-60 N- P_2O_5- K_2O $kgha^{-1}$was superior in respect to growth, yield attributes character and yield of rice under aerobic condition and it was closely observed by 80-40-40 N-P_2O_5.K_2O kg ha^{-1} in all the crop growth stage.

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