Response of Rice (*Oryza sativa* L.) Cultivars to Nitrogen Fertilization under Aerobic and Transplanted Condition

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Abstract

An experiment was conducted during *kharif*, 2007 at Agricultural college farm, ANGRAU, Rajendranagar, Hyderabad where fourteen popular short and medium duration rice varieties were studied at varied N levels for their response under aerobic and transplanted situations in double split plot design with two replications. The grain yield obtained both under aerobic and transplanted condition were comparable in Naveen, MTU 1010 and Erramallelu. On the other hand, varieties IR-64, Tellahamsa, Erramallelu, Rajendra, hybrid ARB-17 (1) K-06, MTU 1010 and Naveen performed better under aerobic condition and varieties Naveen, MTU 1001, MTU 1010 and Erramallelu recorded higher yields under transplanted condition. The grain yield increased significantly with increase in N level from 0 to 50, 100 and 150 kg ha^{-1}. The total water requirement was 7314 and 11757 m^3ha^{-1} in aerobic and transplanted conditions, respectively. The water productivity of cultivars was higher under aerobic condition than that under transplanted condition and ranged from 0.29 to 0.83 and 0.14 to 0.49 kg m^{-3} of water in aerobic and transplanted condition, respectively.

1. Introduction

In India, rice is the major crop grown under canals, tanks and wells. Due to delay in onset of monsoons and frequent droughts, receipt of water in to the filling of reservoirs, tanks and wells is delayed. In the traditional rice cultivated areas this leads to late transplanting with over-aged seedlings there by reduction in yields due to more pest load besides delay in planting of succeeding crop in sequence. Though knowledge on direct seeded rice from other areas is available, experience with this technique in Andhra Pradesh is limited (Reddy and Ramulu, 2008). Introduction of a new sowing technique in the *kharif* rice need to be studied in a systematic way as it has direct consequences for the entire cropping system of a farm. Especially, land preparation (land leveling), water and nutrient management need to be improved for direct seeding to become an attractive alternative to farmers. Even though the aerobic rice is considered as potential technology to save water in rice (Bouman, 2001; Toung et al., 2005), information in terms of suitability of popular cultivars for the aerobic cultivation, their water and nutrient requirements are scanty. Nitrogen fertilization is the major agronomic practice that affects the yield and quality of rice. Aerobic rice is a new method of rice cultivation and the form and availability of nitrogen is entirely differing from traditional paddy field (Sathiya and Ramesh, 2009). Since the concept of aerobic rice is new, the management of irrigation and fertilizers to optimize yield and resource use efficiency and their dynamics are very few (Sinclair, 1990).

Aerobic rice varieties are high-yielding upland varieties distinguished from traditional upland rice that is adapted to low-input, subsistence-oriented management by their improved lodging resistance and higher harvest index (Bouman et al., 2005). The varieties developed for aerobic condition have ability to adapt better to aerobic conditions than other varieties (Casteneda et al., 2002). Further, under aerobic situation, the water productivity was 19-39% higher than under flooded conditions (Reddy et al., 2010). In India, specific varieties for aerobic conditions are not available. Hence, there is a need for identification and evaluation of existing rice cultivars available for low land and upland situations which can perform better both under transplanted and aerobic conditions along with their response to nitrogen application. Hence, a trial was conducted with an objective to evaluate the performance of

rice cultivars at different levels of nitrogen for developing aerobic rice production system with special focus on water and nutrient management.

2. Materials and Methods

The experiment was conducted at Agricultural college farm, ANGRAU, Rajendranagar, Hyderabad, during *kharif* 2007. Fourteen popular short and medium duration rice varieties developed for transplanted and rainfed upland situation in Orissa, Andhra Pradesh, and hybrids developed at DRR, Hyderabad were collected for evaluation based on their performance and duration. These varieties were tested both under aerobic and transplanted conditions with varied N levels (0, 50, 100 and 150 kg N ha^{-1}) in double split-plot design in 2 replications. The nursery for transplanting at later date was also sown on the same date of aerobic rice sowing.

The crop was sown on 13th July, 2007. The nursery was transplanted on 3rd September, 2007. Transplanting was delayed for want of sufficient water in the well for puddling. This type of situation is very common in paddy growing areas in the state. The crop was sown as a solid row at 20 cm spacing under aerobic and 20 cm between rows and 10 cm between hills under transplanted conditions. The P and K were applied at 60 kg each in the form of P_2O_5 and K_2O ha^{-1}. The N in the form of urea was applied as per the treatments. One third of N, entire level of P and K were applied at the time of sowing/ planting. The remaining N was applied in two splits at tillering stage and panicle initiation stage. The crop was irrigated whenever there was no rain for 10 days during rainy season and at 4-5 days interval during post rainy season (October and November). This period coincided with reproductive and maturity stages of the crop. The irrigation water was applied through HDPE pipe to which water meter was attached for measurement. The crop was managed with normal agronomic practices in respect of weeding, plant protection etc., during crop growth period. The varieties were harvested as and when they come to maturity. The effective rainfall was estimated by using CRIWAR method (a Simulation Program for Calculating the Crop Irrigation Water Requirement). The grain and straw yield, irrigation water applied were recorded and effective rainfall, total water requirement and water productivity (kg grain m^{-3}) were estimated under both aerobic and transplanted conditions. The harvest index was calculated as the ratio of economic yield (grain yield) to that of biological yield (grain yield and straw yield). The response to applied N was calculated by using the following formula and expressed in kg grain kg^{-1} N applied.

$$\text{Nitrogen Response} = \frac{\text{Grain yield obtained at given N level (kg ha}^{-1}\text{)} - \text{Grain yield obtained at given 0 level (kg ha}^{-1}\text{)}}{\text{Amount of N applied (kg ha}^{-1}\text{)}}$$

3. Results and Discussion

3.1. Grain yield

The grain yield was not significantly influenced by method of cultivation but was significantly influenced by varieties and N levels (Table 1). Under aerobic conditions, the grain yield varied between 2.20 and 5.33 t ha^{-1} with mean yield of 4.04 t ha^{-1} and under transplanted conditions, it varied from 1.70 to 5.74 t ha^{-1} with a mean yield of 3.65 t ha^{-1}.

Among the fourteen varieties tested, the grain yield of Naveen (5.18 t ha^{-1}) was higher and comparable with the varieties MTU 1010 (4.71 t ha^{-1}), Erramallelu (4.64 t ha^{-1}) and IR-64 (4.53 t ha^{-1}) and significantly higher over other varieties. Lower grain yield was recorded by MTU 1075 (2.12 t ha^{-1}).

The interaction of varieties and method of cultivation on grain yield indicated that under aerobic conditions, among the fourteen varieties tested, IR-64 recorded higher grain yield (5.33 t ha^{-1}) which was comparable with that of Tellahamsa (5.22 t ha^{-1}), Erramallelu (5.04 t ha^{-1}), Rajendra (4.79 t ha^{-1}), hybrid ARB-17(1) x 06 (4.76 t ha^{-1}), MTU 1010 (4.65 t ha^{-1}) and Naveen (4.62 t ha^{-1}) and significantly superior over other varieties. Under transplanted conditions, Naveen recorded higher grain yield (5.74 t ha^{-1}) which was comparable with MTU 1001 (4.84 t ha^{-1}) and MTU 1010 (4.78 t ha^{-1}) and significantly superior over other varieties.

The grain yield obtained both under aerobic and transplanted condition were comparable in Naveen, MTU 1010 and Erramallelu. On the other hand, varieties IR-64, Tellahamsa, Erramallelu, Rajendra, hybrid ARB-1717 (1) K-06, MTU 1010 and Naveen performed better under aerobic condition and varieties Naveen, MTU 1001, MTU 1010.

The grain yield increased significantly with increase in N level from 0 to 50, 100 and 150 kg ha^{-1}. The interaction of nitrogen levels and method of cultivation showed that under aerobic conditions, the grain yield increased significantly from 0 to 50 kg N ha^{-1} and 100 to 150 kg N ha^{-1}. The grain yield observed with 50 and 100 kg N ha^{-1} was comparable. However, under transplanted condition, the grain yield increased with application of N from 0 to 50, 100 and 150 kg ha^{-1}.

3.2. Straw yield

The methods of paddy cultivation did not influence the straw yield significantly (Table 1). However, the effects of varieties, nitrogen levels and the interaction effects of varieties and nitrogen levels with method of cultivation, were significant on straw yield. Under aerobic conditions, the straw yield varied between 3.55 to 7.46 t ha^{-1} with mean yield of 6.12 t ha^{-1} and where as in transplanted conditions, it varied from 4.76 to 8.57 t ha^{-1} with a mean yield of 6.63 t ha^{-1}.

The performance of fourteen varieties revealed that, the straw yield of JGL -11727 (7.47 t ha^{-1}) was higher and comparable

Table1: Grain and straw yield and harvest index of rice cultivars as influenced by method of cultivation and N levels									
Treatments	Grain yield (t ha^{-1})			Straw yield (t ha^{-1})			Harvest index		
	Aerobic	Transplanted	Mean	Aerobic	Transplanted	Mean	Aerobic	Transplanted	Mean
Erramallelu	5.04	4.65	4.85	5.97	5.08	5.52	0.46	0.48	0.47
WGL-14	3.10	2.18	2.64	7.36	5.57	6.47	0.30	0.28	0.29
Jagtial sannalu	3.64	2.32	2.98	5.68	5.77	5.73	0.39	0.29	0.34
JGL-11470	2.20	4.17	3.18	7.34	7.01	7.18	0.23	0.37	0.31
JGL-11727	3.07	3.76	3.41	7.03	7.90	7.47	0.30	0.32	0.31
Tellahamsa	5.22	3.24	4.23	5.44	8.28	6.86	0.49	0.28	0.38
IR-64	5.33	3.73	4.53	5.33	6.46	5.89	0.50	0.37	0.43
Naveen	4.62	5.74	5.18	6.32	8.57	7.45	0.42	0.40	0.41
MTU-1010	4.65	4.78	4.71	4.83	7.50	6.16	0.49	0.39	0.43
MTU-1001	3.48	4.84	4.16	7.10	6.92	7.01	0.33	0.41	0.37
MTU-1075	2.54	1.70	2.12	6.62	6.47	6.55	0.28	0.21	0.24
ARB-2(A) x 3	4.10	4.40	4.25	7.46	6.84	7.15	0.35	0.39	0.37
ARB-1717(1) K-06	4.76	2.77	3.76	5.61	5.68	5.65	0.46	0.33	0.40
Rajendra	4.79	2.84	3.82	3.55	4.76	4.15	0.57	0.37	0.48
Mean	4.04	3.63		6.12	6.63		0.40	0.36	
CD (p=0.05)									
Method of cultivation			NS			NS			
Varieties			0.76			0.90			
Varieties X method of cultivation			1.07			1.27			
N levels									
0 kg ha^{-1}	3.36	2.55	3.01	4.94	6.09	5.51	0.41	0.30	0.35
50 kg ha^{-1}	3.88	3.37	3.62	6.12	6.40	6.26	0.39	0.34	0.37
100 kg ha^{-1}	4.18	4.01	4.09	6.57	6.92	6.75	0.39	0.37	0.38
150 kg ha^{-1}	4.74	4.58	4.66	6.84	7.11	6.98	0.41	0.39	0.40
Mean	4.04	3.63		6.12	6.63		0.40	0.36	
CD (p=0.05)									
N levels			0.24			0.36			
N levels X method of cultivation			0.33			0.51			

with the varieties JGL 11470 (7.18 t ha^{-1}), hybrid ARB-2(A) x 3 (7.15 t ha $^{-1}$), MTU 1001 (7.01 t ha^{-1}) and Tellahamsa (6.86 t ha^{-1}) and significantly higher over other varieties tested.

The interaction effect of varieties and method of cultivation on straw yield indicated that under aerobic conditions, among all the varieties tested, hybrid ARB-2(A) x3 recorded higher straw yield (7.46 t ha^{-1}) which was comparable with WGL-14, JGI-11470, MTU-1001, JGL-11727 and MTU-1075 and significantly superior over other varieties. Rajendra recorded lower straw yield (3.55 t ha^{-1}). Under transplanted conditions, Naveen recorded higher straw yield (8.57 t ha^{-1}) which was comparable with Tellahamsa, JGL -11727 and MTU 1010 and significantly superior over other varieties.

The varieties WGL-14, JGL-11470, JGL-11727, Naveen, MTU-1010 and ARB-2(A) x 3 performed better under aerobic condition and varieties Naveen and Tellahamsa recorded higher straw yield under transplanted condition.

The straw yield increased significantly with increase in N level from 0 to 50, 100 and 150 kg ha^{-1}. The interaction of nitrogen levels and method of cultivation showed that under aerobic conditions, the straw yield increased significantly from 0 to 50 kg N ha^{-1} and 100 to 150 kg N ha^{-1}. The straw yield observed

with 50 and 100 kg N ha^{-1} was comparable. However, under transplanted condition, the straw yield increased significantly with application of N from 0 to 50, 100 and 150 kg ha^{-1}. The straw yield observed with 0 to 50 kg N ha^{-1} and 100 to 150 kg N ha^{-1} were comparable.

3.3. Harvest index (HI)

Slightly higher harvest index (0.4) was observed in aerobic rice (Table 1) as compared to transplanted rice (0.36). Among fourteen varieties evaluated, the HI ranged from 0.29 to 0.48 and the highest was observed with Rajendra (0.48) closely followed by Erramallelu (0.47). The lowest HI was observed with WGL-14 (0.29). The harvest index increased with application of N levels from 0 to 50, 100 and 150 kg ha^{-1}.

3.4. Water requirement and productivity

The total water requirement worked out was 7314 and 11757 m^3ha^{-1} in aerobic and transplanted conditions, respectively (Table 2). The water productivity of cultivars was higher under aerobic condition than that under transplanted condition. It ranged from 0.29 to 0.83 kg m^{-3} of water and 0.14 to 0.49 kg m^{-3} of water in aerobic and transplanted condition, respectively

Table 2: Water productivity and N response of rice as influenced by methods of cultivation and varieties kharif 2007, Rajendranagar, Hyderabad

Cultivars	Total water*, m^3		Water productivity, kg grain m^{-3}		Grain response at N levels over control		
	Aerobic	Transplanted	Aerobic	Transplanted	Aerobic	Transplanted	Mean
Erramallelu	7280	10600	0.69	0.44	10.4	10.7	10.55
WGL-14	7700	12370	0.40	0.18	5.3	13.3	9.3
Jagtial sannalu	7700	12370	0.47	0.19	11.5	15.8	13.65
JGL-11470	7700	12370	0.29	0.34	10.4	10.6	10.5
JGL-11727	7700	12370	0.40	0.30	4	15.5	9.75
Tellahamsa	6460	10600	0.81	0.31	5.2	9.8	7.5
IR-64	6460	11620	0.83	0.32	8.5	13.3	10.9
Naveen	7280	11620	0.63	0.49	8.5	25.5	17
MTU-1010	7280	12370	0.64	0.39	10.9	16.5	13.7
MTU-1001	7700	12370	0.45	0.36	6.7	17.4	12.1
MTU-1075	7700	12370	0.33	0.14	13.1	6.5	9.8
ARB-2(A) x 3	7700	12370	0.53	0.36	12.1	17.1	14.6
ARB-1717(1) K-06	7280	10600	0.65	0.26	6.6	18	12.3
Rajendra	6460	10600	0.74	0.27	12.8	11.4	12.1
N levels							
0 kg ha^{-1}	7314	11757	0.46	0.22	10.4	16.4	13.4
50 kg ha^{-1}	7314	11757	0.53	0.29	8.2	14.6	11.4
100 kg ha^{-1}	7314	11757	0.57	0.34	9.2	13.5	11.35
150 kg ha^{-1}	7314	11757	0.65	0.39	9.2	14.8	12.05
*includes effective rainfall of 200 mm for aerobic and 180 mm for transplanted rice							

At all levels of N, the water productivity was higher in aerobic rice than that of transplanted rice. The water productivity increased with increase in N levels from 0 to 50, 100 and 150 Kg N ha^{-1}.

The mean response to N over 0 level was more in hybrid ARB 2(1) A x 3 (1.46 kg grain kg N^{-1}) followed by Jagtial Sannalu (1.37 kg grain kg N^{-1}), hybrid ARB 17(1) x 06 (1.23 kg grain kg N^{-1}), Rajendra (1.21 kg grain kg N^{-1}) and Erramallelu (1.05 kg grain kg N^{-1}). The mean response to N was higher in transplanted rice compared to aerobic rice (Table 2). Under aerobic condition, MTU 1075 (1.31 kg grain kg N^{-1}) had more N response followed by Rajendra (1.28 kg grain kg N^{-1}) and under transplanted condition, Naveen (2.55 kg grain kg N^{-1}) had more response to N application.

4. Conclusion

From these results, it can be concluded that the varieties Erramallelu and Naveen released for transplanted conditions

produce higher yield under both aerobic and transplanted conditions. Further, there was less decrease in grain yield in these varieties even under late planted conditions. The aerobic rice responds to applied nitrogen upto 150 Kg N ha^{-1} and with increase in N levels, the water productivity increased. The crop response to applied nitrogen was higher in transplanted rice than that in aerobic rice due to late planting.

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