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Influence of Irrigation Regimes and Nitrogen Levels on Growth, Yield and Water Productivity of Rice under Alternate Wetting and Drying (AWD) Method of Water Management

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A B S T R A C T

A field experiment was carried out during kharif 2015 on clay loam soil at college farm, Rajendranagar, Hyderabad with an objective to study the response of rice to irrigation regimes and nitrogen levels under AWD method of water management. The experiment was laid out in a split plot design with three replications. Three irrigation regimes were taken as main plots and three nitrogen levels in subplots include S1: Transplanted low land rice with continuous submergence of 3cm up to panicle initiation stage and then 5cm up to maturity, S2: AWD water management of periodical flooding to 3 cm submergence depth from 15 DAT to maturity when the ponded water disappears on the ground surface, S3: AWD water management of periodical flooding of the field to 5cm submergence depth from 15 DAT to maturity when the ponded water level drops to 5 cm below ground level in the field tube and nitrogen levels viz., N1:120 kg ha^{-1}, N2: 160 kg ha^{-1}, N3: 200 kg ha^{-1}). The results revealed that the combination continuous submergence of 3cm up to panicle initiation stage and then 5cm up to maturity and 200 kg N ha-1 was found to be the best for higher yield (6562 kg/ha) and water productivity compared to the other irrigation regimes and nitrogen levels under AWD method of water management.

Introduction

The water crisis is threatening the sustainability of the irrigated rice system and food security in Asia. Tuong and Bouman (2003) indicated that 2 million ha of irrigated dry-season rice and 13 million ha of irrigated wet-season rice in Asia will experience “physical water scarcity” by 2025. Most of the 22 million ha of irrigated dry-season rice in south and Southeast Asia will suffer “economic water scarcity”. There was also much evidence that water scarcity already prevails in rice growing areas (Bouman *et al.*, 2002), where farmers need technologies to cope with water shortage and ways must be sought to grow rice with less water. Among the various essential nutrient elements, nitrogen plays a pivotal role for growth and metabolic processes in rice plants. Nitrogen management in rice field is different from other crops because of the continuous submergence of the field. Consequently environment of root zone is converted from aerobic to anaerobic conditions. Excessive nitrogen promotes lodging and diseases ultimately reduction in yield of rice. Hybrid rice is more fertilizer responsive, but information about agronomic technology on hybrid rice particularly on nutrition is meager. The present strategy of increasing food production essentially involved the balance use of fertilizers to hybrid rice, because all the varieties of hybrid rice give their fully yield potential with adequate supply of nutrients. Keeping these points in view the present study is proposed to evaluate the influence of irrigation regimes and nitrogen levels on growth, yield of rice under AWD method of water management.

Materials and Methods

A field experiment was conducted at college farm, Rajendranagar, Hyderabad during kharif, 2015. The soil was sandy clay loam in texture, slightly alkaline in reaction and non-saline. The fertility status of the experimental soil was low in available nitrogen, high in available phosphorous and potassium, available N (253 kg/ha), P (42 kg/ha) and K (238) in the 0-30 cm soil layer. The treatments comprised three irrigation regimes, viz. S1: Transplanted low land rice with continuous submergence of 3cm up to panicle initiation stage and then 5cm up to maturity, S2: AWD water management of periodical flooding to 3 cm submergence depth from15 DAT to maturity when the ponded water disappears on the ground surface, S3: AWD water management of periodical flooding of the field to 5cm submergence depth from 15 DAT to maturity when the ponded water level drops to 5 cm below ground level in the field tube and nitrogen levels viz., N1:120 kg ha^{-1}, N2: 160 kg ha^{-1}, N3: 200 kg ha^{-1} in the sub plot split-plot design with three replications. Recommended dose of N was considered as 120 kg/ha. The Rice variety MTU 1010 with the duration of 120-125 days was raised and was transplanted on 16 August 2015 at a spacing of 15 x 15 cm. A uniform dose of 60 kg P_2O_5/ha through single superphosphate and 40 kg K_2O/ha through muriate of potash as well as half the nitrogen through urea as per treatment was applied basal, whereas the remaining dose of nitrogen was applied in two equal splits as top-dressing at tillering and panicle initiation-stage of rice. During the crop period, a total rainfall of 360 mm was received.

Results and Discussion

Irrigation regimes

Maximum plant height, LAI, Drymatter accumulation was observed with continuous submergence of 3cm up to panicle initiation stage and then 5cm up to maturity which was significantly superior to AWD water management of periodical flooding of the field to 5cm submergence depth from 15 DAT to maturity when the ponded water level drops to 5 cm below ground level in the field tube (Table 1) continuous submergence of 3cm up to panicle initiation stage and then 5cm up to maturity registered higher number of panicles m-2, grains/panicle over AWD water management of periodical flooding of the field to 5cm submergence depth from 15 DAT to maturity when the ponded water level drops to 5 cm below ground level in the field tube.

It provided a better conductive rhizosphere condition for better uptake of nutrients and in turn helped the plants to boost their growth, leading to the development of yield attributes through supply of more photosynthates towards reproductive sink (Dhar *et al.*, 2000). Compared to flood irrigation or complete submergence throughout the crop period, maintaining shallow water depth with wetting and drying decreased vertical NH4+ N and total nitrogen leaching. Complete submergence throughout the crop period, on the other hand, leads to continuous hypoxic condition.

Table.1 Plant height (cm), LAI and Dry matter accumulation (gm^{-2}) as influenced by irrigation regimes and N levels under AWD method of water management in rice at harvest

Treatment	Plant height (cm)	LAI	Dry matter Accumulation ($g\ m^{-2}$)
Main Plots: Irrigation Regimes (S)			
S_1 - Transplanted low land rice with continuous submergence of 3 cm up to panicle initiation stage and then 5 cm up to maturity	105.48	4.03	1294.44
S_2–AWD water management of periodical flooding to 3 cm submergence depth from 15 DAT to maturity when the ponded water disappears on the ground surface.	105.65	4.39	1281.44
S_3 - AWD water management of periodical flooding of the field to 5cm submergence depth from 15 DAT to maturity when the ponded water level drops to 5 cm below ground level in the field water tube.	98.48	4.04	1161.00
SEm ±	1.0	0.09	0.09
CD (P = 0.05)	3.90	NS	NS
Sub Plots: Nitrogen (N) Levels (kg ha^{-1})			
N_1 : 120	98.38	3.25	1224
N_2 : 160	105.48	4.56	1244
N_3 : 200	105.65	4.64	1268
SEm ±	0.98	0.04	1.41
CD (P = 0.05)	3.04	0.14	NS
Interaction			
N at same level of S			
SEm ±	1.73	0.16	1.23
CD (P = 0.05)	NS	NS	NS
S at same or different level of N			
SEm ±	1.71	0.11	0.19
CD (P = 0.05)	NS	NS	NS

Table.2 Significant interaction between irrigation regimes and nitrogen levels for grain yield

Treatment	Panicles/ m2	grains/ panicle	1000 grain weight
Main Plots: Irrigation Regimes (S)			
S_1 - Transplanted low land rice with continuous submergence of 3 cm up to panicle initiation stage and then 5 cm up to maturity	300.55	158.63	24.76
S_2–AWD water management of periodical flooding to 3 cm submergence depth from 15 DAT to maturity when the ponded water disappears on the ground surface.	299.11	158.43	25.43
S_3 - AWD water management of periodical flooding of the field to 5cm submergence depth from 15 DAT to maturity when the ponded water level drops to 5 cm below ground level in the field water tube.	282.88	142.77	24.01
SEm ±	2.04	0.09	0.16
CD (P = 0.05)	NS	NS	NS
Sub Plots: Nitrogen (N) Levels (kg ha^{-1})			
N_1 : 120	291	143	24.22
N_2 : 160	293	158.0	24.59
N_3 : 200	297	158.6	25.52
SEm ±	2.37	0.04	0.12
CD (P = 0.05)	NS	0.14	NS
Interaction			
N at same level of S			
SEm ±	1.73	0.16	0.23
CD (P = 0.05)	NS	NS	NS
S at same or different level of N			
SEm ±	1.71	0.11	0.28
CD (P = 0.05)	NS	NS	NS

This limits the ability of the roots to respire, thereby slowing down N-uptake and transport and also slowing the rate of metabolism and growth (Lin *et al.*, 2006 and Wang *et al.*, 2011).

Nitrogen levels

The rice plants fertilized with 200 kg N/ha were tallest with the maximum LAI and dry matter accumulation compared with the other lower N levels (Table 1). Nitrogen plays an important role in the cell growth and developments of rice plant (Dhar *et al.*, 2000). Application of 200 kg N/ha resulted in maximum panicles/m2, grains/panicle than the 120kg N/ha (Table 2). Increased application of nitrogen from 90 to180 kg/ha under saturated condition upto PI stage followed by submergence might have led to availability of N in sufficient quantities required by the crop which encouraged the increased sink formation led to higher number of panicles, filled grains. These results are in line with Santhosh *et al.*, (2013). There was a significant interaction between irrigation regimes and nitrogen levels for grain yield (Table 2). In all the three irrigation regimes, the grain yield was significantly increased by the additional input of 40 kg N/ha starting from 120 upto 200 kg N/ha. Highest grain yield was noticed with the continuous submergence of 3cm up to panicle initiation stage and then 5cm up to maturity followed by saturation and 200 kg N/ha which was superior to 120 and 160 kg N/ha at all the irrigation.

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