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Yield and Water Productivity of Aerobic Rice (*Oryza sativa* L.) as Influenced by Dates of Sowing and Varieties during *kharif* season

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Abstract

An experiment was carried out to study the effect of dates of sowing on yield and water productivity of different duration rice varieties with five sowing dates and four varieties under aerobic situation in two consecutive *kharif* seasons during 2012 and 2013 at Agricultural Research Station, Madhira in Telangana State. The higher grain yield and water productivity was realised from the crop sown on 18 June and 7 July. Among the varieties, the long and medium duration cultivars *viz.,* MTU 1061 and JGL 11470 recorded higher yield but the short and extra short duration cultivars *viz*., MTU 1010 and JGL 17004 were proved to be good in terms of higher water productivity due to less water requirement.

Key words: Aerobic rice, dates of sowing, varieties, grain yield, water productivity.

Introduction

Rice is the staple food for nearly half of the world's population. In Asia, more than 90 per cent of rice is produced catering the needs of nearly 560 million hungry people (Mohanty, 2013). Globally, India stands first in rice area and second in production after China. More than 80 per cent of the developed fresh water resources in Asia are used for irrigation purposes and consumes up to 43 per cent of the world's developed irrigation resources (Bouman et al., 2007). About 22 M ha of irrigated dry season rice experience economic water scarcity in South and South-East Asia (Tuong and Bouman, 2002). The availability of water for agriculture is declining steadily due to urbanization and rapid increase in population (Xue et al., 2008). The common method of rice cultivation is transplanting and water requirement of this crop is ranged from 1000 to 1500 mm and besides this, raising nursery is very laborious and time consuming. To address these problems, growing rice under aerobic conditions is evolved. Aerobic rice could successfully be cultivated with 600 to 700 mm of total water in summer and entirely on rainfall in wet season (Hittalmani, 2007 a and b). The exact sowing date for direct seeding of rice also plays a vital role in improving its growth, yield and water productivity. Further, most of our cultivars are developed for puddled transplanted conditions. In the absence of a strong rice improvement programme for dry seeded rice, suitable varieties for aerobic system are generally not available. Therefore, there is a need to identify suitable cultivars among existing varieties developed under transplanted conditions. Considering the above facts, the present investigation was carried out to identify optimum time of sowing and suitable varieties under aerobic condition to realise higher yield and water productivity.

Material and Methods

A field experiment was conducted during *kharif* 2012 and 2013 at Agricultural Research Station, Madhira (at an altitude of 189 m above mean sea level at 16°53' and 80°22' E and 189 m), Telangana State. The location of the site is semi arid tropics. During the crop growth season, the mean maximum and minimum temperatures ranged from 29.5 to 36.9°C with an average of 32.4°C in 2012 and 28.9 to 36.1°C with an average of 32.3°C in 2013, respectively, and the rainfall 1086.3 mm was received in 55 rainy days during first year and 937.8 mm in 47 rainy days during second year, respectively. The experimental soils are clayey with pH 8.2, low in organic carbon (0.52%), available nitrogen (144 kg/ha) and available phosphorus (18 kg/ha) and high in available potassium (398.5 kg/ ha). The experiment was conducted in split plot design with 5 sowing dates as main plots *viz.,*18 Jun. (D_1), 7Jul. (D_2), 20 Jul. (D_3), 4 Aug. (D_4) and 18 Aug. (D_5) and 4 varieties as sub plots *viz.,* JGL 17004 (105 days), MTU 1010 (120 days), JGL 11470 (135 days) and MTU 1061 (160 days), replicated thrice. The net size of each plot was 16 m^2 (4.0 × 4.0 m). Crop was sown at 20 cm apart in solid rows with seed rate of 40 kg ha^{-1}.

One-fourth of the recommended dose of nitrogen (120 kg/ha) and full dose of phosphorus (60 kg/ha) half potash (30 kg/ha) and zinc sulphate (25 kg/ha) were applied at the time of sowing as basal and the remaining nitrogen was top dressed in three equal splits at 15 days after sowing, active tillering (30-35), and at panicle initiation stage, respectively. The remaining half of the potassium was applied at panicle initiation stage. For effective weed control, Pendimethalin (1 kg *a.i.*/ha) was used in moist condition at evening hours in all the treatments just after sowing of rice. Bispyribacsodium @ 25.0 a.i/ha was applied as post emergence spray at 2 to 3 leaf stage of the weeds. One hand weeding was done at 35 to 40 days after sowing to reduce the competition between weeds and crop for nutrients and spaces. Two sprayings of Fe SO_4 was done at weekly interval at 20 to 25 DAS to correct iron deficiency in the crop. Irrigations were given at weekly interval (5 cm) measuring through water meter. Soil samples from every 15 cm depth up to 60 cm were collected prior to each irrigation and after rainfall events and soil moisture % estimated through gravimetric method. The effective rainfall was estimated through soil moisture balance method. The crop water productivity was estimated as ratio of rice yield (kg) to total water used (effective rainfall+ irrigation water applied) to crop in the season.

Results and Discussion

Grain yield

The results obtained from dates of sowing and varieties under aerobic situation was presented in Table 1 and depicted in Fig. 1 and 2. Significantly more grain yield (5422 kg/ha and 4944 kg/ha) was realized from the crop sown on 18 Jun. (D1) and was comparable with grain yield (5254 and 4893 kg/ha) of 7 Jul. (D2) sown crop and thereafter reduction in grain yield was noticed with every successive 15 days delay in sowing from 20 Jul. (D3) to 18 Aug. (D5) during 2012 and 2013, respectively. These results were in conformity with the results of Rai and Kushwaha (2008) who reported that, 15.3 per cent more grain yield of aerobic rice was obtained from 15 Jun. sown crop when compared to late sowing of 15 Jul. which might be due to optimum period available for growth and development resulted in more storage of photosynthates in the grain in early sown crop.

Among the varieties tested, the long duration variety MTU 1061 (V_4) produced more grain yield (5547 kg/ha and 5132 kg/ha) and was on par with the medium duration variety JGL 11470 (V_3), which in turn significantly superior to short (MTU 1010) and extra short (JGL 17004) duration varieties during 2012 and 2013, respectively. These results are in line with the findings of Patra *et al.* (2008) and Gopal (2008) who reported that, the grain yields in short and medium duration varieties were lower than long duration varieties.

Water productivity

The data obtained on effective rainfall, total water use and water productivity of rice varieties sown under different dates during 2012 and 2013 were presented in Table 1 and depicted in Fig.1 and 2. The crop sown on 18 June (D_1) received more effective rainfall of 318mm and 236 mm and it was decreased linearly with every successive 15 days delay in sowing during 2012 and 2013, respectively. Among the varieties the highest amount of effective rainfall (262 mm and 229 mm) was received by the long duration variety during 2012 and 2013, respectively. The medium, short and extra short duration varieties ranked 2nd, 3rd and 4th respectively in terms of quantity of effectively rainfall received by them during both the years under study. The number of irrigations and total water used increased with every successive 15 delay in sowing from 18 June to 18 August in 2012 and in 2013. However, the more amount of total water (759 mm) was used by 4 August sown crop due to prolonged dry spell experienced by the crop in the month of September in 2013. Among the varieties, the total water consumption (712 mm and 849 mm) was high in long duration variety MTU 1061 (V4) and lowest total water (481 mm and 592 mm) was used by the extra short duration variety JGL 17004 (V1) in both the years. This differential response in total water use among the varieties was due to difference in the length of crop growth period.

The water productivity of the aerobic rice was higher (1.04 kg/m^3 and 0.73 kg/m^3) with 18 June sown crop and decreased with every successive 15 days delay in sowing in both the years. Among the varieties, the short duration cultivar MTU 1010 (V_2) recorded the highest water productivity of 0.96 and 0.72 kg/m^3 in 2012 and 2013, respectively, followed by the extra short duration variety JGL 17004 (V_1) which produced 0.84 kg/m^3 in 2012. Whereas, in 2013, the medium duration variety JGL 11470 (V_3) produced 0.66 kg grain yield/m^3 of water. The lowest water productivity (0.78 and 0.61 kg/m3) was recorded by the long duration variety MTU 1061 (V_4) in both the years. James *et al.* (2007) evidently claimed that, the water productivity varied among the varieties depending upon their field duration. The variety PMK 3 with duration of 137 days registered the highest water productivity of 7.06 kg rice per ha mm of water. While Ponni, which matured in 184 days, recorded the lowest water productivity of 1.5kg of rice per ha mm of water.

Conclusions

More grain yield and higher water productivity can be obtained under assured irrigated conditions from the crop sown with onset of monsoon season. Among the varieties, long and medium duration varieties produce more grain yield. However, in terms of higher water productivity, short and extra short duration cultivars would be the better option under aerobic system which has lesser crop growth period.

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Table 1. Grain yield, total water use and water productivity as influenced by dates of sowing and varieties under aerobic culture

Treatment	Effective RF (mm)		Irrigation (mm)		Total water Use (mm)		Grain yield (kg ha^{-1})		Water productivity (kg m^{-3})	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Dates of sowing										
D1- 18 Jun	318	236	213	450	530	686	5422	4944	1.04	0.73
D2- 07 Jul	286	238	263	450	548	688	5254	4893	0.98	0.72
D3- 20 Jul	274	209	338	525	612	734	5005	4754	0.82	0.66
D4- 04 Aug	220	209	425	550	645	759	4769	4377	0.74	0.58
D5- 18 Aug	168	170	488	550	655	720	4573	4257	0.70	0.59
S.Em±							65	48		
CD (p=0.05)							211	156		
Varieties										
V1- JGL 17004	241	192	240	400	481	592	3946	3752	0.84	0.64
V2- MTU 1010	251	204	290	450	541	654	5066	4632	0.96	0.72
V3- JGL 11470	258	223	400	550	658	773	5459	5063	0.84	0.66
V4- MTU 1061	262	229	450	620	712	849	5546	5132	0.78	0.61
S.Em±							63	66		
CD (p=0.05)							183	190		
Interaction							NS	NS		

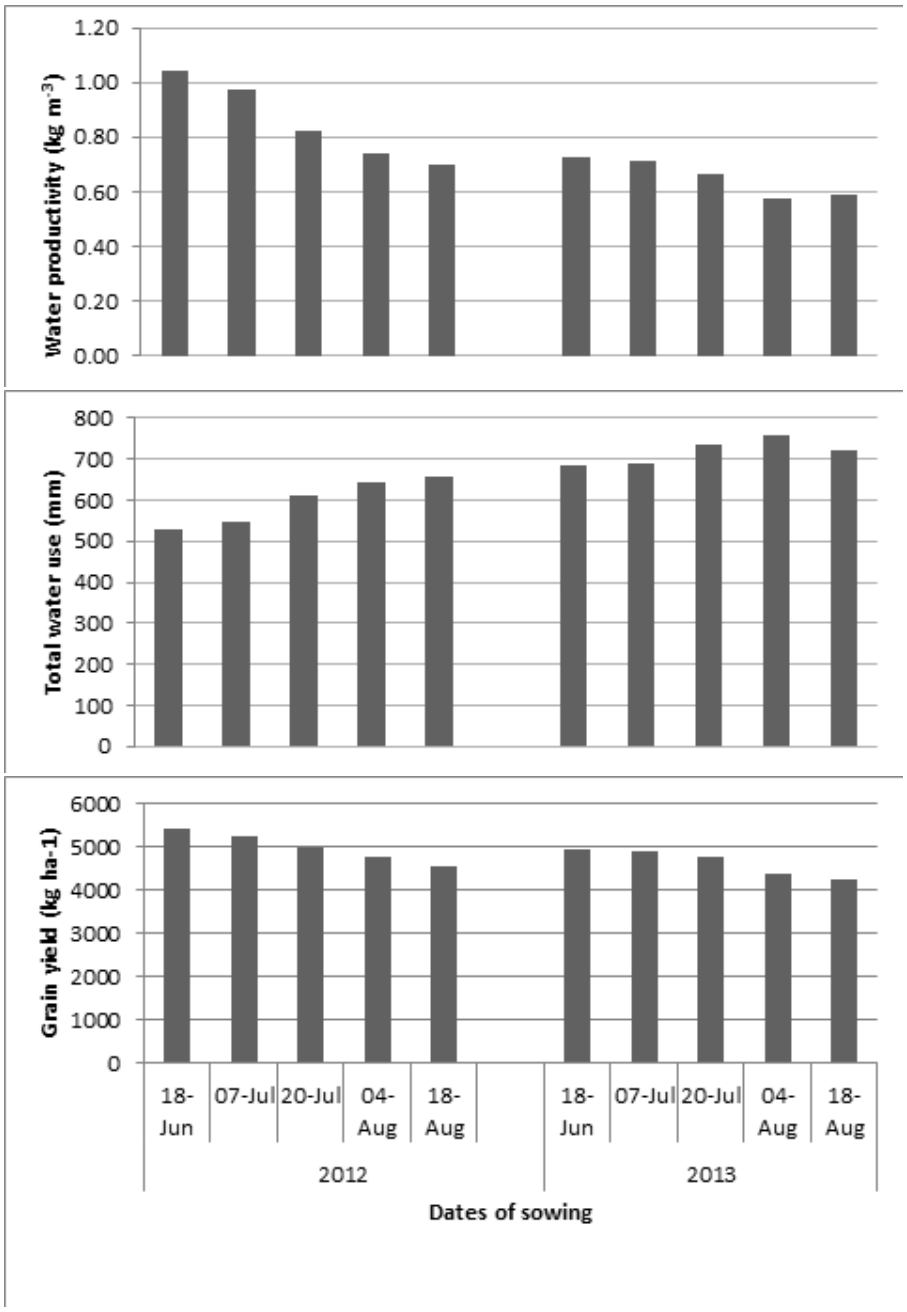

Fig. 1. Grain yield, total water use and water productivity of aerobic rice as influenced by dates of sowing

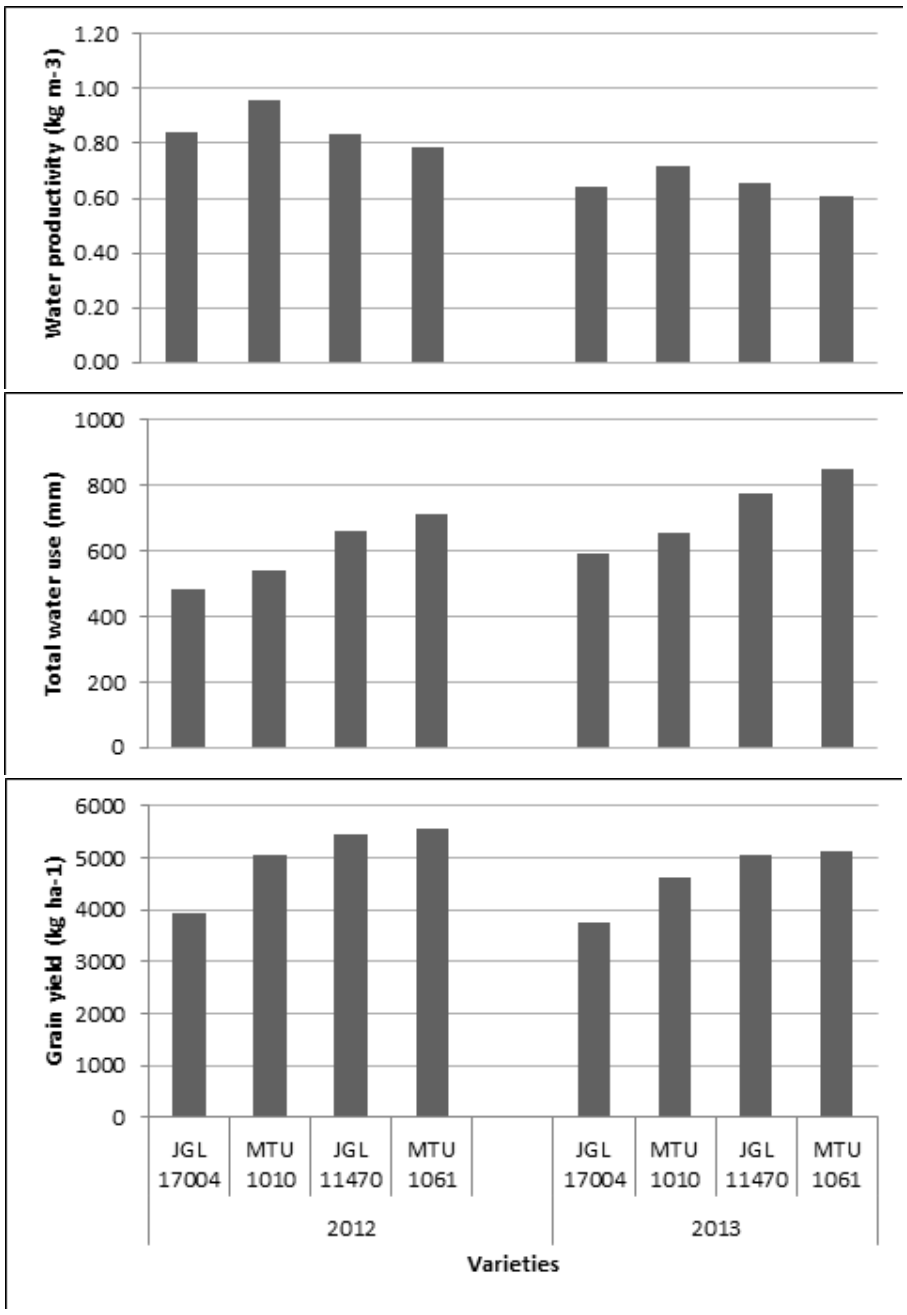

Fig. 2. Grain yield, total water use and water productivity of rice varieties under aerobic culture