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Evaluation of water saving rice production systems

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Abstract
An experiment was conducted during *kharif,* 2010 at the College Farm, Prof.jayashanakar Telangana State Agril.University (Formerly Acharya N.G.Ranga Agril.University), Rajendranagar, Hyderabad to evaluate different rice production technologies in order to assess the rice water productivity and water input under different methods of establishment. The treatments consisted of four methods of rice establishment -aerobic rice on raised beds with drip fertigation, aerobic rice on flat beds with surface irrigation, System of Rice Intensification (SRI) and transplanted low land rice (conventional method) as main plots and three levels of Nitrogen (100, 150 and 200 kg N ha^{-1}) in subplots. The grain yield obtained with transplanted low land and SRI methods of rice cultivation was comparable (non-significant) and significantly higher than that of aerobic rice grown either on raised beds with drip fertigation or on flat beds with surface irrigation. Among N levels - the grain yield obtained with 100 kg N ha^{-1} was comparable with that of 150 kg N ha^{-1} and significantly lower than that of 200 kg N ha^{-1}. The results indicated that the aerobic rice grown either on raised beds or on flat beds has consumed less quantity of irrigation water as compared to SRI and conventional transplanted low land rice. The water productivity was higher in SRI followed by aerobic rice sown on raised beds. The lowest water productivity was observed in conventional transplanted low land rice.

Keywords: aerobic rice, system of rice intensification, transplanted low land rice, water productivity.

Introduction
Scarcity of water for agril.production is becoming a major problem in rice producing countries particularly India and China due to increasing demand from the other sectors. Further, rainfall patterns many countries are changing in the recent years with extremes of drought and untimely floods are more common. With increasing population, expanding residential requirements, increased water demand for industry and household use, and the looming water crisis due to climate change, it is clear that severe water shortages are going to intensify not only in rain fed areas but also in irrigated rice-growing areas. The looming water crisis, however, has threatened the sustainability of traditional lowland rice production, which necessitates a strategic development of water-saving rice production systems such as direct-seeded rice (aerobic cultivation) and rice cultivation under micro-irrigation. Further, the dwindling water resources, rising labor costs and inadequate labor during the peak farming periods, enforce the paradigm shift to alternate crop establishment methods in place of the traditional transplanted rice system. The rice crop is established different ways – dry seeding in dry soil (aerobic), dry seeding in puddle soil (drum seeding), normal transplanting and transplanting single seedling at wider spacing with other management practices (SRI) for reduction in water use. Cultivating high yielding rice as dry field crop promises substantial water saving by eliminating seepage and percolation and greatly reducing evaporation. Experimentally, growing high yielding low land rice varieties under aerobic conditions has shown great potential to save water, but with a severe yield penalty. In majority of studies, it was observed that compared to low land rice cultivation, the water used by aerobic rice was lower by more than 30-70% (Castaneda *et al.*, 2004; Belder *et al.*, 2005; Bouman *et al.*, 2005; Reddy *et al.*, 2010) [5, 1, 3, 14] and the total water productivity was 1.6 to 1.9 times higher than that of flooded rice. The shortage in water has stimulated the development of direct seeding in rice. Besides saving water and increasing/ sustaining grain yields, direct seeding may have other benefits such as the maintenance of soil structure beneficial to non rice crops in a rotation; extension of the irrigated area in a command area, thereby improving soil quality. It has been reported that the water saving is lower in SRI method of cultivation than that of conventional transplanting method where standing water is maintained in the field. Significant yield responses to applied N were observed in almost all types of soils (De Datta *et al*., 1988) [8] and there are reports that irrigated dry / aerobic rice responds to nitrogen application up to

100, 150 (Reddy *et al.*, 1993 and Maheswari *et al.*, 2007) [13, 12], 180 (Ghobrial, 1983) [9] and 200 (Venugopal, 2005) kg N ha^{-1}. In an experiment on sandy loam soil at Warangal, there was significant increase in grain yield with increase in N level from 60 to 90 and 90 to 150 kg N ha^{-1}. Though there are reports of comparison of SRI with conventional transplanted rice production and water use aspects, their comparison with aerobic either on raised beds or flat beds with limited irrigation during *kharif s*eason is lacking. Hence, an experiment was conducted to assess the water saving in different methods of rice crop establishment at various nitrogen fertilizer levels.

Materials and Methods

An experiment was conducted during wet (*kharif*) season of 2010 at College Farm, Prof.jayashanakar Telangana State Agril.University (Formerly Acharya N.G. Ranga Agril.University), Rajendranagar, Hyderabad to evaluate the water saving in rice production technologies and assess the water productivity of rice grown under different methods of establishment. The experiment was conducted in strip plot design with three replications. The treatments consisted of four methods of rice establishment– aerobic rice on raised beds with fertigation, aerobic rice on flat beds with surface irrigation, System of Rice Intensification (SRI) and transplanted low land rice (conventional method) as main plots and three levels of Nitrogen (100, 150 and 200 kg N ha^{-1}) in sub plots. The variety used was MTU 1010. The recommended fertilizers - P_2O_5 and K_2O (60 and 60 kg ha^{-1}, respectively) were applied in the form of super phosphate and murate of potash. Entire dose of P_2O_5 was applied as a basal at the time of sowing/ planting and K_2O was made in two splits one at sowing/ transplanting and second at panicle initiation along with final split of N. The N was applied in the form of urea in three equal splits at sowing/ transplanting, maximum tillering and panicle initiation stages in all the treatments except in aerobic rice with drip fetigation. In this treatment, the entire N was fertigated in 8 equal installments at weekly intervals starting from 15 DAS. The aerobic and transplanted rice plots were separate entities in a contiguous block with 2 m wide buffer zone with three buffer channels between main (aerobic and transplanted) plots. The land for dry seeded and transplanted plots were dry ploughed to fine tilth and later the plots marked for transplanting were puddled under submergence by power tiller. The plots were bunded with 20 cm bottom and 15 cm top width bunds with 30 cm channel in between two bunds of plots to facilitate safe disposal of drain water in the event of heavy rain and to avoid the movement water soluble applied N in between the adjacent plots. For aerobic rice on raised beds, the beds were raised to a height of 15cm with a width of 80 cm separated by 30 cm furrow in each plot constituted of such beds. In *kharif,* 2010, standing water of 3 to 6 cm depth was observed 3 times due to heavy rain events during night as result there was rise in water table to a depth of 2 m below the ground.

The experimental soil was sandy loam with low N, medium P and K. The water holding capacity of the soil was 20%. The aerobic rice and nursery for transplanting both for SRI and normal transplanting was sown on 3rd July in 2010 *kharif* season. The aerobic rice was sown at 20 cm apart as solid rows on flat beds as well as on raised beds. Drip system with 80cm lateral spacing with 2 LPH discharge was laid out on each bed. Whereas, single seedlings of 12 days old and 30 days old seedlings were Transplanted in SRI and conventional transplanted plots, respectively. The spacing adopted under SRI and normal transplanting were 25cm x 25cm and 20 cm x 15 cm from hill to hill. Herbicides, pendimethalin (3.0 l ha^{-1}) and Butachlor (3.0 l ha^{-1}) were applied as pre-emergence at 3 days after sowing and 5 days after transplanting in aerobic and transplanted rice, respectively followed by one manual weeding between 30-35 days after sowing and transplanting in aerobic and transplanted rice

The total rain fall received during June to October, 2010 was 948 mm in 55 rainy days with nearly 12 % excess rainfall than the normal with more less uniform distribution. The crop was irrigated whenever there was no rain for 10 days during rainy season and at 4-5 day interval after cessation of rains i.e. during October and November from the ground water source (opens well) where in it coincided with reproductive and maturity stages of the crop. The irrigation water was applied to each plot through HDPE pipe to which water meter was attached for measurement of water. The seepage that was collected from the puddle plots was safely disposed of through the adjacent buffer channel drawn in between puddle transplanted and aerobic plots. The effective rainfall was estimated by using CRIWAR method (Bos *et al.*, 2009) [2]. The entire net plot was harvested and threshed and grain yield was determined at 14% moisture content.

The water productivity (WP) (kg grain m^{-3} of water) was calculated by following equation

$$WP= Y/ WA (IR+ER)$$

Where Y= grain yield (kg ha-1) and WA (total water used), (IR- irrigation, ER- effective rainfall)

The data collected in the present experiment on yield of was analyzed as per the statistical methods given by Gomez and Gomez (1984) [10] and wherever the treatment differences were found significant (F test), the critical difference was calculated at 5% probability.

Results

Yield

During *kharif,* 2010 experimentation, among different methods of rice cultivation, aerobic rice on flat beds given significantly lower grain yield as compared to SRI or traditional transplanted method. However, it was on par with that of aerobic rice on raised beds with fertigation (Table 1). The grain yield obtained with transplanted low land and SRI methods of rice cultivation was comparable (non-significant). Among levels, the grain yield obtained with 100 kg N ha^{-1} was comparable with that of 150 kg N ha^{-1} and significantly lower than that of 200 kg N ha^{-1}. The grain yield obtained at 150 and 200 kg N ha^{-1} was comparable with each other. The interaction of rice establishment methods and N levels were not shown any significant effect on rice grain yield in the present study.

Water productivity

The quantity of water applied was only 150 mm in aerobic rice either on flat beds or on raised beds while the irrigation water consumed by SRI was 420 mm and that of transplanted rice was 650 mm. Further, the effective rainfall was higher in aerobic rice than that of transplanted rice. Same pattern was observed in total water consumed (Table 2). The water productivity was higher in SRI followed by aerobic rice on raised bed with fertigation, dry seeded rice on flat beds and lowest was observed in transplanted rice. Similar results of higher water productivity in SRI were reported by (Thiyagarajan *et al.*, 2002) [6].

Table 1: Grain Yield (t ha^{-1}) of Rice as influenced by method of cultivation and nitrogen levels during *kharif, 2010*

Methods of cultivation	Levels of nitrogen, t ha^{-1}			Mean
	100	150	200	
Aerobic rice on raised beds with fertigation	3.0	3.38	3.67	3.35
Aerobic rice on flat beds	2.41	2.86	3.0	2.76
SRI cultivation	5.56	6.0	6.4	5.98
Transplanted low land rice	4.5	4.9	5.73	5.04
Mean	3.87	4.28	4.7	
	S.Em.+/-	CD at 5%		
Methods of crop establishment	0.54	1.87		
Levels of N	0.27	0.82		
Methods of crop establishment x Levels of N	NS	NS		

Table 2: Water productivity of rice as influenced by the methods of cultivation during *kharif*, 2010.

Methods of cultivation	Irrigation water applied, mm	Effective rainfall, mm	Total water, mm	Total water, m^3	Water productivity, kg grain/ m^3
Aerobic rice on raised beds with fertigation	150	330	480	4800	0.70
Aerobic rice on flat beds	150	330	480	4800	0.58
SRI cultivation	420	266	686	6860	0.87
Transplanted low land rice	650	266	916	9160	0.55

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