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Water Production Parameters and Yield of Rice - Affected by Methods of Transplanting and Irrigation Management Practices

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A B S T R A C T

A Field experiment was carried out at wetland farm, AC & RI, Coimbatore during *rabi* season 2015-2016 to assess the water production parameters and yield of rice under different methods of transplanting and irrigation management practices. The experiment was laid out in strip plot design with replicated thrice. The treatments comprised of four different method of transplanting *viz.*, machine transplanting with 30 cm x 14 cm, 30 cm x 18 cm, SRI transplanting (25 cm x 25 cm) and conventional transplanting (20 cm x 10 cm), respectively in main plots and four method of irrigation management practices in sub plots *viz.*, continuous submergence of 5 cm, cyclic irrigation management, SRI irrigation management and Field water tube irrigation management. It was found that SRI transplanting registered lower consumption of water with less number of irrigation, higher water use efficiency and water productivity. At the same time, field water tube with intermittent irrigation reduced the total consumption with lesser number of irrigation. This method of irrigation also increased the water use efficiency and water productivity of rice. Machine transplanting (30 cm x 14 cm) and SRI method of irrigation practice had a profound influence on the grain and straw yield of rice.

Introduction

Conventional transplanting is the most common practice of rice cultivation in South and South East Asia. Transplanting of rice is very labour intensive and at least 30 man days are required to transplant one hectare. Generally, rice growers face the problem of skilled labour shortage at the time of transplanting which results into delayed transplantation, low plant population and eventually low yield (Aslam *et al.,* 2008). Urbanisation, migration of labour from agriculture to non-agriculture sector and increased labour costs are seriously threating the cultivation of crops in general and rice in particular (Yadav *et al.,* 2014).

It is essential to reduce the factor by adopting the appropriate transplanting techniques for rice production to control the competitive prices in local and international markets. Therefore, there is need of alternative methods to replace manual transplanting to tackle the problem of high cost of production and labour scarcity in puddled rice. The mechanical rice transplanting is an alternate and promising option, as it saves labour, ensures timely transplanting and also contributes to higher grain yield.

Rice is one of the greatest water user among cereal crops, consuming about 80% of the total irrigated fresh water resources in Asia. In Asia, with relatively more suitable growing conditions for rice, production has declined due to increasing water stress (Tao *et al.,* 2004). Therefore, it is important to cut down water supply for rice cultivation but without affecting rice yield. So there is an imperative need to find ways to reduce water use, while maintaining high yields in rice cultivation. Since water for rice production has become increasingly scarce water saving is the main issue in maintaining the sustainability of rice production when water resources are becoming scarce (Arif *et al.*, 2012). There are a number of alternatives to continuous flooding of rice. One approach which can be used is intermittent irrigation or alternate wetting and drying (AWD). Instead of keeping rice fields continuously flooded, the adoption of AWD methods means that irrigation water is applied to fields to restore flooded conditions on an intermittent basis, only after a certain number of days have passed since the disappearance of ponded (standing) water (Zhang *et al.*, 2009).

The practice of safe AWD as a mature water saving technology entails irrigation when water depth falls to a threshold depth of below the soil surface. The recommended water management for ‘‘safe’’ (no yield loss) AWD involves applying irrigation (to depth of around 5 cm) when the perched water table falls to 15 cm below the soil surface (Bouman *et al.*, 2007). Several studies have shown that safe AWD reduces water input significantly without penalty in grain yield (Samoy *et al.,* 2008). Kulkarni (2011) reported that using of field water tube in AWD is safe to limit the water use upto 25% without reduction in rice yield. Compared to famers practice of continuous flooding, safe AWD saves as much as irrigation water (30%) without any reduction in yield and increases farmers' income by 30% (Lampayan, 2013). Hence, the present investigation was taken up to study the effect of different method of transplanting and irrigation management on water production parameters and yield of rice.

Materials and Methods

A Field experiment was conducted during *rabi* season of 2015-2016 at Research Farm, Agricultural College and Research Institute, Coimbatore, Tamil Nadu. The experimental site is geographically located in the Western Agro Climatic Zone of Tamil Nadu at 11 °N latitude, 77 °E longitude with an altitude of 426.7 m above mean sea level. The soil of the experimental site was clay loam in texture having alkaline pH (8.10) and medium organic carbon (0.62%), With regard nutrient status, the soil was low in available nitrogen (215.7 kg ha^{-1}), medium in phosphorus (15.8 kg ha^{-1}) and high in potassium (420.8 kg ha^{-1}), respectively. Rice variety CO (R) 50 with the duration of 135 days was used as test variety.

Experiment was laid out in strip plot design with replicated thrice. The treatments comprised of four different method of transplanting *viz*., machine transplanting with 30 cm x 14 cm (M_1), machine transplanting with 30 cm x 18 cm (M_2), SRI transplanting with 25 cm x 25 cm (M_3) and conventional transplanting with 20 cm x 10 cm (M_4), respectively in main plots and four method of irrigation management practices in sub plots *viz.*, Farmer practice of continuous submergence of 5 cm throughout the crop period (I_1), Cyclic irrigation management of irrigating the field with 5 cm depth of irrigation one day after disappearance of previously ponded (I_2), SRI irrigation management of irrigation given @ 2.5 cm depth after the formation of hair line cracks in the field upto panicle initiation stage and thereafter the irrigation was given immediately after the disappearance of previously ponded water up to 10 days before harvest (I_3) and field water tube irrigation management of maintenance of 5 cm water level at panicle initiation stage and remaining period irrigation to 5 cm depth after 15 cm depletion of ponded water from ground level (I_4). In order to evaluate the effect of different method of transplanting and irrigation management practices on water use efficiency (WUE), water productivity and yield, the data were statistically analyzed using "Analysis of variance test".

The critical difference at 5% level of significance was calculated to find out the significance of different treatments over each other (Gomez and Gomez, 1984). The total consumptive use of water, water use efficiency and water productivity were calculated as per the standard procedure.

Total water consumed

The total water consumed was computed by summing the irrigation water applied and the effective rainfall. Effective rainfall calculated as fifty percentage of total rainfall during the cropping period.

$$W = ND + Re$$

Where,

W = Total water consumed in mm
N = Number of irrigations
D = Applied water depth for each irrigation (mm)
Re = Effective rainfall (mm), during the cropping period

Water use efficiency

Water use efficiency (WUE) was computed using the equation of Viets (1962) and expressed as kg ha^{-1} mm^{-1}.

$$\text{WUE} = \frac{\text{Grain yield (kg ha}^{-1}\text{)}}{\text{Total water consumed in (mm)}}$$

Water productivity

Water productivity is a function of total water used and grain yield produced by the crop and expressed in lit. kg^{-1}.

$$\text{Water Productivity} = \frac{\text{Volume of water used (lit.)}}{\text{Grain yield (kg ha}^{-1}\text{)}}$$

Results and Discussion

Effect on consumptive water use, number of irrigation and water saving percentage

The amount of water required meeting the demands of evapotranspiration and metabolic activities of rice together constitute the consumptive water use, which includes the effective rainfall during the growing season (Fig. 1). Among various method of transplanting, SRI transplanting registered lower consumptive use of water (907 mm), less number of irrigation (15) and higher percentage of water saving (34.2 %). Whereas, higher consumptive use of water (1095 mm), number of irrigation (19) and lower percentage of water saving (27.3 %) was observed with conventional transplanting. As such, the farmers' practice of irrigation consumed more water of 1194 mm with higher number of 23 irrigation. On the contrary, lesser consumptive use of water (804 mm) was observed under field water tube irrigation at 15 cm drop of water table was due to lesser number of irrigations (12) and recorded higher water saving percentage of 41.7%. Similar observations were also reported by Ngo Thanh Son *et al.*, (2008).

Effect on water use efficiency (WUE) and water productivity (WP)

The higher water use efficiency (WUE) and water productivity (WP) can be increased either by increasing yield or by maintaining the yield level with reduced quantity of water input. Among various method of transplanting, SRI transplanting registered higher WUE of 6.7 kg ha^{-1} mm^{-1} and WP of 1533 lit. kg^{-1} (Table 1). Whereas, lower WUE and WP found with conventional method of transplanting.

On the other hand, reduction in consumptive water use under field water tube irrigation at 15 cm drop of water table coupled with the maintenance of yield at an optimum level increased the WUE and WP. The higher WUE of 6.9 kg ha^{-1} mm^{-1} and WP of 1467 lit. kg^{-1} was observed under field water tube irrigation treatment and was on par with SRI method of irrigation (6.6 kg ha^{-1} mm^{-1} and 1559 lit. kg^{-1}, respectively). The increased water use efficiency obtained under these treatments could be attributed due to optimum need based irrigation using monitoring device *i.e.* field water tube coupled with increased grain yield levels. The higher consumptive use with more frequent irrigations without corresponding increase in grain yields could have led to decreased WUE under farmers' practice of irrigation practice. This is in agreement with the findings of Bouman *et al.*, (2007).

Effect on grain and straw yield

Method of transplanting and irrigation management practices had a profound influence on the grain and straw yield of rice and is shown in table 2. Machine transplanted rice (30 cm x 14 cm) recorded higher grain yield (6065 kg ha^{-1}) and straw yield (7237 kg ha^{-1}) and was on par with SRI method of transplanted rice (5952 and 7006 kg ha^{-1}, respectively). Higher yield realized with mechanized transplanting might be due to the use of younger seedlings, which preserves a potential for higher tillering and rooting. Better vegetative growth and assimilate translocation leads to increased number of panicles per square meter and fertile grains per panicle resulting in higher grain and straw yield. Machine transplanting recorded higher grain yield and was at par with SRI square transplanting was also reported by Kumar (2014) and Sangeetha *et al.*, (2015).

Fig.1 Effect of different transplanting methods and water management practices on consumptive water use (mm), number of irrigation and water saving percentage of rice

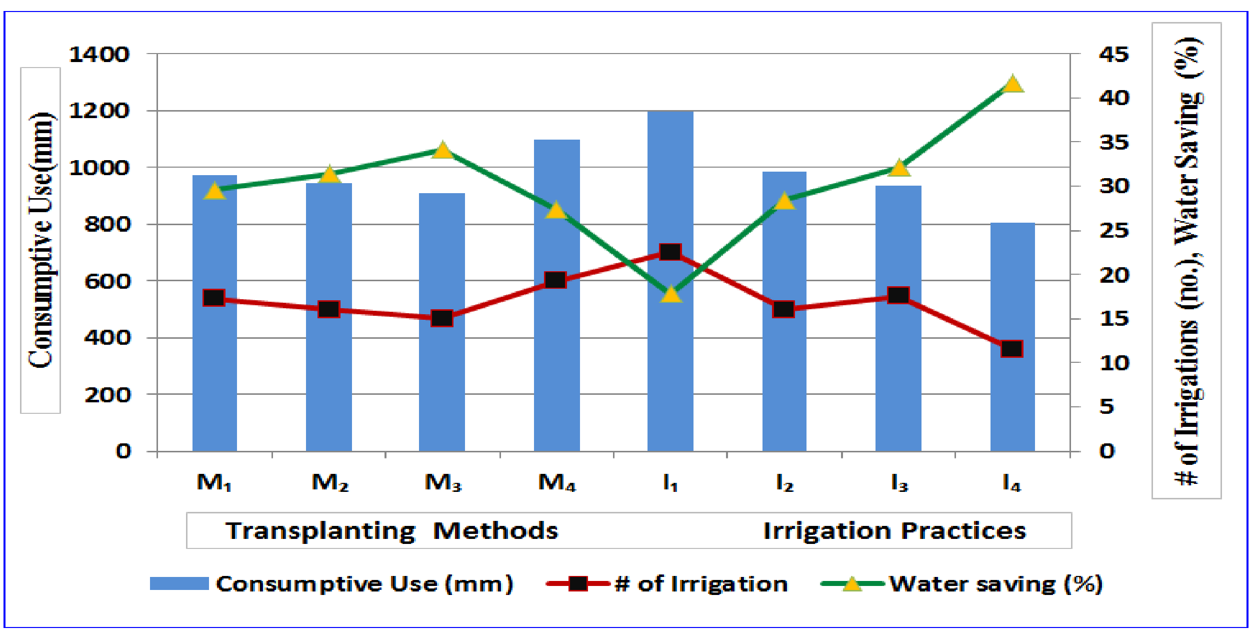

Table.1 Effect of different transplanting and water management practices on water use efficiency (kg ha^{-1} mm^{-1}) and water productivity (lit. kg^{-1})

Treatment	Water Use Efficiency (kg ha^{-1} mm^{-1})						Water Productivity (lit. kg^{-1})				
	M_1	**M_2**	**M_3**	**M_4**	**Mean**		**M_1**	**M_2**	**M_3**	**M_4**	**Mean**
I_1	4.8	4.6	5.2	3.8	**4.6**	**I_1**	2090	2174	1913	2627	**2201**
I_2	6.4	6.0	6.4	5.1	**6.0**	**I_2**	1571	1661	1552	1974	**1690**
I_3	7.1	6.8	7.4	5.0	**6.6**	**I_3**	1413	1467	1351	2004	**1559**
I_4	7.3	6.9	7.6	5.7	**6.9**	**I_4**	1366	1445	1316	1742	**1467**
Mean	**6.4**	**6.1**	**6.7**	**4.9**			**1610**	**1687**	**1533**	**2087**	
	M	**I**	**M at I**	**I at M**			**M**	**I**	**M at I**	**I at M**	
SEd	0.2	0.2	0.3	0.3			44	49	80	83	
CD (p=0.05)	0.4	0.5	NS	NS			108	120	NS	NS	

Table.2 Effect of different transplanting and water management practices on grain yield (kg ha^{-1}) and straw yield (kg ha^{-1}) of rice

Treatment	Grain Yield (kg ha^{-1})						Straw Yield (kg ha^{-1})				
	M_1	**M_2**	**M_3**	**M_4**	**Mean**		**M_1**	**M_2**	**M_3**	**M_4**	**Mean**
I_1	5675	5276	5562	5246	**5440**	**I_1**	6734	6116	6493	6147	**6373**
I_2	6142	5685	5978	5613	**5855**	**I_2**	7361	6495	6999	6423	**6819**
I_3	6566	6150	6476	5170	**6091**	**I_3**	7800	7371	7769	6041	**7245**
I_4	5878	5467	5790	4937	**5518**	**I_4**	7051	6280	6765	5917	**6503**
Mean	**6065**	**5645**	**5952**	**5242**			**7237**	**6566**	**7006**	**6132**	
	M	**I**	**M at I**	**I at M**			**M**	**I**	**M at I**	**I at M**	
SEd	94	120	188	202			110	141	221	238	
CD (p=0.05)	230	293	410	449			269	345	483	529	

Irrigation management practices greatly influenced the rice grain yield. Among the Irrigation management practices, SRI method of irrigation recorded higher grain and straw yield of 6091 and 7245 kg ha^{-1}, respectively. This was on par with cyclic irrigation management. The increased yields under SRI method of irrigation might be due to favourable growing and nutrition supply environment and with increased uptake of nutrients under SRI method of irrigation which lead the plants with superior growth and the favourable growth traits enhanced the yield attributing characters with higher source to sink conversion, which in turn resulted in higher grain and straw yield. This is in line with findings of Thiyagarajan *et al.*, (2002) and Geethalakshmi *et al.*, (2009). On the other hand, need based water management practice of field water tube irrigation at 15 cm drop of water table also created same condition as that of SRI method of irrigation with reduced irrigation which recorded increased level of yield. This was supported by Bouman *et al.*, (2007) and Oliver *et al.*, (2008).

Interaction found to exist between method of transplanting and irrigation management practices with respect to rice grain yields. At all method of transplanting, the SRI method of irrigation registered higher grain and straw yields except in conventional transplanting. At all the irrigation management practices, machine transplanting with 30 cm x 14 cm registered higher grain yield in rice. In combination also, these two treatments produced higher grain yields indicated that the physico-chemical environment prevailed under these treatment combinations produced favourable growth and yield attributes, which in turn reflected on grain and straw yields.

In this experiment it was found that SRI transplanting registered lower consumptive use of water with less number of irrigation. This treatment also recorded higher percentage of water saving, water use efficiency and water productivity. Use of younger seedlings and wider spacing proved to be better than other combinations with different method of water management. Even under normal cultivation, adoption of wider spacing gave more satisfactory yield than closer spacing. At the same time, field water tube with intermittent irrigation was observed to be a suitable method for reducing total consumptive use of water with lesser number of irrigation. This method of irrigation also increased the water use efficiency and water productivity of rice. Machine transplanting (30 cm x 14 cm) and SRI method of irrigation practice had a profound influence on the grain and straw yield of rice.

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