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RESEARCH ARTICLE :

Different methods of transplanting and irrigation management practices on water use studies on summer rice

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SUMMARY : Field experiment was conducted at wetland farm, Agriculture College and Research Institute, Coimbatore during summer season 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.

KEY WORDS :
Field water tube, Machine transplanting, SRI irrigation, Water productivity, Water use efficiency

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BACKGROUND AND OBJECTIVES

Transplanting has been the most important and common method of crop establishment under favourable rainfed and irrigated lowland rice in Tropical Asia. Manual transplanting is the most common practice of rice cultivation in South and South East Asia. Generally, rice growers face the problem of skilled labour shortage at the time of transplanting which results into delay transplantation, low plant population and eventually low rice yield (Aslam *et al*., 2008). Manual transplanting takes about 300 to 350 man hr ha^{-1} which is roughly 25 per cent of the total labour requirement of the crop (Goel *et al*., 2008). Urbanisation, migration of labour from agriculture to non-agriculture sector and increased labour costs are seriously threatening the cultivation of crops in general and rice in particular (Yadav *et al.*, 2014). Non availability of labourers for transplanting at appropriate time leads to delay in transplanting. Delay in transplanting from normal date causes considerable reduction in yield (Islam *et al*., 2008 and Safdar *et al.*, 2008). It is essential to reduce the labour shortage by adopting the appropriate transplanting techniques for rice production to control the competitive prices in local and international markets. For this purpose research and development activities are initiated on new rice establishment technologies in various parts of the world. These technologies are to be adopted in countries like India because of the water shortage in most parts of the country. Alternative methods of rice transplanting seem to be the only viable solution of this problem.

Good crop stand establishment is one of the key components for efficient use of resources, inputs and consequently for achieving desired level of productivity. Proper row arrangement and appropriate inter and intra row spacing are important for improving the crop growth, sink capacity and ultimately the yield of rice (Sridevi, 2011). Optimizing plant density and timeliness of operation is considered essential for maximizing yield in rice. In order to get the maximum returns, cost of cultivation has to be reduced through minimizing the dependence on labour for transplanting. Under such conditions mechanized transplanting of rice can be considered as the most promising option, as it saves labour, ensures timely transplanting and attains optimum plant density that attributes to high productivity.

Fresh water is becoming increasingly scarce, the demand of water towards domestic, municipal, industrial and environmental purpose will rise in future, and less water will be available for agriculture. India is no exception to this general trend. Water availability for agriculture which is 78.2% of total water used today, will shrink to 71.6% in 2025 and 64.6% in 2050 (IWMI, 2008). The challenge is to develop novel technologies that will allow rice production to be maintained or increased in the face of declining water availability.

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 (Arif *et al*., 2012).

Traditional transplanted rice with continuous standing of water needs relatively high water inputs. Increasing irrigation efficiencies seems to be the practical way to save water. By applying appropriate irrigation management during growing season of rice, a large volume of water can be saved which may help to bring more area under irrigation particularly where there are limited water resources (Bouman *et al*., 2005). Such a way for increasing water use efficiency in rice, irrigation to particular depth after disappearance of previously ponded water in which rice fields are not kept continuously submerged, but are allowed to dry intermittently during rice growing stages and irrigation given after the formation of hair line cracks in the field. 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 with the use of field water tube. 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. 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.

RESOURCES AND METHODS

Field experiment was carried out during summer season of 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 clayey loam in texture having alkaline pH (8.16) and medium organic carbon (0.68%), With regard nutrient status, the soil was low in available nitrogen (210.6 kg ha^{-1}), medium in phosphorus (16.4 kg ha^{-1}) and high in potassium (428.5 kg ha^{-1}), respectively. Rice variety CO (R) 51 with the duration of 110 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}.

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

Water productivity :

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

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

OBSERVATIONS AND ANALYSIS

The results obtained from the present study as well as discussions have been summarized under following heads :

Water use studies :

Studies on total consumptive water use, number of irrigation, water saving percentage, water use efficiency and its productivity will help to rationalize the water application and its use (Table 1 and 2).

Total water consumed :

The amount of water required to meet the demands of evapotranspiration and metabolic activities of rice together constitute the consumptive water use, which includes the effective rainfall during the growing season. Among different methods of transplanting, SRI transplanting (M_3) consumed lesser water (860 mm) as compared to other methods of transplanting. Whereas, conventional method of transplanting utilised more water than other methods. Similarly, the higher amount of water used (1,143 mm) by conventional transplanting was reported by Thakur *et al.* (2014).

As such, the farmers' practice of irrigation (I_1) *i.e., continuous submergence of 5 cm* throughout the crop period consumed more water (1121 mm). Increased total water consumption by crop with continuous submergence was also reported by Banerjee *et al.* (2008) and Oliver *et al.* (2008). This was followed by cyclic method of irrigation (I_2), which registered the next higher consumptive water use. Practicing field water tube of irrigation (I_4) recorded lesser water consumption of 762 mm. This might be due to lesser number of irrigations and increased dry cycles with reduced evapotranspiration. There is a strong relationship between standing water depth in the field and the seepage, percolation rates. The experimental results showed that field water tube technology played good role to reduce the water loss. This result of lower total water use by field water tube irrigation method was corroborated with the findings of Latif (2010) and Faruki *et al.* (2011).

Total number of irrigation :

In case of total numbers of irrigation, more number of irrigation (22) was needed by conventional transplanting method (M_4). While, lesser number of irrigation required with SRI method of transplanting (M_3). Among the irrigation management practices, the farmers' irrigation practice (I_1) required more number of irrigation of 24. Where, field water tube of irrigation (I_4) needed lesser numbers of irrigation (16). Banerjee *et al.* (2008) observed that crop under continuous submergence required 37 number of irrigation for rice production.

Water saving percentage :

Water saving percentage was calculated from the base of volume of water used in conventional transplanting with farmers' practice of irrigation (M_4I_1-). Among different methods of transplanting, SRI transplanting (M_3) recorded higher water saving percentage of 32.0%. In case of irrigation practices, field water tube of irrigation (I_4) registered higher water saving percentage than other treatments (39.8). With respect to treatment combinations, invariably in all the growing seasons, SRI transplanting with field water tube method of irrigation (M_3I_4) recorded highest water saving percentage. Field water tube technology showed significant performance to measure the water availability in below ground level as well as water requirement by the plant. It exhibited right timing of irrigation to produce rice crop in water-wise way. This results in conformity with the finding of Chapagain and Yamaji (2010). Feng *et al.* (2007) reported that 36.6% water saving of field water tube irrigation practice over continuous flooding and 30% was reported by Lampayan (2013).

Table 1 : Effect of different transplanting and water management practices on consumptive use (mm) and number of irrigation and water saving percentage of summer rice 2016

Treatment	Consumptive Use (mm)						Number of irrigation						Water Saving (%)				
	M_1	M_2	M_3	M_4	Mean		M_1	M_2	M_3	M_4	Mean		M_1	M_2	M_3	M_4	Mean
I_1	1124	1087	1008	1265	1121	I_1	24	23	21	28	24	I_1	11.1	14.1	20.3	-	15.2
I_2	915	895	879	1050	935	I_2	17	17	16	20	17	I_2	27.7	29.3	30.5	17.0	26.1
I_3	879	855	829	982	886	I_3	23	22	22	26	23	I_3	30.5	32.4	34.4	22.4	29.9
I_4	761	749	722	815	762	I_4	13	13	12	14	13	I_4	39.8	40.8	42.9	35.6	39.8
Mean	920	896	860	1028			19	19	18	22			27.3	29.1	32.0	25.0	

Data not statistically analyzed

Main Plot: Rice transplanting methods

M_1 : Machine transplanting (30 cm x 14 cm)
M_2 : Machine transplanting (30 cm x 18 cm)
M_3 : SRI transplanting (25 cm x 25 cm)
M_4 : Conventional transplanting (20 cm x 10 cm)

Sub plot: Water management practices

I_1 : Farmer practice
I_2 : Cyclic water management
I_3 : SRI water management
I_4 : Field water tube water management

Table 2 : Effect of different transplanting and water management practices on water use efficiency (kg $ha^{-1}mm^{-1}$) and water productivity (lit. kg^{-1}) of summer rice 2016

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	5.48	5.29	6.02	4.37	5.29	I_1	1824	1890	1660	2287	1915
I_2	7.03	6.67	7.12	5.62	6.61	I_2	1423	1499	1404	1780	1527
I_3	7.79	7.53	8.15	5.56	7.26	I_3	1284	1328	1226	1800	1410
I_4	7.83	7.43	8.10	6.41	7.44	I_4	1277	1346	1235	1561	1355
Mean	7.03	6.73	7.35	5.49			1452	1516	1381	1857	
	M	I	M at I	I at M			M	I	M at I	I at M	
S.E.±	0.17	0.22	0.29	0.32			39	44	71	74	
C.D. (P=0.05)	0.42	0.53	NS	NS			96	109	NS	NS	

NS=Non-significant

Main Plot: Rice transplanting methods

M_1 : Machine transplanting (30 cm x 14 cm)
M_2 : Machine transplanting (30 cm x 18 cm)
M_3 : SRI transplanting (25 cm x 25 cm)
M_4 : Conventional transplanting (20 cm x 10 cm)

Sub plot: Water management practices

I_1 : Farmer practice
I_2 : Cyclic water management
I_3 : SRI water management
I_4 : Field water tube water management

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. Water use efficiency determination in irrigation commands will indicate the unit quantity of grain yield obtained per unit quantity of water used. The different methods of transplanting substantially influenced the WUE of the rice. Among various methods of transplanting, higher WUE was registered with SRI method of transplanting (M_3) (7.35 kg ha^{-1} mm^{-1}). While, conventional transplanting (M_4) registered lower WUE. Irrigation management practices also had significant influence on WUE. The WUE was significantly higher in field water tube of irrigation (I_4), which was registered 7.44 kg ha^{-1} mm^{-1}. However, this treatment was on par with SRI method of irrigation practice (I_3). The poor WUE was accounted with farmers' practice of irrigation (I_1). Different methods of transplanting and irrigation management practices did not show any interaction effect.

Water productivity will indicate the unit quantity of water used to produce per unit of grain yield. SRI method of transplanting (M_3) required lesser quantity of water to produce per unit of grain yield (1381 lit. kg^{-1}) than other methods of transplanting. Whereas, conventional method (M_4) of transplanting needed larger quantity of water to produce per unit of grain yield. With regard to water management practices, field water tube of irrigation (I_4) recorded higher water productivity with lesser water consumed to produce per unit of grain yield (1355 lit. kg^{-1}). However, the lower WP was documented with farmers' practice of irrigation (I_1).

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 (I_1). Field water tube irrigation practice at 10 cm depletion of water from ground level was found to be superior than other irrigation practices with highest water use efficiency of 6.14 kg ha^{-1} mm^{-1} (Santheepan and Ramanathan, 2016). This is also in agreement with the findings of Bouman *et al.* (2007) and Kannan (2012).

Conclusion :

In the present study 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 seedlingsand 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.

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