Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.4058

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **6 (1):** 611-617 (2018)

Research Article

International Journal of Pure & Applied Bioscience

OPEN ACCESS

Energy Production, Utilization and Yield of Rice under Different Methods of Transplanting and Irrigation Management Practices

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Received: 15.06.2017 | Revised: 22.07.2017 | Accepted: 28.07.2017

ABSTRACT

Field investigation was conducted at research farm, AC & RI, Coimbatore during rabi season 2015-2016 to assess the energy production and utilization of rice under different methods of transplanting and irrigation management practices. The experiment was laid out in strip plot design with three replications. The treatments comprised of four different method of transplanting viz., machine transplanting with 30 x 14 cm (M_1), 30 x 18 cm (M_2), SRI transplanting (25 x 25 cm) (M_3) and conventional transplanting (20 cm x 10 cm) (M_4), respectively in main plots and four method of irrigation management practices in sub plots viz., continuous submergence of 5 cm (I_1), cyclic irrigation management (I_2), SRI irrigation management (I_3) and field water tube irrigation management *(I_4). The results of this study showed that the machine transplanting with 30 cm x 14 cm spacing coupled with SRI irrigation practice (M_1I_3) registered higher output energy and energy efficiency with higher yield of rice.*

Key words: *Energy efficiency, Field water tube irrigation, Input energy, Machine transplanting, Output energy, SRI irrigation, SRI transplanting, Yield*

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food of more than a half of the World population. In Asia alone, more than 2 billion people obtained 60 to 70 per cent of their food energy from rice and its derived products[13]. Rice is grown mainly as a wetland crop by transplanting seedlings into puddled fields. 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. The typical system of low land rice cultivation in puddled soils discourages the labour to attend the field operations. 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[2]. Often, the peak labour demand coincides with release of water from canals leading to labour shortage in canal command area[21]. 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[24].

Cite this article: Sureshkumar, R. and Pandian, B.J., Energy Production, Utilization and Yield of Rice under Different Methods of Transplanting and Irrigation Management Practices, *Int. J. Pure App. Biosci.* **6(1):** 611-617 (2018). doi: http://dx.doi.org/10.18782/2320-7051.4058

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[22]. 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[1].

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[4]. 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[18]. Kulkarni[12] reported that using of field water tube in AWD is safe to limit the water use upto 25% without reduction in rice yield.

Rice cultivation requires many energy consuming operations such as tillage, transplanting, irrigation, application of fertilizers, agro-chemicals for plant protection, harvesting, transportation etc. In order to sustain agricultural production, effective energy use is required, since it provides ultimate financial saving, preservation of fossil resources and reduction of environment distortion[6]. In the present era of energy crisis, for formulating any policy on energy use and conservation, it is imperative to examine the pattern of energy consumption for agricultural production especially for rice. In comparison with traditional practice, eight row rice transplanter could reduce drudgery by 17.55% in terms of energy expenditure per hectare[16]. The comparison of the crop establishment methods in the scale of energetics revealed that conventional transplanting used the maximum energy (11.96 and 12.04 MJ×10^3 in 2009 and 2010, respectively) and the least energy was expended by SRI method of cultivation (11.28 and 11.36 MJ×10^3 in respective years) for production of rice and the energy productivity and the energy ratio were higher with SRI during both the years[15]. Hence, the present investigation was taken up to study the effect of different methods of transplanting and irrigation management on input and output energy, energy efficiency and yield of rice.

MATERIALS AND METHODS

A Field investigation 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.

Field experiments were laid out in strip plot design with three replications. The treatments comprised of four different methods 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 methods of irrigation management practices in sub plots *viz*., farmers' irrigation practice (continuous submergence of 5 cm throughout the crop period) (I_1), Cyclic water management (irrigating the field with 5 cm depth of irrigation one day after disappearance of previously ponded water) (I_2), SRI water management (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) (I_3) and field water tube irrigation management (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).

The required data from the experiment was collected and computed using the method suggested by Devasenapathy *et al*[7]., and Kalbande and More[11]. Cultural energy utilized through inputs and energy produced as products are calculated and expressed in Mega Joules (MJ ha^{-1}).

Energy efficiency was worked out taking in account the input and output energy for each treatment[5].

$$\text{Energy efficiency} = \frac{\text{Energy Output (MJ ha}^{-1}\text{)}}{\text{Energy Input (MJ ha}^{-1}\text{)}}$$

RESULTS AND DISCUSSION

Input Energy

Conventional method of transplanting consumes more energy (15618 MJ ha^{-1}) for rice production as compared to other methods of transplanting (Table 1). Among different water management practices, farmers' method of irrigation registered higher input energy of 15279 MJ ha^{-1}. Whereas, lower energy input was noted with field water tube method of irrigation practice. SRI method of transplanting registered lower input energy due to seed rate and weeding. On the other hand, field water tube method of irrigation recorded lower input energy due to less number of irrigation coupled with reduced total water use. The comparison of the crop establishment methods in the scale of energetics was revealed by Mohanty *et al*[15]., that conventional method of transplanting used the maximum energy (12.04 MJ×10^3) as compared to SRI method (11.36 MJ×10^3).

Output Energy

In terms of energy output, machine transplanting with 30 cm x 14 cm (M_1) spacing recorded higher energy output of 179616 MJ ha^{-1} (Table 1). Whereas, conventional transplanting recorded lower output energy. With regard to irrigation management practices, SRI method of irrigation recorded higher energy output of 180098 MJ ha^{-1}. The lower output energy registered with farmers' method of irrigation. The reason might be due to higher grain and straw yield which resulted in increased energy output. This was in agreement with the findings of Jayadeva *et al*[10]., and Sangeetha[19].

Energy Efficiency

Similar trend has been observed with energy efficiency as that of energy output. Machine transplanting (30 cm x 14 cm) recorded higher energy efficiency of 12.11 (Fig. 1). Whereas, conventional transplanting (M_4) recorded lower energy efficiency. With regard to irrigation management practices, SRI method of irrigation recorded higher energy efficiency of 12.08. The lower energy efficiency was registered with farmers' method of irrigation. Energy efficiency indicates the ratio between output and input energy. This result corroborates with Govindarajan *et al*[9]., who observed that improved energy use efficiency was due to higher productivity.

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[14] and Sangeetha *et al*[20].

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 inturn resulted in higher grain and straw yield. This is in line with findings of Thiyagarajan *et al*[23]., and Geethalakshmi *et al*[8]. 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*[3]., and Oliver *et al*[17].

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 inturn reflected on grain and straw yields.

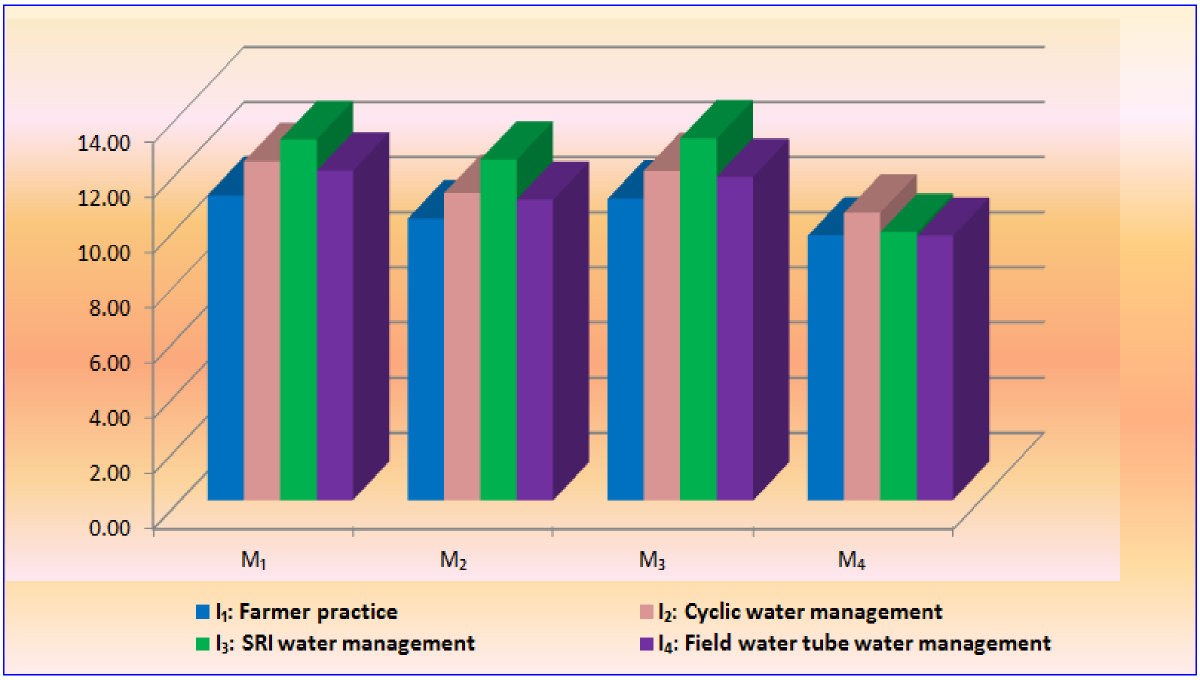

Fig. 1: Effect of different transplanting and water management practices on Energy Efficiency of *rabi* rice

Table 1: Effect of different transplanting and water management practices on Energy input (MJ ha^{-1}), Energy output (MJ ha^{-1}) of *rabi* rice

Treatment	Energy input (MJ ha^{-1})					Energy output (MJ ha^{-1})				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
I_1	15152	15065	14874	16024	**15279**	167597	154013	162925	153950	**159621**
I_2	14817	14780	14672	15607	**14969**	182295	164758	175365	162798	**171304**
I_3	14811	14768	14650	15565	**14948**	194025	182547	192305	151513	**180098**
I_4	14589	14560	14456	15276	**14720**	174547	158864	169676	146543	**162407**
Mean	**14842**	**14793**	**14663**	**15618**		**179616**	**165046**	**175068**	**153701**	

Data not statistically analysed

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**	6734	6116	6493	6147	**6373**
I_2	6142	5685	5978	5613	**5855**	7361	6495	6999	6423	**6819**
I_3	6566	6150	6476	5170	**6091**	7800	7371	7769	6041	**7245**
I_4	5878	5467	5790	4937	**5518**	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	

CONCLUSION

Based on the experimental results, it can be concluded that adoption of machine transplanting with 30 cm x 14 cm spacing coupled with SRI method of irrigation was found to be an ideal agronomic options to save energy besides being economically competitive and productive under soil and climatic conditions of Western zone of Tamil Nadu.

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