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S Anbumani
Agricultural College and Research Institute, Vazhavachanur, Tamil Nadu Agricultural University, Tamil Nadu, India

S Selvakumar
Agricultural Engineering College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

K Thirukumaran
Krishi Vigyan Kendra, Thirupathisaram, Tamil Nadu Agricultural University Tamil Nadu, India

Corresponding Author:
S Anbumani
Agricultural College and Research Institute, Vazhavachanur, Tamil Nadu Agricultural University, Tamil Nadu, India

Mechanized transplanting in system of rice intensification and its evaluation

S Anbumani, S Selvakumar and K Thirukumaran

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Abstract
World Bank funded Irrigated Agriculture Modernization and Water Bodies Restoration and Management project was implemented in river basins to produce more with less input in Tamil Nadu. SRI was introduced in mission mode approach over larger areas with the objective of maximizing the productivity of crop and water. One of the main constraints was labourers' availability and acceptance for square planting of young seedlings. The on farm trial was conducted with 3 treatments *viz.,* Conventional transplanting @ 20 x10 cm spacing, SRI (all components), Machine planted SRI (except planting all SRI components). Results showed that SRI with full components performed superior owing more no. of productive tillers of 22.1 /hill, 148 grains/panicle and 21.4 cm panicle length over machine planted SRI and Conventional transplanted rice (8.3 productive tillers/hill, 105 grains/panicle and 18.8 cm panicle length). Higher net income of Rs. 64,630/ha were obtained in SRI, whilst the benefit cost ratio were higher in Machine planted SRI of Rs.2.68 than SRI of Rs.2.64. SRI resulted higher water productivity of 8.38 kg/ha mm followed by machine planted SRI of 8.2 kg/ ha mm when compared to CTR owes low water productivity of 4.85 kg/ha mm. Machine planting has reduced the labour requirement for the crop establishment which in turn increased the labour productivity of 7.93 kg/man days when compared to CTR of 4.4 kg/man days. Labour saving was very much upfront with the machine. Hence, with lesser water and labour more rice can be produced in unit area by using the modified SRI transplanter.

Keywords: SRI, rice transplanter, root volume, alternate wetting and drying irrigation, water productivity

Introduction

Rice is a traditional food grain crop which is being grown from time immemorial in India which is predominantly grown in Tamil Nadu by accounting nearly 65 % of the irrigated area. Of late, water scarcity due to climate change led variations in rainfall distribution and less profitability, the area under rice cultivation is shrinking every year with increasing productivity (Thiyagarajan, 2005) [10]. Surface water is key source of irrigation wherein irrigation tanks supports the rice farmers in their command area of traditional paddy growing zones in southern India. The paucity of water in the surface storage structures like tanks and reservoirs threatens the sustainability of lowland rice ecosystem. There is greater competition for sharing of the existing water resources from industrial and domestic sector which necessitate for economizing the water usage in agriculture sector. Decline in availability of water for rice farming has become a global concern and need water saving techniques with renewed attention (Bouman and Tuong, 2001) [1]. System of Rice Intensification is a resource efficient production system being adopted very well in Asian countries for the past one decade with promising results on rice productivity (Uphoff, 2013) [11]. Tamil Nadu Agricultural University has taken SRI as one of the water saving technology in IAMWARM project funded by World Bank with the objective of enhancing the productivity of the crop and water tank fed irrigation system.

Among the 5 principles in SRI, Square planting of young seedlings deters the adoption level due appalling paucity of skilled labours for planting as observed during the project implementation and feedback analysis. Urbanization and diversified employment opportunity are key factor for paucity of human energy for manual planting which leads to rice farming as lacklustre in tank fed irrigation system. To address the issue TNAU has taken pro active initiative in collaboration with VST Company under PPP mode to refine the existing the low cost 'Yanchi' model rice transplanter for square planting at 23 cm and lesser number of young seedlings per hill, to full fill our objective to speed up the SRI adoption level. SRI machine planting and SRI, except planting by machine all the principles were same namely, young seedlings, square planting at wider spacing, conoweeding, irrigation up to 2.5 cm water column after disappearance of water and integrated nutrient management.

Material and Methods

IAMWARM project was implemented in 54 sub basin across Tamil Nadu state in tank fed irrigation system to bridge the gap between water requirement and availability through modernization of the tanks to maximize the water storage capacity and adoption of various water saving technologies in hands with TNAU and other line departments. Ongur sub basin was one among the project area with an irrigation potential of 14,263 hectares irrigated through tank fed system (Fig.1). Northeast and southwest monsoons contribute to the total annual rainfall. The normal rainfall of the district has been 1213.3 mm.

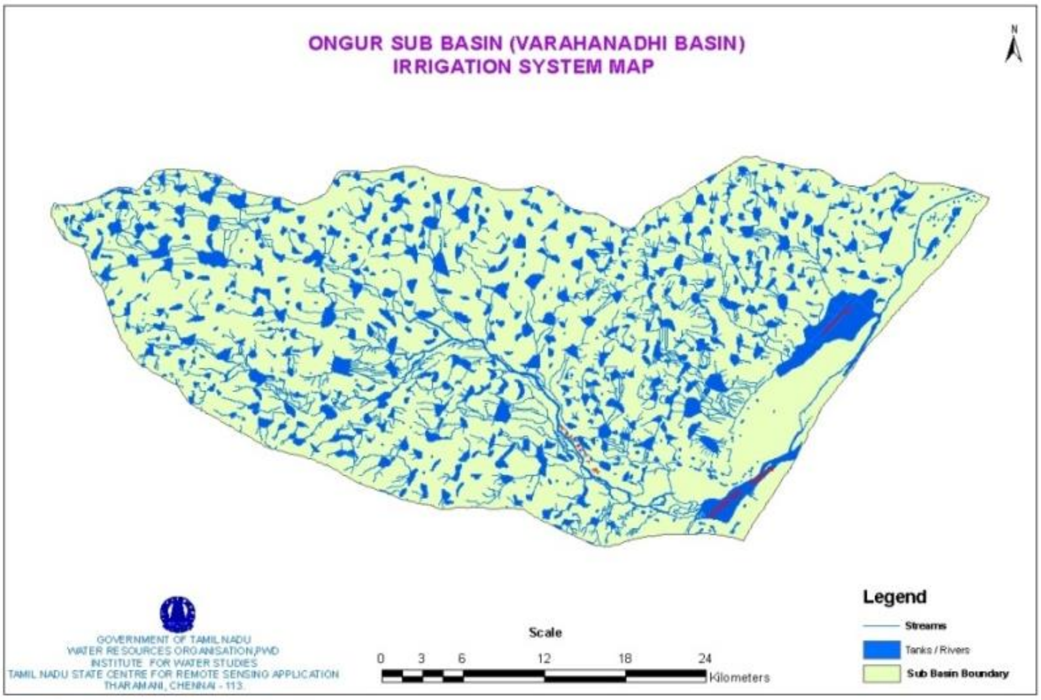

Fig 1: Ongur sub basin irrigation system map

The farmer's participatory research was conducted in 50 farmers holding covering 5 villages, namely Indhalur, Irumbuli, Keelathivakkam, Athur & Veliyampakkam at Kancepuram district belongs to Ongur sub basins. Each village 10 OFT's were conducted (50 OFT's) during Samba (Sept, 12 to Jan. 13 with farmers participation. The soil type in the study area were clay loam with medium in available soil nitrogen, low to medium in available phosphorus and high in available potassium. Tank is source of irrigation in the command area where in water sharing decisions taken collectively among the farmers is in vogue. The experimental sites are,

Village	Latitude	Longitude
Irumbuli	12.6438° N	80.0701° E
Indalur	12.3648° N	79.8381° E
Keelathivakkam	12.4935° N	79.9123° E
Athur	12.7344° N	79.9473° E
Villiambakkam	12.7643° N	79.9597° E

The on farm trial (OFT's) were conducted with 3 treatments *viz.*, Conventional transplanted rice (CTR) @ 20 x10 cm spacing, SRI (all components), Machine planted SRI (with all other components same as SRI). VST 4 row transplanter with slight gear adjustment has been used for machine transplanting at 23 cm spacing both inter and intra row (Fig. 2). Medium duration rice variety ADT 49 (135 days) was grown with in 0.2 hectare area for each treatment

Fig 2: Modified VST 4 row transplanter for square planting

The major components of SRI *viz.*, lesser seed rate of 7.5 kg/ha grown in mat nursery transplanted at young age (14-15 days) as square planting of 25 x 25 cm with one seedlings /hill, mechanical weeder for weeding (15, 30,45 DAT) and alternate wetting drying irrigation (2.5 cm depth) was adopted. For machine planting except planting through modified transplanter, remaining are same as SRI. Conventional Transplanted Rice (CTR) includes adoption of 30-35 days old seedlings planted at randomly with continuous submergence of irrigation water at 5 cm depth until harvest of the crop was practiced. Water quantification at field level based on depth study and number irrigation for each treatments to work out water productivity (Mishra and Saloke, 2010) [5].

The biometric observations were taken in 5 plants/plot in each OFT's at 5 villages and it was pooled for the analysis. OFT's were conducted in randomized block design with each village was taken as replication. The root volume measured by water displacement method and expressed in cc/hill. The above ground biomass (DMP) was weighed separately on dry weight basis and expressed as kg/ha. Net income and benefit cost ratio were arrived based on the cost of cultivation per hectare and market price of Rs.12/kg rice grain to arrive gross income. The data were subjected for statistical analysis by following standard statistical method (Gomez and Gomez, 1984) [3].

Results and Discussion

Rice establishment methods were compared through OFT's conducted with the active participation of farmers during 2013-14 to find out the economically viable and ecological acceptable crop establishment method in rice cultivation. Results emanated from the OFT are given hereunder along with the scientific relationship with the observed parameters taken at different stages were discussed appropriately.

Root volume and DMP

Among the establishment methods SRI has more root volume of 11.2, 21.2 and 27.4 cc/hill at active tillering, panicle initiation and flowering stage when compared to random planting. Whist the machine transplanting also significantly development of the root growth and DMP over conventional transplanted rice (CTP), but there were no striking difference between the SRI and machine planted SRI (Fig.3 & 4). SRI combined with mechanical weeder and intermittent irrigation (AWDI) resulted better aeration in rhizosphere which triggered the root growth expansion with stronger roots which has ability to access nutrients as compared to CTR. (Stoop *et al.*, 2009) [9]. CTR rice grown with continuous submergence of water which leads to roots degenerate under flooding and losing three fourth of their roots by the time of plants reach flowering stage (Kar *et al.*, 1974) [2].

There were progressive and conspicuous increases in the root volume and dry matter production with the advancement of the stages. While compare the root volume and dry matter production indicated that both were dependent on each other as root volume increases DMP also increase and vice versa. This is in corroboration with the findings of Uphoff, 2003 [12] who noticed the synergistic effect between root growth and bio mass accumulation in rice cultivation. Moreover, younger seedlings have improved root characteristics like root growth than planting of aged seedlings.

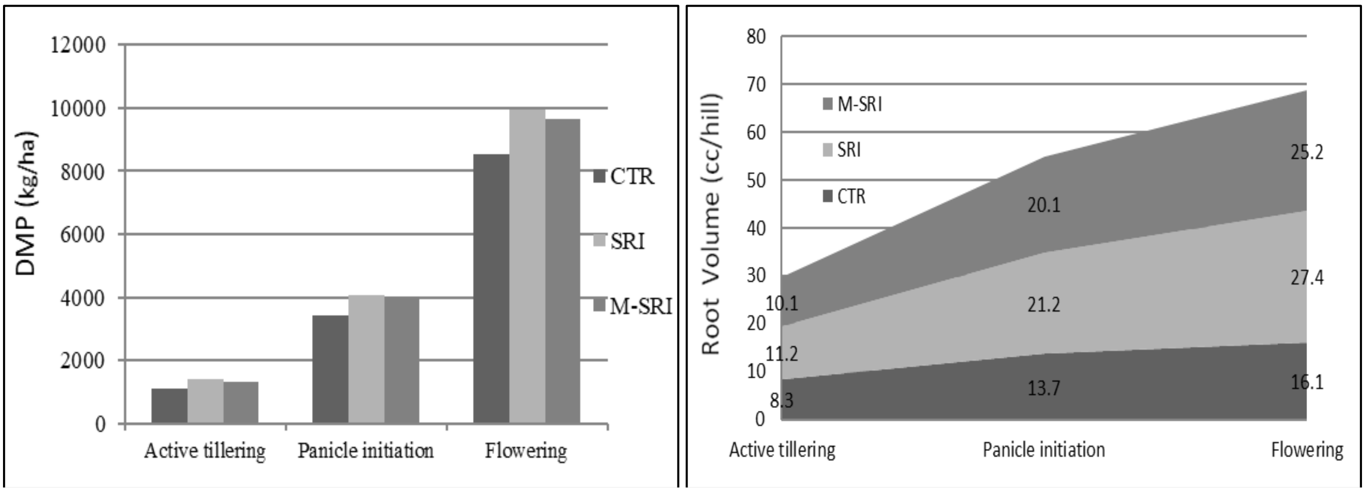

Fig 3-4: Rice Establishment methods on DMP (kg/ha) & root volume (cc/hill)

Yield attributes and Grain yield

Results showed that SRI with full components performed superior in terms of having 22.1 productive tillers/hill, 148 filled grains/panicle and 21.4 cm panicle length over machine planted SRI and CTR of 8.3 productive tillers/hill, 105 grains/panicle and 18.8 cm panicle length. The machine planted SRI closely follows the SRI in number of filled grains /panicle (139) which was statistically on par with the SRI (Table 1). SRI and machine planted SRI were on par in terms of grain yield whilst both has edge over the CTR with the tune of 20.3 and 17.7 % increased yield over CTR. Grain weight none of the establishment method has significant influences. Planting of young seedlings under optimal growing condition is responsible for accelerated growth rate in SRI plants as these make possible to complete more phyllochrons before entering into their reproductive phase. Completion of more phyllochrons at early stage resulted in more productive tillers per hill and grain number per panicle as grain yield. These results are in tandem with the findings of Nemoto *et al.*, 1995 [4] & Pandian *et al.*, 2014 [7].

Table 1: Establishment methods on yield attributes and Grain yield

Establishment method	No. of tillers/hill	No. of PT/hill	No.of filled grains/ panicle	Panicle length (cm)	Grain weight (gm)	Grain yield (t/ha)
CTR	12.4	8.3	105	18.9	14.0	6.10
SRI	25.3	22.1	148	21.4	14.1	7.34
Machine planted SRI	22.1	19.3	139	20.8	14.0	7.18
SEd	0.8	0.69	4.3	0.34	0.09	0.18
CD (p= 0.05)	1.7	1.4	9.4	0.7	NS	0.39

Economic gain

Higher net income of Rs. 64,630/ha were obtained in SRI, whilst the benefit cost ratio were higher in Machine planted SRI of Rs.2.68 than SRI of Rs.2.64 (Table 2).On economic analysis found that machine planted SRI have reduced the cost of production for the crop establishment over the manual planting of SRI. Ravichandran *et al.*, 2015 [8] found that SRI has more economic gain over conventional planting of rice in Tamil Nadu.

Table 2: Establishment methods on profitability, productivity of water and labour.

Establishment method	CC (Rs./ha)	Net income (Rs./ha)	BC ratio (Rs.)	Man days (Nos.)	Water requirement (m^3)	WP (litres/kg of grain)
CTR	26400	46800	1.77	1385	12650	2074
SRI	24450	64630	2.64	1118	8750	1192
Machine planted SRI	23200	62960	2.68	905	8760	1120

Water and labour productivity

The water productivity of SRI was 8.38 kg/ha mm, it was followed by machine planted SRI of 8.20 kg/ha mm when compared to CTR of 4.85 kg/ha mm (Fig. 5.) Alternate wetting drying irrigation in both SRI and machine planted SRI has a positive influence on yield and water saving to the tune of 44.5 % over continuous submergence practiced in CTR.This clearly indicate that the water requirement was less under SRI of 8750 m^3 than CTR of 12650 m^3. The water required to produce per kg of rice grain was around 2074 litres whereas it was 1192 and 1120 litres to produce one kg of rice grain in SRI and Machine planted SRI.Water saving under SRI was due to alternate wetting and drying and shallow depth of irrigation water. Nyamai *et al.* (2012) [6] opined that practice of alternate wetting and drying irrigation under SRI has potential to save water and maximized the productivity.

Machine planting has reduced the labour requirement for the crop establishment which in turn increased the labour productivity of 7.93 kg/man days when compared to CTR of 4.40 kg/man days and SRI of 6.56 kg/man days. Due to uniform shallow planting of 2.9 seedlings per hill with 17 days old seedlings at 23 cm apart by using 905 man days (8 hours each) has reduced the skilled labour requirement for square planting which is a drudgery work for woman labourers in rice cultivation.

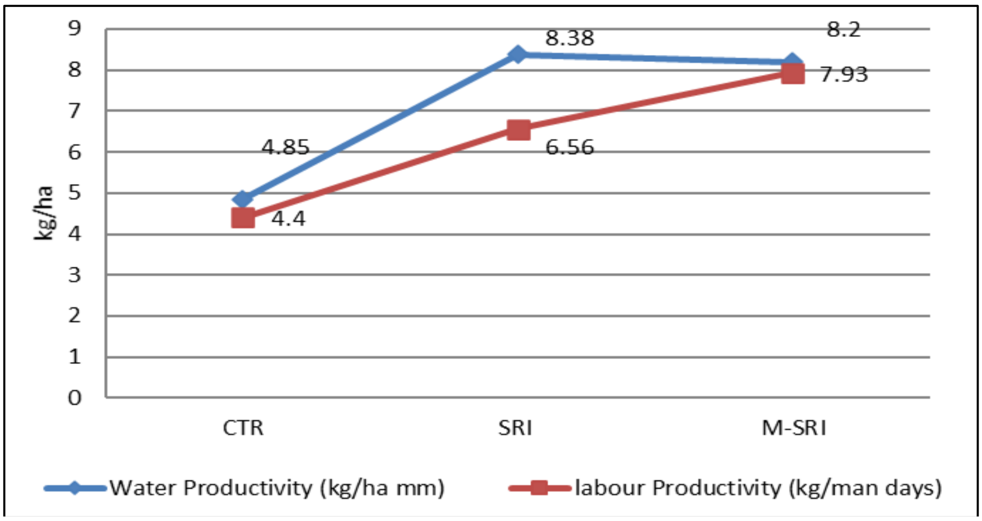

Fig 5: Establishment methods on Productivity of water and labour in rice farming

Conclusion

Machine transplanting is handy, easier, less time consuming and effective than that of manual planting in SRI due to non availability and higher wages for the skilled labours for square planting. Both in modified SRI transplanter and SRI, water saving was obvious than conventional. Labour saving was very much upfront with the machine. Hence, with lesser water and labour more rice can be produced in unit area by using the modified SRI transplanter in rice growing region.

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