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Impact of Small Scale Mechanical Rice Transplanters on the Yield, Economics of Rice System in North Coastal Zone of Andhra Pradesh, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Rice is a principal food crop for about half of the population in the world. In India the rice cultivation area has declined due to many reasons labor scarcity, climate change, inapt market price, increased cost of cultivation, yield stabilization. At present, to meet the increased demand, to the growing population it is apparent to increase the area under rice crop with low manpower is needed. In wet transplanting, Mechanized System Rice Intensification (MSRI) planting technology was

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demonstrated by the Krishi Vigyan Kendra, Amadalavalasa to popularize in the farmer fields. As part of the demonstrations, the production and economic parameters in Paddy transplanted with MSRI and manual planting methods were compared for two years from 2022 and 2023 during *kharif*. The results revealed that, the higher number of productive tillers 16 & 20 per hill and yield 6000 & 6975 kg ha^{-1} were recorded with the MSRI planting when compared to the Manual planting method 11 & 13 productive tillers per hill and 5600 kg & 6252 kg ha^{-1} respectively in both the years of the study. An economic point of view in MSRI planting recorded lower cost of cultivation (Rs. 52570 & Rs.55875 ha^{-1}), higher net returns (Rs. 69500 & Rs. 92981 ha^{-1}) and B:C ratio (2.3:1 & 2.66:1) respectively, compared to the manual planting in both the years.

Keywords: MSRI planting; rice; labor scarcity; manual planting; yield; economics.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is the most important staple food for more than half of the world's including populated regions as well the countries with rapid growth. India has the largest area among rice-growing countries and stands second in production with an area of 43.90 million hectares producing 114.45 million tons and productivity of 2.6 tones ha^{-1}. In Andhra Pradesh, an area of 2.25 million hectares is under rice cultivation with a production of 7.79 million tons and productivity of 3.4 t ha^{-1} [1]. Andhra Pradesh contributes to 4.84% of the total area and 5.98 % to total rice production in India. In Srikakulam district, rice cultivated in 1.6 lakh ha with an average productivity of 5.4 t ha^{-1}, the transplanting of rice crop requires nearly 25% of the additional labor for irrigated rice production [2] .

Though, rice is an important food crop to the world's population [3] and is one of the two most important cereals [4], for several reasons area under paddy cultivation decreasing at an increasing rate. High cost of cultivation, conversion of cultivated lands into non-agricultural lands and converting for commercial purposes, climatic changes is some of the reasons for decreased rice area [5]. Rice is more labor demanding crop from nursery raising to harvest. The timely availability of manpower itself a major hurdle to the farmer. Agriculture work force also declined very rapidly in present day agriculture. The fields those are tail ends of the river canals received very late irrigations for land preparations is one more major constraints in paddy growing belt of North coastal zone of the Andhra Pradesh, resulting inconsistence in rice transplanting. In these conditions the adaptability of small machine transplanters has the great significance to apprehend the mechanization of rice [6]. The machine transplanting system also facilitates a possibility of determining the performance of rice with early transplanting, rather than delayed transplanting [7]. In order to address these issues Krishi Vigyan Kendra, Amadalavalasa has taken up demonstration on Mechanized System of Rice Cultivation (MSRI) to study the impact of introduction of small scale transpalnters on the production and economic parameters in paddy cultivation.

2. MATERIALS AND METHODS

Krishi Vigyan Kendra Amadalavalasa conducted Front Line Demonstrations (FLD) on Paddy mechanization with MSRI was conducted for two years (2022,2023) during *kharif* in the farmers' fields in 5 clusters in 10 locations across the Srikakulam district. The soils of the selected fields were clay loam in texture, low in available nitrogen, medium in phosphorus, potassium and low in organic carbon.

Treatment Details:

T1: Paddy transplanting with MSRI Planter
T2: Manual transplanting.

Each treatment was imposed in 0.4 ha in the farmers' fields and the yield attributes, yield and economics of each treatment.

The variety used for this demonstration was MTU 1061 (Indra) which is a long duration (155 days), non-lodging, suitable for over-aged seedling planting, tolerant to BPH, with stands under inundated conditions, performs well even slightly saline soils.

Nursery Rising: For MSRI planting nursery rising is the important management aspect. The following precautions has taken for successful nursery rising

- Nursery was raised in the trays which have the dimensions of 60cm x 30 cm x 2.5 cm Fig 1.

- Each tray filled with 2-2.5 kg of finely pulverized soil as the first layer after that 120 g of overnight soaked seed placed with the help of a manual seeding mechine. of For one hactre 200 trays were fillied, and utilized 30-35 kg of seed.
- The seeding tray with the seed was moistened with sparkling water
- Finally, 1.0 to 1.5 kg fine soil along with vermicompost was added as the top layer of the tray, to cover the seed as well. The trays are allowed to stake overnight in the shade. Next day, trays are shifted to the field and spread on the plain laser leveled field covered with paddy straw for three days.
- At seedling emergence, covered paddy straw removed from the trays and start regular watering.
- To support the seedling growth, 19:19:19 @ 3-5 g per lit was sprayed.
- 18 days old seedlings from nursery was used to transplanting with MSRI Planter.
- The Entire process tray filling was done with the help of an automatic seeding machine (Taekwang Industrial Corporation, Korea) with the support of skilled staff.

MSRI Planter: Four row and six row MSRI planters (Kubota Manufacturer company) of Krishi Vigyan Kendra Amadalavalasa were used by the farmers for wet transplanting of rice. The planters is with 18-22 HP capacity, operated by petrol. These planters can plant 2.4 hectares per man-day. The planter can plant 4 seedlings per hill with a spacing of 30 cm X 14-18 cm.

Main field Preparation: Main fields used for demonstration was properly puddled and leveled. initial puddling was done 5-6 days before planting and the second puddling was performed one day before planting.

Weed management: As part of the weed management protocol, immediately after planting pre emergence application of Pretilaclore @ 2 ml/lit in 500 lit water per ha was recommended. At 15 DAT, Bispyribac Sodium @ 250 ml/ha and Metsulfuron Methyl+ Chlorimuron Ethyl 20 g/ha were recommended as tank mix for control of Grasses, Sedges, and BLW control.

Nutrient Management: All the demonstrated fields received uniform dose of nutrients as per the recommendation (80:60:50 kg NPK ha^{-1}) for the North Coastal Andhra Pradesh by Acharya N.G. Ranga Agricultural University

Data Collection: The observations were recorded from 5 randomly selected plants in each field. plant population per m^{-2} was taken in the field randomly with the help of quadrant. Yield attributes viz., No. of productive tillers $plant^{-1}$ and m^{-2} were also taken.

Grain yield was taken with help of a Crop Cutting (CC) experiment. In the CC experiment 5 m x 5 m plot was marked in the field and the crop was harvested, threshing was completed and grain yield was noted in kgs and converted into kg ha^{-1}.

3. RESULTS AND DISCUSSION

The data on plant population m^{-2}, No of Productive tillers per hill and yield of rice depicted in Table 1. revealed that, in the manual planting method (without proper spacing), number of productive tillers per hill was less (11 and 13 respectively in 2022 and 2023) it was attributed due to high intra competition within the hill among the seedlings, deep placement of the seedlings in the muddy fields [8]. In manual planting, generally, the workers kept more number of seedlings (6 or more) per hill, also inadequate plant stand per m^{-2} due to the deep placement of seedlings, tillers producing node of the rice plant kept very deep (>4-5 cm) in the mud reduces the tillering ability of the plant which in turn reduce the productive tillers too. Maintaining the optimal number of seedlings is required to minimize the missing hills [9]. While in the MSRI planting, no of seedlings per hill we can adjust as per our requirement. In machine transplanting it was observed 4 seedlings per hill were kept at uniform inter and intra row spacing (30 cm X 14 cm) and shallow depth placement of rice seedlings resulted more number of tillers per hill contributed increase productive tillers 16 and 20 respectively in both the years of the study. In mechanical transplanting the ideal seedlings per hill was influenced to obtain optimum plant population [9,10]. Pasha *et al.,* [11] reported that, better tillering, number of loaded grains $panicle^{-1}$, and more panicle hills, with yangi eight-row transplanter than conventional transplanting in rice. Singh *et al.,* [12] reported, quick establishment, and consistent development of rice seedlings was due to the consistent placement of seedlings at a particular depth and spacing with a comparable number of seedlings per hill under one square meter. Plant height, total panicles m^{-2}, effective panicles m^{-2}, grains per panicle, and 1000 grain weight were noticed in the self-propelled rice transplanter which in

turn produces the highest grain yields compared to manual transplanting and direct seeding. The number of seedlings is very important for the growth and agronomic parameters of transplanting [13]. Mechanical transplanting increased number of panicles hill^{-1} and viable grains per panicle [14]. Rao *et.al.,* [8] revealed that the highest no of productive tillers m^{-2} (254 and 242) and grains per panicle (211 and 188) were noticed in MSRI planting when compared to the manual planting (203,206, 188 and 189) in 2018 and 2019 during *kharif* respectively.

Uniform wider spacing in the MSRI planting method in turn improves the solar radiation interception in all directions of the rice plant and CO_2 replacement may happen in the plant microclimate, which could be attributed to increased photosynthetic rate, photosynthate translocation also. The increased number of filled grains per panicle which turn result in 7.1 % and 11.5 % increased yield in the MSRI planting, when compared to manual planting during both the years (Table 1). These findings are in conformity with Haung *et al*., [7] and identified early sowing can improved biomass translocation, and grain yield in machine-transplanted late-season rice under single-seedling sowing than conventional seeding [15]. Similar results were reported with Singh et.al., 2006. Mechanical transplanting significantly increased grain yield by about 23, 37 and 63 %, straw yield by about 17,14 and 22 % and biological yield by about 20, 24 and 39 % over manual transplanting, dry direct seeding and direct seeding of sprouted rice in puddled conditions, respectively. Rao et.al., [8] recorded the higher grain yield in the demo plot (6975 kg ha^{-1}& 6537 kg ha^{-1}) which was planted with the MSRI planter than in manual planting (5860 kg ha^{-1}& 5337 kg ha^{-1}) in two consecutive years.

In the manual method of planting aged seedlings, (30 days or even more aged seedlings) were used to be planted in the main field but in MSRI planting, young aged (18 days) seedlings are used because of age advantage, these younger seedlings have more vigor potential to put forth high tillering ability in the main field. Mechanically transplanted rice had the most effective tillers m^{-2} because younger seedlings were transplanted at the proper distance and depth, minimizing transplanting tremors and allowing early establishment and growth factor exploitation [16]. Srinivas *et.al.,*[17] revealed in their study that, with the young seedlings (12 -14days), the minimum number (two-three) seedlings per hill and maximum (20 cm) intra-row space adjustment to sufficient number matrix of hills per square meter is adjusted with the MSRI planter which can contribute to higher yields. Revathi *et al*., [18] observed higher mean grain, straw yield and B:C ratio (average of two years) in machine transplanting (7.0, 16.02 t ha^{-1} & 2.20) followed by farmers method (manual) of planting (6.30, 13.32t ha^{-1} & 2.00) and was found on par to SRI method (5.8,11.40 t ha^{-1} & 1.60). The higher number of panicles m^{-2} (317), grains per panicle (277), grain yield (5345 kg ha^{-1}) and straw yield (6305 kg ha^{-1}) were recorded in machine transplanting over conventional, broadcasting and drum seeding establishment methods [5,19]. Mechanical transplanting improved productive tiller, panicle length, panicle^{-1} grains, and rice test weight over hand transplantation [17]. Mechanically transplanted rice yielded 9-14% more than hand-transplanted rice was reported [20]. Mechanically transplanted paddy yielded 7.42 t ha^{-1}, while broadcasted paddy yielded 5.31 reported [21].

3.1 Economic Parameters

The economic parameters of both systems were depicted in Table 2, and compared in Table 3. The results revealed that, in normal planting cost of cultivation was high due to 1. Seed cost, 2. High labour involvement, 3. Nursery pulling and planting, 4. More pest and disease incidence and lower yield. In case of the MSRI planting savings on expenditure noticed on seed, labour and pesticides. In addition apart from the increased yiled, MSRI Planting, observed lower cost of cultivation of Rs. 54200 ha^{-1} than in manual planting Rs 62125 ha^{-1} (Table 3). In MSRI planting highest net returns (Rs. 69500 and Rs. 92981 ha^{-1}) were noticed in both the years (Table 2). A similar trend was noticed in B: C ratio also. These findings are similar with the other researchers [5,17] reported that, On-farm trials indicated that the yield parameters and yield were higher in mechanized transplanting than in manual transplanting. Mechanized transplanting recorded more grain yield (6359 kg ha^{-1}) and net returns (Rs. 31870/- ha^{-1}) with less cost of cultivation (Rs. 29796/- ha^{-1}) compared to manual transplanting. Among the two different transplanting systems in the studied period of two years, mechanical transplanting method resulted lower cost of cultivation by 9 to 15 %, and higher net returns by 23 to 40 %, in comparing with manual transplanting method. Similarly, the reduced cost on cultivation and increased net returns were reported in machine planting over conventional panting [22].

Table 1. Yield attributes and yield of paddy influenced by normal and MSRI planting methods.

Treatment	Plant population m^{-2}		No. of Productive tillers/hill		Yield kg ha^{-1}	
	2022	**2023**	**2022**	**2023**	**2022**	**2023**
T1: Paddy transplanting with MSRI Planter	24	24	16	20	6000	6975
T2: Manual transplanting	28	27	11	13	5600	6252
% Increase			45.4	53.8	7.1	11.5

Table 2. Yield, Economic parameters of Paddy in Manual and MSRI planting methods.

Treatment	Yield (Kg ha^{-1})		Cost of Cultivation (Rs. per ha)		Net returns (Rs. per ha)		B:C ratio	
	2022	**2023**	**2022**	**2023**	**2022**	**2023**	**2022**	**2023**
T1: Paddy transplanting with MSRI Planter	6000	6975	52570	55875	69500	92981	2.3:1	2.66:1
T2: Manual transplanting	5600	6252	57850	66375	56250	66375	1.9:1	2:1
% Increase	7.1	11.5	(-)9.1	(-)15.8	23.5	40.1		

Table 3. Minimum Expenditure per ha on paddy under Manual and MSRI planting conditions

S.No.	Particulars	Manual Method (in Rs)	MSRI (in Rs)
1	Seed	3000	1500
2	Nursery raising (including ploughing)	2250	-
3	Field preparation	3750	3750
3	Trays filling @ 20 per tray (200 trays)	-	4000
4.	19:19:19 spray	-	500
5.	Nursery pulling and spreading of nursery or tray transportation	8000	3000
6.	Transplanting	7500	6500
7	Fertilizers	6410	6410
8	Formation of Alley ways and one hand weeding	3500	3000
8	weedicides	7050	6400
9	Pesticides	8500	7000
10	Harvesting	8750	8750
11	Labour charges for fertilizers and irrigation	3400	3400
	Total	**62125**	**54200**

Fig.1. Nursery in Trays initial stage and ready to transplanting

Fig. 2a. Planting of the paddy with MSRI Planter

Fig. 2b. Planting of the paddy with MSRI Planter

Fig. 3 . After planting with MSRI planter

Fig. 4. Taking of Biometric Observations

4. CONCLUSION

Currently rice is being transplanted manually in north coastal Andhra Pradesh increasing the cost of cultivation. The use of small scale machinery in wet transplantation is inevitable to reduce the expenditure. In conclusion the results of this study recommends use of mechanization in rice transplantation for higher productive tillers, grain yield, reduced cost for small and marginal farming community.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors hereby declare that NO generative AI technologies such as Large Language Models (Chat GPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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