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Comparative Study on Cost Analysis of Mechanical and Manual Transplanting of Rice

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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

In Telangana, rice cultivation predominantly relies on traditional manual transplanting, which requires a significant labor force. However, the migration of agricultural laborers to urban areas in search of better wages has led to a shortage of workers, particularly during the critical transplanting season. To address this labor shortage and reduce cultivation costs, an efficient and cost-effective method of rice transplanting is essential, without compromising grain yield.
To explore such a solution, Krishi Vigyan Kendra in Jammikunta, Karimnagar district, conducted 30 frontline demonstrations between 2018-19 and 2020-21, showcasing rice cultivation using a self-propelled, walk-behind six-row mechanical transplanter. The performance of this mechanical method was evaluated by collecting data on various growth parameters, including plant height,

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number of productive tillers per hill, panicle length, grains per panicle, and grain yield, and comparing it with traditional manual transplanting.
Economic analysis revealed that the gross returns from mechanical transplanting were Rs. 135,956, compared to Rs. 128,629 for manual transplanting. Similarly, the net returns for mechanical and manual methods were Rs. 95,106 and Rs. 82,204, respectively. The benefit-cost ratio was found to be 3.32 for mechanical transplanting and 2.77 for manual transplanting. These findings indicate that mechanical rice transplanting offers a viable, cost-effective alternative, reducing labor requirements and drudgery while delivering higher yields.

Keywords: Rice; Oryza sativa; mechanization; front line demonstrations; mechanical transplanting.

1. INTRODUCTION

Rice (*Oryza sativa* L.), the staple food for most Indians, is a key cereal crop grown across 94.99 lakh hectares, producing 129.66 million tonnes as per Paddy Outlook, July 2022 [1]. In Telangana, rice is cultivated over an area of 2.8 million hectares, yielding a total production of 98 million tonnes with an average yield of 35 quintals per hectare [2].

Despite its effectiveness, traditional manual transplanting remains the dominant rice cultivation method in Telangana, though it poses challenges such as being labour-intensive, time-consuming, and physically demanding. Labour shortages during peak seasons further exacerbate these issues, leading to higher transplanting costs and delays, which can significantly reduce rice yields by up to 9% if transplanting is not done on time [3]. Research by Ved Prakash Chaudhary and Varshney [4] highlights that manual transplanting demands around 250-300 man-hours per hectare, representing roughly 25% of the total labor required for the entire crop cycle.

Given these challenges, there is an urgent need for labour-saving, cost-effective transplanting techniques that do not compromise grain yields. Mechanical transplanting emerges as a viable solution, offering timely and efficient transplanting while reducing labor demands. Recognizing this potential, Krishi Vigyan Kendra, Jammikunta, conducted 30 demonstrations in Karimnagar district using a self-propelled, six-row mechanical transplanter to showcase the advantages of mechanized rice transplantation.

2. MATERIALS AND METHODS

This study was conducted by Krishi Vigyan Kendra during the rabi season from 2018-19 to 2020-21 on farmers' fields across four villages in Karimnagar district, Telangana (located at 18°08'28" N latitude and 79°18'02" E longitude). For mechanical transplanting, rice seedlings were raised using a specialized mat nursery method. The nursery beds, measuring 10 meters in length, 1.2 meters in width, and 2.5 cm in height, were covered with a 1.2-meter wide polythene sheet of 50-micron thickness. Iron frames sized 21x50 cm were placed on the plastic sheet to create uniform nursery mats suitable for feeding into the mechanical transplanter. These frames were filled with well-prepared wet soil, mixed with decomposed farmyard manure for optimal seedling growth, and free of trash and stones. Sprouted paddy seeds were spread evenly on the wet soil and covered with paddy straw, which protected the seedlings from birds and promoted healthy growth. Watering was done using rose cans for the first 4-5 days, after which the straw was removed and regular watering continued. Seedlings, reaching a height of 10-15 cm with 3-4 leaves, were ready for transplanting after 16 to 18 days of sowing. A self-propelled walk-behind six-row transplanter was used for the mechanical transplantation. Before transplanting, the main field was prepared, levelled, and allowed to settle for 12 hours to prevent the transplanter from sinking. The machine transplanted rice in 6 rows, with a spacing of 22.8 cm between rows and 15 cm between hills. The nursery was raised according to standard practices used in manual transplanting.

Data on plant height, number of productive tillers per hill, panicle length, grains per panicle, and yield were collected from the mechanical and manual transplanting plots for comparison. Additionally, an economic analysis and benefit-cost ratio (B:C) comparison were conducted for both methods.

3. RESULTS AND DISCUSSION

During the three consecutive rabi seasons of 2019, 2020, and 2021, experimental results showed that mechanized transplanting placed 4-6 seedlings per hill at a planting depth of approximately 5 cm. The transplanter's productivity was measured at 0.20 hectares per hour, requiring 5.10 hours to cover one hectare. While the machine could not alter the spacing between rows, the distance between hills was adjustable to 12, 15, or 17 cm.

The study found that the average plant height (cm), productive number of tillers/hill, panicle length, number of grains/panicle and grain yield (kg/ha) of KNM-118 in mechanically transplanted plots were 106 cm, 21, 16.8 cm, 130 and 7048 kg/ha respectively. In the control plots where manual transplantation was performed, they were 102 cm, 16, 14.9 cm, 108 and 6671 kg/ha.

The variation in yield and yield-related traits can be attributed to the age of seedlings used in transplanting. Transplanting younger seedlings, around 20 days old, with intact soil and roots, leads to quicker adaptation to the soil, resulting in improved yield performance [5], compared to transplanting older seedlings (25-30 days old) in manual methods. Additionally, the mat nursery method used in mechanical transplanting minimizes root damage during uprooting, unlike manual transplanting where seedlings may suffer from root cutting.

Mechanical transplanting generally places 2-3 seedlings per hill, while manual methods typically use 4-5 seedlings per hill. This difference in seedling numbers also influences yield outcomes. As explained by Maiti and Bhattacharya [6] and Rasool et al. [7], fewer seedlings per hill allow for the development of healthier leaves and tillers, ultimately contributing to a higher grain yield. The increased number of tillers and improved yield in mechanically transplanted rice may also be attributed to the precise row and plant spacing, which contrasts with the random spacing seen in manual transplanting.

The cost analysis of paddy cultivation through mechanical and manual transplanting, as shown in Table 1, reveals that the expense of preparing a mat nursery for mechanical transplanting (Rs. 1950) was higher compared to the cost of preparing a conventional nursery bed for manual transplanting (Rs. 800). However, the table also highlights that the charges for transplanting with a mechanical transplanter (Rs. 8125/ha) and weeding operations (Rs. 2250/ha) were significantly lower than those for manual transplanting (Rs. 12000/ha) and manual weeding (Rs. 5250/ha), thanks to the use of a mechanical paddy transplanter and power weeder.

The Table 1 also indicates that the cost of plant protection was lower in mechanical transplanting (Rs. 2185) compared to manual transplanting (Rs. 2850). This reduction is likely due to the consistent row and plant spacing maintained in mechanical transplanting. Previous studies suggest that using a power weeder in paddy fields decreases the incidence of pests and diseases, as some pathogens survive in weeds and serve as inoculum for the main crop. The power weeder effectively reduces weed presence, contributing to improved yield performance. According to Rajendran et al. [8], power weeders promote better tiller sprouting per hill by enhancing root aeration and improving nutrient uptake from the soil, ultimately resulting in higher yields compared to conventional methods.

Table 1. Cost of cultivation (Rs/ha)

S. No	Operations	Manual transplanting	Mechanical transplanting
1	Nursery bed preparation	800	1950
2	Seed cost	2000	2000
3	Land preparation	6600	6600
4	Fertilizers	7875	7875
5	Labour cost for transplanting	12000	8125
6	Fuel cost for machine	-	648
7	Labour cost for weeding	5250	2250
8	Fuel for power weeder	-	825
9	Plant protection	2850	2185
10	Harvesting	5000	5000
11	Transport	1800	1800
12	Threshing	2250	2250

Table 2. Economic analysis

Particulars	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	C:B Ratio
Manual transplanting	46425	128629	82204	1:2.77
Mechanical transplanting	41508	135956	95106	1:3.32

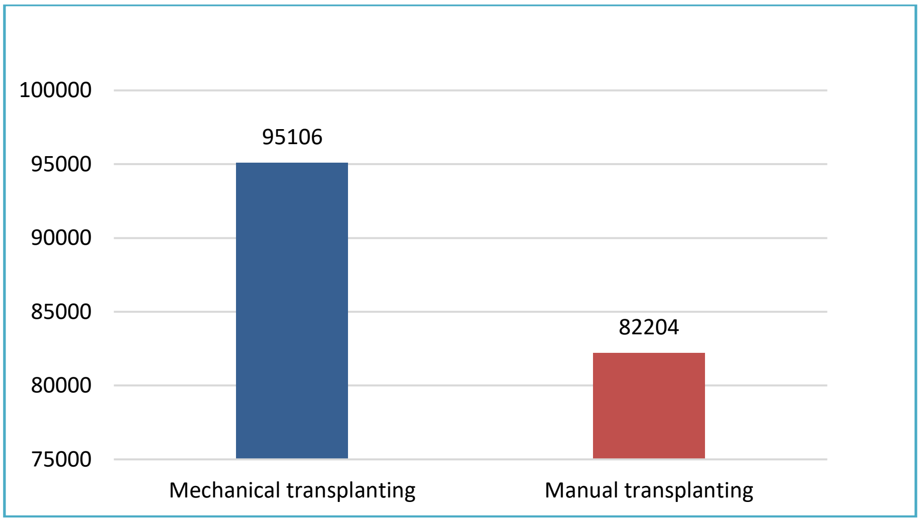

Fig. 1. Comparative analysis of net returns (Rs/ha)

The economic analysis of the two transplanting methods (Table 2) shows that the average cost of cultivation for manual transplanting (Rs.46425) was more than that of mechanical transplanting (Rs.41508). Gross return for both manual and mechanical transplanting was Rs. 128629 and Rs.135956 respectively. Net return for mechanical transplanting (Rs.95106) was also higher than manual transplanting (Rs.82204). From the study it was revealed that the average cost of cultivation in mechanical transplanting was reduced by Rs. 4917/ha compared to manual transplanting.

An additional benefit of Rs. 12,902/- was observed with mechanical transplanting compared to manual methods, primarily due to reduced labor costs for transplanting and weeding. Similar findings were reported by Mohapatra et al. [9] and Sheeja et al. [10], who noted that using a transplanter in rice cultivation lowered the cost of production and increased net returns. Furthermore, the highest benefit-cost ratio of 3.32 was achieved through mechanical transplanting, as opposed to 2.77 for manual transplanting. Studies by Sajitha Rani and Jayakiran [11] and Sreenivasulu et al. [12] also highlighted the superior benefit-cost ratio associated with mechanical transplanting.

4. CONCLUSION

Mechanized transplanting proved to be the most effective method for achieving higher net returns and a better benefit-cost ratio compared to manual transplanting. It reduced the overall cultivation cost by Rs. 4917/ha and provided an additional benefit of Rs. 12,902/ha.

To promote the adoption of mechanical transplanting, the establishment of custom hiring centers is essential. These centers would offer farmers a more economical approach to paddy cultivation over traditional methods. Mechanical transplanting not only reduces labor costs but also helps decrease pest and disease incidence, minimize weed presence, and shorten the overall cultivation time.

In conclusion, the rice transplanter serves as a viable alternative to manual transplanting, enabling higher grain yields and lowering cultivation costs by reducing labor demands and physical effort.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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