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Profitability of Mechanical Transplanting of Rice Farming in Nepal

THAPA, Dhan Bahadur[1]* & AMGAI, Sujan[2]
[1]Prime Minister Agriculture Modernization Project, Dhading
[2]Beekeeping Development Center, Chitwan
***Corresponding Author's email:** sujanamgai@gmail.com

ABSTRACT

Most farmers in Nepal practice manual transplanting, which is labor-intensive and costly as well. Rice farming has considerable challenges due to labor scarcity and growing labor costs. Manual transplantation also creates delays owing to labor constraints, as well as the difficulty of handling younger seedlings during transplanting, causing older seedlings to be used, resulting in a lower yield. In such circumstances, mechanical transplanting may be the best alternative to manual transplanting since it ensures timely transplanting, involves fewer labors, maintains appropriate plant population, lowers production costs, contributes to higher yield, and is a more cost-effective technique of rice production. Despite its numerous benefits, the adoption of mechanical rice transplanting technique among Nepalese farmers is sluggish due to the majority of small-holder farmers, expensive starting costs, and a lack of knowledge about the technology related mat-type nursery growth. So, to enhance farmers' acceptance of mechanical transplanting, providing technical knowledge of raising mat type or tray nursery, as well as capacity building for custom hiring, could be a solution. This review examines the impact of mechanical transplanter on the growth, yield, and economics of rice production.

Key words: Grain yield, production cost, growth, transplanter, cost effective

INTRODUCTION

Rice is recognized as the global grain since it is the primary staple food for more than half of the world's population. It was grown across an area of 166.3 million hectares in over a hundred countries, with an annual yield of over 789 tons in 2021 (FAO, 2022). Rice is the principal food for most of the Nepalese population. Rice has a significant role in agriculture and the economy of Nepal as it contributes 13.6 % to agriculture GDP and 7% to national GDP (MOALD, 2023). It is grown in an area of 14,77,378 ha, with a yield of 5,130,625 tons in the fiscal year 2021/22 (MOALD, 2023). The rice productivity of Nepal is 3.9 tons/ha (MOALD, 2023)) which is comparatively lower than neighboring countries China and India.

Most farmers in Nepal follow traditional methods of rice cultivation, which are labor- and capital-intensive. Human labor costs account for 59.4% of the overall production costs (Acharya et al., 2020). Similarly, rice transplantation done manually alone costs 19.9% of the total labor requirement for rice cultivation (Acharya et al., 2020). It requires 30-35 men a day's labor to transplant manually one hectare of paddy land (Bhandari et al., 2022). The scarcity of labor and rising labor expenses are significant issues in rice farming. Manual transplanting causes transplantation delays due to labor constraints, which force older seedlings to be used, resulting in a low yield. Under these conditions, the use of a mechanical transplanter is essential for lowering production costs, enabling transplants at the right time, and addressing labor shortages.

Comparing mechanical transplanting of rice to the prevalent hand transplanting method, it ensures timely transplanting, requires less labor, maintains an optimal plant population, contributes a higher yield, and is a more economical way of producing rice. According to Goswami et al. (2020), rice transplanting with mechanical transplanting is three times cheaper than rice transplanting by hand. Significantly higher yield was observed in mechanical transplanting systems than in manual transplanting systems (Regmi et al., 2020, Kumar et al., 2012). Nadga et al. (2021) also reported a higher benefit-cost ratio in the MTR system than in the manual transplanting system.

The most important factor among all the agro-techniques used to increase grain production is the age of the seedling. The age of the seedling greatly affects the rice's growth and development, tiller production, grain formation, and other traits that affect yield (Manir et al., 2022). Younger seedlings that are less than 20 days old can be transplanted mechanically; however, hand transplanting makes it more difficult to transplant younger seedlings. Therefore, mechanical transplanting can result in a higher grain yield since younger seedlings can be transplanted.

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In Nepal, agricultural mechanization dates back to the 1970s, when two- and four-wheeled tractors from Japan were introduced (Biggs and Justice, 2015). Since then, different agricultural machines have been used to reduce human labor and production cost. The government of Nepal has been promoting agricultural mechanization to increase farming's profitability. Four-wheeled rice transplanters, walking behind rice transplanters, and self-propelled riding rice transplanters are the three types of rice transplanters that are most used in Nepal. Among these, four-wheeled riding machines are growing in popularity in the Terai region due to their durability and speed of operation. The adoption of mechanical rice transplanters is sluggish because of small-holder farmers, high initial costs, and a lack of technical knowledge regarding mat-type nursery growth (Bhat et al., 2023; Poudel et al., 2021). This review examines the impact of mechanical transplanter on the growth, yield, and economics of rice production.

NURSERY MANAGEMENT

Tray nursery or mat nursery are prerequisites for mechanical transplanting. In mat-type nursery, rice seedlings are raised on about 2.5 cm thin layer of soil and farmyard manure (FYM) or compost mixture placed on a perforated polythene sheet (Rickman et al., 2015). In tray nursery, rice seedlings are raised on a tray that vary in size according to the types of rice transplanter being used. Sieved soil is mixed with farmyard manure in a 4:1 ratio, with approximately 4 m^3 of soil mixture required (Rickman et al., 2015). A 70:30 mix of soil and vermicompost is recommended as a media for tray nursery growing (Reddy et al., 2020). For each hectare of transplanting, a 100 m^2 nursery area and 20 kg of seed are adequate. Zohaib et al., (2022) found that a seed rate of 90 g per tray of 60cm * 30 cm increased productivity in fine basmati rice. Then, the pre-germinated seeds are evenly spread with the help of manual seeder to achieve a uniform density and seeds are covered with about 0.5 cm soil layer (Bhandari et al., 2022). Currently, a semi-automatic stationary rice nursery sowing equipment is available that can perform various activities at the same time, such as tray moving, soil spreading, seed sowing, watering, and topsoil covering, and three people can prepare 600-700 nursery trays per hour. Keep the bed moist for the first 3-4 days by sprinkling water from the top using a watering can. After that, irrigate the nursery using floods. Use a foliar application of 0.5% urea (5 g urea per liter water) or 3-5 g/ml NPK (19:19:19) per liter water if there are nutritional deficiencies (yellowing). Foliar spraying of 0.5% urea at 10 days after sowing is recommended for tray nurseries due to its better growth results compared to other foliar applications

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tested (Reddy et al., 2020). Seedlings of 18-20 cm height (2-3 leaves) are produced in 14-18 days. Hossain et al. (2017) observed 14 cm-tall seedlings with 3-4 leaves in 12 days that were grown in plastic trays filled with mixture of sandy loam soil and organic fertilizer.

PLANT POPULATION

Optimal plant population is critical for achieving optimal production. Manual transplantation involves transplanting seedlings that are more than 25 days old, and seedlings are transplanted with root eroded seedling. The root washed seedlings get shocked before establishment in puddled soil. On the other hand, mat type nursery or tray nursery is required for mechanical transplanting and seedlings with soil attached within root net are transplanted, reducing transplanting tremor and preventing floating. Mechanical transplanting also allows for the transplantation of younger seedlings (12-18 days old seedling). It was found that transplanting younger seedlings resulted in significantly higher tillers number per hill than transplanting older seedlings (Mupeta et al., 2022; Manir et. al, 2022). Therefore, plant populations per m^2 are therefore greater in mechanical transplanting than in hand transplanting because of all the aforementioned factors. Same results were reported by Basir et al., (2020) and Regmi et al., (2020).

PLANTS GROWTH AND YIELD ATTRIBUTES

No significant difference in plant height was observed between mechanical transplanting and manual transplanting (Islam et al (2020) and Kang et al., 2019). Similarly, Kang et al. (2019) reported that there was no significant effect on leaf area index and dry matter accumulation at harvesting between mechanical transplanting and manual transplanting practices. However, significantly higher plant height was observed by Regmi et al., (2020) and Munnaf et al. (2014). It might be due to the fact that transplanting at proper time, depth and spacing by mechanical transplanter helped in quick establishment and thereby enhanced cell division and enlargement, ultimately leading to higher plant height.

Different yield attributing characters, such as 1000 grain weight, number of grains per panicle, and number of effective tillers/m^2 determine the variety's final grain yield. Regmi et al., (2020) reported that the number of effective tillers/m^2, panicle length and number of grains/panicles were significantly higher in mechanically

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rice transplanter than manually transplanting, use of drum seeder and seed drill machine. Similarly, Vijay et al. (2020) recorded higher number of tillers/hills, number of grains/panicle and panicle length in mechanical rice transplanting than manual transplanting. Munnaf et al. (2014) also reported higher numbers of panicle/m^2, number of tillers/hill and panicle length in mechanically transplanting method in comparison to manual transplanting. Elsoragaby et al. (2018) recorded mechanical transplanting resulted in a 25.18% increase in planting density (522 versus 417 stems/m^2), 20% increase in panicles (480 versus 400 panicles/m^2), 23.5% increase in grain weight/panicle (4.1 versus 3.4 g/panicle), and 7.3% less weedy rice population (4.89% versus 12.16%) compared to the control field. In contrast, Kumar et al. (2014) and Kang et al. (2019) reported no significant difference in number of effective tillers/m^2, panicle length and number of grains/panicles between manually transplanting and mechanical transplanting. A higher number of effective tillers in mechanical transplanting methods is due to the use of younger seedling, optimum spacing, quick establishment, and less seedling root injury (Regmi et al., 2020; Munnaf et al., 2014).

GRAIN YIELD

Grain yield is one of the crucial and complex attributes of rice. Number of grains/panicles, number of effective tillers per unit area, 1000 grain weight determine grain yield. Islam et al. (2016) reported significantly higher grain yield in mechanical transplanting than manual transplanting and recorded 14-23% higher grain yield in mechanical transplanting than manual transplanting. According to Elsoragaby et al. (2018), there was a 24.3% increase in grain yield in the mechanical transplanting plot while comparing the plots broadcasted by the Hary mist duster and transplanted by the riding type four-wheeled rice transplanter. Similarly, Regmi et al., (2020) conducted the experiment on comparison of different establishment practices of rice and observed significantly higher grain yield in mechanical transplanting than manual transplanting, drum seeder sowing and seed drill sowing. Similarly, Vijay et al., (2020); Munnaf et al., (2014); Basir et al., (2019) and Kumar et al., (2012) also reported that mechanized transplanting recorded higher yield than manual transplanting. Mechanical transplanting results in higher grain yield than hand transplanting because of transplanting younger seedlings with optimal spacing. This caused better photosynthate translocation from source to sink, resulting in a higher number of productive tillers per hill, more filled grains per panicle, and, ultimately, increased grain yield. However, Kumar et al. (2014) and Kang et al. (2019) observed no

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significant differences in grain yield between mechanical transplanting and manual transplanting.

ECONOMIC INDICATORS

Mechanical transplanting practice has lower production cost compared to manual transplanting, mainly due to low seed rate and a smaller number of labors required in transplanting operation. The seed rate required in mechanized transplanting varies with size of seed and ranges from 20 to 30 kg/ha (Rajaiah et al., 2019). However, about 50 kg of seed sown in 500 m^2 of seedbed area is required to transplant manually one hectare of main field (Kega et al., 2015). The recommended seed rate is 100-120 kg/ha for broadcasting or dry direct seeding practice and 50-60 kg/ha in seed drill machine used (Zaman, 2018). The labor requirement for transplanting operation in mechanical rice transplanter is only 2-man day/ha (Vasantgouda et al., (2014) and Elsoragaby et al. (2018). Similarly, Samal et al. (2020) observed the requirement of 6 man-hour/ha in 8 rows mechanical rice transplanter and 250 man-hours in manual transplanting. Dixit & Khan (2011) also reported number of man-hour/ha required in manual transplanting and mechanical transplanting were 238 and 32, respectively. The number of man-hour/ha required for transplanting decreased to 25 from 220 while using a self-propelled walking behind type rice transplanter (Kumar et al., 2012).

Table 1. Comparison of Benefit Cost ratio between manual transplanting and mechanical rice transplanting.

S.No.	Benefit Cost ratio		Authors
	Manual transplanting	Mechanical rice transplanting	
1.	2.82	3.63	Nadga et al., (2021)
2.	2.51	3.21	Goswami et al. (2020)
3.	2.53	3.87	Deshmukh et al., (2017)
4.	1.32	1.62	Islam et al. (2016)
5.	1.66	3.00	Raj et al. (2014)

According to Munnaf et al. (2014), the cost of seedling raising in mechanical transplanting was 22.2% higher than in manual transplanting, whereas the cost of transplanting in mechanical transplanting was 65.3% lower than in manual transplanting, resulting in an 8.03% reduction in total cost. Similarly, Goswami et al. (2020) recorded 2.4 times increase in cost of raising seedling in mechanical transplanting practice than manual transplanting practice, but 3.2 times decrease in cost of transplanting, resulting in an 18.5% reduction in total cost of production. In addition, Raj et al. (2014) found that mechanical transplanting had higher net returns than hand transplanting, drum seeding, and broadcasting techniques. Reddy et al., (2018) reported that the breakeven point and payback period of Kuboto and Yanmar transplanters were observed as 43.45%, 2.3 years and 48.34%, 2.6 years, respectively. The benefit-cost ratio of the mechanical transplantation was more than that of manual transplantation in the various studies done, as indicated in Table 1.

CONCLUSION

Mechanical transplanting is more efficient but requires significant capital investment, making it suitable for larger-scale operations. Manual transplanting, while more labor-intensive, is cheaper and more adaptable, making it ideal for small-scale farmers or regions with low mechanization. Manual transplanting is often seen as more environmentally friendly due to lower fuel consumption, but mechanical transplanting offers faster and more consistent outcomes, which can lead to higher yields. As manual transplanting is labor and capital intensive. Mechanical rice transplanting can be used successfully as a substitute to manual transplanting to increase grain production, reduce cultivation costs, and eventually attain a better benefit-cost ratio.

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