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Impact of Mechanical Transplanting on Rice Productivity and Profitability- Review

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Abstract

Conventional rice transplanting methods are laboured exhaustive and involves drudgery. On an average only transplanting operation takes one fourth of the total labour requirement of rice production under traditional system. Shifting of agricultural labourer towards urban areas for better remuneration creates labour shortage during peak time of transplanting. Lower plant density compared to desirable level under traditional transplanting method habitually farmers force to apply higher amounts of agro-input to compensate as result cost of cultivation has increased considerably and eventually get lesser grain yield. Under such circumstances, a cheap and labour redeemable way of rice transplanting without compromising grain yield is the need of the time. The mechanical rice transplanting is an alternative and encouraging choice for ensuring timely transplanting and also contributes to higher grain yield. Mechanical transplanting of rice is profitable over traditional methods and easy to operate. In spite of having superiority over the conventional transplanting, acceptance in the field level is stumpy due to high preliminary investment and dearth of awareness in growing mat type nursery. Divulging technical skill, confirming timely accessibility and boosting custom hiring may be some of the practical solutions for increasing the adoption rate of mechanical transplanting among farmers. This review focused on the positive and negative impact of mechanical transplanting on productivity and profitability of rice production.

Keywords: Mechanical transplanting, productivity and economics, rice

1. Introduction

Among the cereals, rice (*Oryza sativa* L.) is one of the most vital crops because it is the principal food for the majority of Indian population. In order to meet the food demand of the rising population country has to produce about 137.29 mt of rice by 2030–31 with an annual incremental rate of 2.15% (Pathak, 2020). Indian farmers grow rice either by manual transplanting or by direct seeding method (Kumar et al., 2016 and 2017). Manual transplanting is more common among farmers because it gives comparatively higher yield than direct seeding method, besides it is labour-exhaustive and involves more energy (Verma, 2010). On an average, traditional method of rice transplanting required 238 man hour per hectare (Dixit and Khan, 2011). Manjunatha et al. (2009), also testified pleasing result of mechanical transplanter, where 3 man-days was sufficient to transplant one hectare compared to 33 man days in case of traditional transplanting system. Labour requirements in rice production accounts for the maximum input cost (Clayton, 2010). Continued submerged rice cultivation over eras has led to weakening of soil physical properties through structural degradation of soil aggregates and capillary pores and clay dispersion thus limiting

germination and rooting of succeeding crops (Tomar et al., 2006). Recently many research has emphasized the challenges with manual transplanting in puddled soil comprising huge yield differences (Lobell et al., 2009) compared to other establishment techniques, poor water and nutrient use efficiencies (Humphreys et al., 2010; Sudhir-Yadav et al., 2011b), emits considerable amounts of greenhouse gases (Wassmann et al., 2004), escalating shortage of man-power (Devkota et al., 2019a,b), and allied augmented pays (Sudhir-Yadav et al., 2017; Bandumula et al., 2018). Together, these vagaries have amplified the workload of women (Akter et al., 2017), resulted into higher production cost and condensed profitability (Ditzler et al., 2018).

Furthermore, plant population is reasonably low in manual transplanting method, which forces the farmers to use additional nitrogenous fertilizer to boost tillering, which usually outcomes in multifarious biotic stresses and eventually lower yields. Gill and Walia (2013) opined that yield determinants like length of panicle and 100 grain weight were statistically at par among different establishment methods in rice, but number of grains panicle⁻¹ was significantly higher with machine transplanted rice.



At present Indian agriculture is tremendously suffering due to lack of manpower in general and skilled manpower in particulars. Immigration of agricultural labourer to the urban areas, non-farm employment openings having exciting remunerations and low eminence in the society are the major reasons for labour crisis during peak sowing time. As a result crops are not sown or planted timely. Delayed sowing or planting actually expose the crops against unfavourable climatic condition and prevalence of pest attack which leads to lower production. To ensure planting at right time and also to achieve ideal plant population mechanical transplanting had been found encouraging choices for attaining maximum yield (Tripathi et al., 2004; Manjunatha et al., 2009). Incremental grain yield with self-propelled walk behind type and self-propelled four wheels type transplanters over conventional method was noticed by Manesh et al. (2013). Baldev et al. (2013) noted 3 to 11% yield advantage by machine transplanting as compared to conventional puddled transplanted rice. Pasha et al. (2012) also found higher grain yield of rice with yangi eight row transplanter over conventional transplanting owing to more tillering ability, filled grains panicle⁻¹ and more number of panicle hill.

Among all agro-techniques inducing grain yield of mechanically transplanted rice, age of seedling is the most significant aspect (Shen et al., 2006). Seedling age less than 25 days is considered ideal for achieving higher yield in mechanical method. Accurate running of the transplanters and lessening root damage, three weeks old seedling were found appropriate (Aswini et al., 2009). Significant yield reduction had been noticed whenever transplanted aged seedling through mechanical method (Islam et al., 2008; Liu et al., 2015; Liu et al., 2017). So in order to achieve good yield and impressive return proper land preparation and timely transplanting are the keys of success under mechanical method. In spite of having superiority over the conventional transplanting method, small land holding and feeble financial status of the Indian farmers are the major shortcomings for the adoption of this technology.

This review scrutinizes the affirmative and deleterious impression on yield and economic of mechanized rice production.

2. Related Literatures

2.1. Effect of plant population

Optimum plant population is one of the most significant factors for attaining maximum yield. In manual transplanting, 30-40 days old root eroded seedlings are used while root washed and soil attached seedlings are used in mechanical transplanting. The soil adhered with seedling works as connecting components, which assists to uphold homogeneity, seedlings establishments, minimize transplanting tremor and inhibits floating, which are the key criterion for mechanical transplanting. Transplanting at proper depth and distance actually helps in maintaining optimum population by

mechanical method (Singh and Vatsa, 2006). In order to achieve optimum plant population for higher yield and to curtail labour necessity mechanical transplanting appears to be most suitable way (Farooq et al., 2001; Tripathi et al., 2004).

2.2. Effect on growth attributes

It is established fact that, transplanting at proper time, depth and distance by mechanical transplanter helped in quick establishment and thereby enhanced cell division and enlargement which results in higher plant height as compared to conventional method (Singh and Rao, 2010; Kang et al., 2019). Timely transplanting along with correct spacing through mechanical method promotes leaf emergence and expansion. Higher number of leaves and larger leaf area ultimately helped in synthesis of more photosynthesis and thereby more dry matter accumulation (Kang et al., 2019).

In order to achieve more dry matter with better apportioning towards panicle followed by stem and leaf, transplanting of 25 days old seedling was ideal (Vijayalaxmi et al., 2016). Gangwar et al. (2008) found higher shoot and root dry matter of rice under wet bed drum seeding method compared to manual and mechanical transplanting. Roots of wider spaced rice grow mechanically have encountered minimum competition over traditional method and thereby growth is activated by solar radiation and create enough space for canopy development (Rajesh and Thanunathan, 2003).

2.3. Effect on yield attributes

Among the yield attributes, number of effective tillers m⁻², panicle length, number of filled grains panicle⁻¹ and test weight are the dominant parameter contributing grain yield. Highest number of effective tillers m⁻² was obtained in mechanically transplanted rice, due to transplantation of younger seedling (less than 25 days old) at proper distance and depth which minimized transplanting tremors and brings about early establishment and effectual exploitation of growth factors (Manjunatha et al., 2009). Mechanical transplanting improved number of panicles hill⁻¹ and fertile grains panicle⁻¹ (Sheeja et al., 2012).

Pasha et al. (2012) observed longest panicle (23.61 cm) and maximum number of grains per panicle (156) with machine transplanting in comparison with broad casting, drum seeding and conventional method of transplanting.

Sreenivasulu et al. (2014) reported that mechanical transplanting helped in improvement of yield attributes namely number of productive tiller, panicle length, number of grains panicle⁻¹ and test weight of rice over manual method (Figure 1).

2.4. Effect on grain yield

Final yield of crops are the collective contribution of yield determinants. Higher the yield attributes higher will be the yield. Incremental yield was witnessed in mechanical transplanting over conventional method, might be due to transplanting of younger seedlings with appropriate spacing



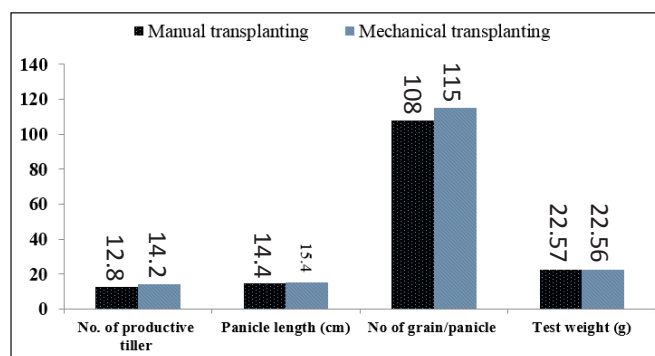


Figure 1: Comparative performances of yield attributes of rice under manual and mechanical method

and depth, which utilized the growth resources capably and facilitated enhanced translocation of photo assimilates from source to sink leading to higher number of productive tillers m^{-2} and thereby increased number of filled grains panicle⁻¹ and finally higher grain yield (Manjunatha et al., 2009; Kumar et al., 2012). 200-240 kg $acre^{-1}$ higher yield was obtained whenever transplanting was done mechanically over manual transplanting with the same levels of inputs (Farooq et al., 2001). Singh and Vatsa, 2006 was also found 30-35% yield advantage through mechanical method than hand transplanting. Mechanical transplanting augmented yield by 5.71% and 3.80% over manual and broadcast transplanting (Yao et al., 2000) might be due to early tillering, development of more panicles on earlier tillers, longer panicles, extended active leaf life and decreased rate of leaf area reduction.

Grain yield of 21 days old seedling transplanted mechanically and manually at a spacing of $30 \times 12 \text{ cm}^{-2}$ was found statistically similar (Kang et al., 2019). Under intensive rice-wheat system, delayed harvesting of wheat and adverse weather conditions along with lack of transplanter often causing seedlings to age. Transplanting of aged seedling with machine significantly resulted into lower grain yield compared to artificial transplanting due to reduction of tiller emergence, photosynthetic efficiency and assimilate remobilization efficacy (Liu et al., 2015).

Singh et al., (2006) reported that among the different methods of rice transplanting, mechanical method was found superior and offered 23.04%, 36.92% and 62.80% higher grain yield over manual, dry direct seeding and wet direct seeding respectively (Table 1).

2.5. Effect on economics

Success or failure of any technology depends on its economic feasibility. Conventional method of rice transplanting needs more man power in the operations like land preparation for seedling rising, uprooting of seedlings, carrying of seedlings to main field and transplanting over mechanical method (Sreenivasulu et al., 2014). More man power involvement in seed bed preparation, uprooting, transportation and planting ultimately heightened the total cost of cultivation in manual method. Mechanization with SRI technology minimized the

Table 1: Yields and harvest index of rice (variety: Saket-4) as influenced by different establishment methods

Planting methods	Grain yield ($t \text{ ha}^{-1}$)	Straw yield ($t \text{ ha}^{-1}$)	Biological yield ($t \text{ ha}^{-1}$)	Harvest index
Manual	4.34	4.72	9.06	0.480
Mechanical	5.34	5.52	10.86	0.492
Dry direct seeding	3.90	4.86	8.72	0.446
Wet direct seeding	3.28	4.54	7.82	0.420
CD ($p=0.05$)	0.190	0.512	0.575	0.025

seed and labour requirements to the extent of 50 and 60% respectively, thereby lessen the production cost by 27% and increase the earnings by $36\% \text{ ha}^{-1}$ (Upriety et al., 2010). Mechanical transplanting become profitable to adopt as it gives yield aids due to higher population stand (Farooq et al., 2001). Saving in labour cost in one hand and higher yield in another side helped in getting higher gross return, net return and benefit: cost (Mohapatra et al., 2012; Sheeja et al., 2012). Mohanty and Barik (2010) also reported 34.46% incremental benefit cost ratio in mechanical method over manual transplanting method.

Sajitha and Jayakaran, 2010 reported lower gross return in machine planting while net returns and B: C ratio was higher compared to line transplanting as of the low cost incurred in transplanting and nursery preparation. Pasha et al. (2014) was conducted an experiment during 2011-12 to evaluate the superiority of the diverse crop establishment methods in puddled rice and found that drum seeding gave the highest net return.

3. Conclusion

Mechanized transplanting can be used magnificently as an economic, practicable and alternative opportunity for attaining higher productivity and curtail the cost of farming as the traditional rice transplanting needs more workforce.

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