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Energy and economic assessment of manual and self-propelled rice transplanter

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Abstract
The energy and economic investigating of self-propelled rice transplanter and manually method of rice transplanting in the area of Sonpur, Chhattisgarh. The energy consumption for rice transplanting calculated by the use of standard formulas and the cost economy intended with the standard method. The data was collected with the reference of the field performance of different method of rice cultivation. Self-propelled rice transplanter has consumed 210 MJ/ha energy whereas the manual method consumes 470 MJ/ha energy. The cost of rice transplanting was Rs. 1145 and Rs. 6000 for self-propelled and manually method respectively.

Keywords: Transplanting, energy, cost-economics, self-propelled

Introduction

Rice (*Oryza-sativa*) is one of the most important crops of India growing over an area of 43.2mha with the production of 110 Mt according to the annual report 2017-18, Ministry of Agriculture and Farmer Welfare, GoI. The demand for rice in India to be increased 156 Mt by 2030. (ICAR, 2010). Harvesting of the rice in Chhattisgarh is in around 3.61mha with a production of 5.48 Mt and a productivity of 1517 kg per ha. Chhattisgarh is popularly known as the "Rice Bowl" of India. To meet the demand of rice is the major challenge for our government and scientist of India. The demand of rice is to be fulfilled by producing more rice in less land, optimum use of the energy inputs and farm mechanization (Jain *et al*., 2019) [11].

The energy requirement in the agricultural sector depends on the level of mechanization, cropping pattern, climatic condition, size of land and types of soil. All of them the mechanization is perform the lead role in agricultural energy management. Agriculture uses large quantities of locally available non-commercial energy, such as manure and animal energy, and commercial energy, directly and indirectly in the form of seed, diesel, electricity, fertilizer, plant protection chemicals, irrigation water, machinery, etc. (Singh, 2002; Alam *et al.,* 2005) [2, 3].

Manual transplanting is tedious, tiresome and labour consuming because a person has to stand in a puddled field and bending posture for many hours for putting seedling into the soil by hand. Manual transplanting is one of the labour-intensive operation comprising of nursery raising, uprooting of the seedlings and transplanting them in the main field, with total labour requirement of about 280-350 man-hours/ha. Some of the postures, taken by them were very harmful, but they were compelled to adopt those postures during work for a long time. During transplanting, the workers adopt a strongly bent posture in the muddy field for a long time. In all the tasks of rice cultivation are repetitive. So that the manually transplanting consuming more energy to transplant the rice plant (Guru *et al.,* 2018) [4]. The appropriate mechanization coupled with skill operators gives high productivity in agriculture. Mechanization means the introduction of impressed tools and implements that increase production and productivity with reduce the unit cost of production without drudgery and reducing the time of production. Mechanization can reduce the energy requirement into the farm who consumed by the labours (Dave *et al.,* 2000) [5].

In this study, we calculated the energy input in the operation of transplanting for the production of rice in the area of Sonpur, Block-Patan, District-Durg, and Chhattisgarh. To compare the energy consumption and cost economics in self-propelled rice transplanter and manually transplanting with objective of the energy and cost of the rice transplanting.

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Methodology

The study was conducted at the farm of the Sonpur village. The field performance of the self-propelled 8-row transplanter was evaluated. In terms of overall dimensions, weight of the machine, planting speed, row to row and plant to plant spacing was evaluated and calculating. The technical specification of self-propelled rice transplanter is shown in Table-1.

Energy Calculation

The energy input of both mechanical and manually operation of rice transplanting was calculating using relevant energy equivalent shown in Table-2. The data was converted into a suitable energy unit and express in MJ/ha. The following formulas were used for energy calculation. (Nguyen *et al*., 2016) [10]

- Fuel Energy-
- $E_{fuel} = h \times FC \times FE_q$
- Labour energy-
- $E_{labour} = (\text{No. of labour} \times \text{Time} \times H_q)/ \text{Area}$
- Machine Energy-
- $E_{machine} = (W \times ME_q \times h)/L$

Table 1: Technical specification of self-propelled rice transplanter

Model	Yanji Shakti 8 row self- propelled rice transplanter; Model 2 ZT-238-8
Overall dimension L x W x H (mm)	2410 x 2290 x 1200
Weight (kg)	320
Power unit	2.94 KW(4HP) single cylinder air cooled diesel engine
Planting speed (km/h)	1-2
Road traveling speed (km/h)	8.2
Number of rows	8
Row spacing (mm)	238
Distance between hill (mm)	140-170
Growing density of seedlings hills/m^2	34-42
No. of seedlings per hill, (adjustable)	3-8
Width of seedling mat (cm)	22
Planting depth, (cm, adjustable)	2-6
Capacity (m^2/h)	1300-2000

Where, E_{fuel}, direct fuel energy use, MJ/ha; h, working hours per operation, h/ha; FC, average fuel consumption, l; FE_q, fuel energy equivalent, MJ/l. H_q, human energy equivalent. W, total weight of machine, kg; ME_q, machine energy equivalent, MJ/kg; L, life of machine, hr.

The fuel energy was calculated with measured fuel consumption and actual field capacity of the machine. The machine energy was estimated by the total weight of machine, a life of machine and total operating hour per operation.

Table 2: Energy equivalence of different inputs and outputs

Particulars	Energy equivalent (MJ/unit)	References
Human labour (h)	1.96	(Tabar *et al.* 2010) [9], (Mobtaker *et al.*, 2010) [8]
Diesel (l)	56.31	(Mobtaker *et al.*, 2010) [8],(Kumar *et al.*, 2018) [4]
Farm machinery (Excluding self-propelled) (kg)	62.7	(Mobtaker *et al.*, 2010) [8], (Pradhan *et al.*, 2015) [6]

Cost Economics

The economic analysis of self-propelled rice transplanter was calculated according to (Kamboj *et al.,* 2012) [12].

A. Fixed cost
a) Depreciation, Rs/h

$$D = \frac{C - S}{L \times H}$$

B. Interest, Rs/h

$$I = \frac{C + S}{2} \times \frac{i}{H}$$

C. Insurance, tax and housing cost Rs/h: 3% of purchase price

B. Variable cost
a) Repair and maintenance, Rs/h : 2.5% of purchase price
b) Fuel cost, Rs/h : Fuel price (Rs/l) × Fuel consumption (l/h)
c) Lubricants cost, Rs/h: 30% of fuel cost
d) Operator or labour cost, Rs/h: Number of day × Operator charges (Rs/day)

C. Total operating cost, Rs/h: Total fixed cost +Total variable cost

Where, C, the initial cost of the machine, Rs; S, salvage value, @10% of C; L, life of the machine, year; H, annual use, Hour and I, interest rate. The cost economics of self-propelled was estimated by the following assumptions shown in Table 3

Table 3: Assumptions of self-propelled for cost economics

Total initial cost (Rs.)	1,82,000
Expected life of machine (year)	10
Annually use of machine (days)	30
Fuel cost (Rs.)	80
Operating cost (Rs.)	300

Fig 1: Transplanting of rice in manual and mechanical method

Results and Discussion
The performance of the self-propelled rice transplanter was done in Sonpur village. The area of the experiment was 0.8 ha and performance was conduct in leveled and well-puddled field. The actual field capacity of the machine was found at 0.21 ha/h. the other parameters of the field test of machine are shown in Table 4.

The energy analysis of different methods of rice transplanting was estimated and compared. The total energy consumption by self-propelled transplanter is 210 MJ/ha and by manually energy consumption is 470 MJ/ha shown in Table 5. In the manual method, there was no indirect energy used in the process of transplanting. The energy consumption of self-propelled transplanter has included energy consumption by fuel energy, the total human hour for the operation of self-propelled and included machine own energy.

Table 4: Field test data of self-propelled rice transplanter

Sr. No	Parameters	
1	Total study area, (ha)	0.8
2	Speed of operation, (km/h)	1.433
3	Actual field capacity, (ha/h)	0.21
4	Theoretical field capacity, (ha/h)	0.27
5	Field efficiency (%)	77.79
6	Labour required, (man-days/ha)	6
7	Fuel consumption, (l/h)	0.522

The manually process was engaged 30 labours to cover 1 ha area for rice transplanting. That means 240 man-hours was consumed for covering the area of cultivation (Dave *et al*., 2000) [5]. Manually process consumed more time and more energy than self-propelled. It also has many limitations like planting laborers can suffer from back problems (health risk), difficult to get enough labor at peak periods to plant on time and difficult to maintain optimum spacing and uniform plant density, especially with random transplanting and contract labor.

Table 5: Energy inputs of mechanical and manual transplanting operation

Parameters	By Self-propelled (MJ/ha)	By Manually (MJ/ha)
Total Fuel Energy	47	-
Total Indirect Energy	47	-
Human Energy	10	470
Machine Energy	153	-
Total Direct energy	163	470
Total	210	470

The use of self-propelled transplanter provides economic benefits to the farmers over the manual transplanting methods because the total energy required for complete operation for transplanting with self-propelled was less than manually process. The operation with self-propelled consume less energy means less afford that can decrease the time and cost of the operation and save the energy of the farmers.

The economics of the mechanical rice transplanting and manually rice transplanting was calculated. The manual rice transplanting method is taken 240 h for covering the area of one hectare as compared to the self-propelled is taken 4.76 h. The labour charge for transplanting has Rs. 200 per day and driver charges Rs. 300 per day was taken. The variable cost and fixed cost are shown in Table 6.

Table 6: Cost economics of mechanical and manual rice transplanting

Particular	By Self-propelled (Rs)	By manually (Rs)
Fixed Cost	133	
Variable Cost	108	25
Total Cost per hour	241	25
Total Cost per hectare	1145	6000

Conclusions
The observation of the results shown that the energy consumption of the manually rice transplanting is more than double than self-propelled transplanting or mechanically transplanting method. As well as the cost of the transplanting is 81% lower in the self-propelled rice transplanting method. Results showed that the manually rice transplanting is a highly time-consuming process and more labour is required. In the peak season period, the availability of enough labour could very difficult. The result concluded that for improving our farmer's profitability and doubling the income in agricultural the mechanization must be required.

References
1. Indian Council of Agricultural Research (ICAR). Vision 2030. Indian Council of Agricultural Research, New Delhi, 2010.
2. Singh JM. On farm use pattern in different cropping systems in Haryana, India. M.S. thesis. Int. Inst. of Manage. Univ. of Flensburg, Flensburg, Germany, 2002.
3. Alam MS, Alam MR, Islam KK. Energy flow in agriculture: Bangladesh. American Journal of Environmental Sciences. 2005; 1(3):213-220. Doi:10.3844/ajessp.2005.213.220.
4. Guru PK, Chhuneja NK, Dixit A, Tiwari P, Kumar A. Mechanical transplanting of rice in India: status, technological gaps and future thrust. *Oryza*. 2018; 55(1):100-106.
5. Dave AK, Thakare SK, Shahare PU. Report on Status and Strategies of Farm Mechanization in Rajasthan. Department of Farm Machinery and Power Engineering College of Technology and Engineering, Maharana Pratap University of Agriculture and Technology, Udaipur-313001, 2000
6. Pradhan P, Naik PK, Sahu M, Thakur C. A Study on the Energy use Pattern and Cost of Production under Transplanted Paddy Production System in Chhattisgarh, India. International Journal of Engineering Research And, 2015, V4(07). https://doi.org/10.17577/ijertv4is070812
7. Kumar U, Thakurz TC. Performance evaluation of a conventional field baler for collecting paddy straw after combining. Agricultural Engineering Today. 2006; 30(5&6):16-24.
8. Mobtaker HG, Keyhani A, Mohammadi A, Rafiee S, Akram A. Agriculture, Ecosystems and Environment Sensitivity analysis of energy inputs for barley production in Hamedan Province of Iran. "Agriculture, Ecosystems and Environment". 2010; 137(3-4):367-372. https://doi.org/10.1016/j.agee.2010.03.011
9. Beheshti Tabar I, Keyhani A, Rafiee S. Energy balance in Iran's agronomy (1990-2006). Renewable and Sustainable Energy Reviews, 2010. https://doi.org/10.1016/j.rser.2009.10.024
10. Nguyen HV, Nguyen CD, Tran TV, Hau HD, Nguyen NT, Gummert M. Energy efficiency, greenhouse gas

emissions, and cost of rice straw collection in the mekong river delta of vietnam. Field Crops Research. 2016; 198:16-22. https://doi.org/10.1016/j.fcr.2016.08.024

11. Jain A, Chaudhary JL, Beck MK, Kumar L. Developing regression model to forecast the rice yield at Raipur condition. Journal of Pharmacognosy and Phytochemistry. 2019; 8(1):72-76.

12. Kamboj, Parminder, Khurana R, Dixit A. "Farm Machinery Services Provided by Selected Cooperative Societies". Agricultural Engineering International: CIGR Journal. 2012; 14(4):123-33.