

Ergo-Economical Analysis of Different Paddy Transplanting Operations in Eastern India

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Abstract: Transplanting of paddy is very tedious job mostly done by female workers during Kharif season and by 2020 there would be 50 percent women against 42 percent at present. Manual hand transplanting consumes a lot of energy and time and full of fatigue, but the poor socio-economic condition of the farmers does not allow them to adopt power operated transplanter. Transplanting operation by different research centres have been developed as 2 row, 3 row, 4 row paddy transplanter. Keeping this in view fifteen female subjects were selected in the age group 18-45years in the central farm of OUAT. The mean value of age, weight, height, VO₂ max and Body surface area were found to be 31.1 years, 51.7 Kg, 153 cm, 1.71 l/min and 1.52 m². Physiological parameters like Heart rate, Oxygen consumption rate and Relative cost of workload were measured in different transplanting operations. The mean value of working heart rate was observed to be maximum 137.4 beats/min in 4 row paddy transplanter followed by 130.8 beats/min in 3 row transplanter and 127.7 beats/min in 2 row transplanter and 113.4 beats/min in local transplanting. The Oxygen consumption rate and Relative cost of workload were observed to be maximum 1.10 l/min and 64.3 percent in 4 row transplanter followed by 1.02 l/min and 59.6 percent in 3 row transplanter followed by 0.9 l/min and 57.8 percent in 2 row transplanter and lowest in local practices, i.e. 0.5 l/min and 33.4 percent. The field capacity was observed to be maximum 0.016 ha/h in 4 row transplanting followed by 0.014, 0.011, 0.009 ha/h in 3 row, 2 row and local method of transplanting. The cost of operation was observed to be Rs.2237 per ha in 4 row, Rs.2346 per ha in 3 row, Rs.2484 per ha in 2 row paddy transplanter and Rs.2550 per ha in local practice of transplanting. The 3 row paddy transplanter was observed to be the best among all manual operated paddy transplanters.

Key words: Transplanter, Working Heart Rate, Oxygen Consumption Rate, Rest pause, Relative cost of workload

I. Introduction

Farm women perform hard physical work in planting crops with care and maintenance, harvesting and processing, marketing and bartering of product simultaneously (Samants, 1995). Presently workers engaged in various agricultural activities in our country and it's around 242 million. By 2020, the ratio of agricultural workers to the total workers is expected to decline to 40 percent from 52 percent, though the total number would remain the same (Gite, 2012). From these about 50 percent would be women against 42% at present. In paddy cultivation transplanting is very drudgerious operation in overall paddy cultivation processes and 22.3 percent of total time is spent in this operation. Generally it is found that the production increases 10-12 percent in transplanting from direct sowing. In India several attempts have been taken to mechanize this transplanting operation by introducing various transplanters and this research is under progress to improve the cost of production with less fatigue. In OUAT two row transplanter and three row transplanter have been developed for female workers. Therefore the study is conducted to compare the ergo-economical suitability of different transplanters (two row transplanter, three row transplanter, four row transplanter) with local hand transplanting procedure. The human physiology study is done to compare the comfortness of mechanical transplanters with local transplanting. Generally a female worker has 2/3rd of energy of male worker (Satpathy and Mohanty, 2005). The local transplanting requires frequent bending down and straighten up for transplanting process where as mechanical transplanter require energy for pulling the transplanter in puddled field.

II. Material and Methods

This study was done at OUAT central farm in the month July-August. For Physiological data at first the HR_{rest}, VO₂_{rest}, BSA, BMI, weight, age of the workers were measured and the mean value was considered for ergonomic evaluation. The fifteen selected subjects are in the age 18-44 and their body weight varies from 45- 59 kg. The transplanting operation was done for 10 A.M. to 1.30 P.M. and 3 P.M. to 5 P.M. before going to field their HR_{rest}, Body Mass Index, Body Surface Area, and Volume of oxygen uptake were measured at lab. The operation was done in continuous transplanting for 30 minutes and taking 10 minutes break. After 30

minutes of continuous operation Blood Lactate Accumulation, HR work, Energy Expenditure, RCWL were measured.

A. Selection of subject and field

The selected fifteen subjects were in the age group of 18-45 years as at this age maximum strength can be utilised they cover the 5th to 95th physical characteristics of total female population. The test was conducted in OUAT central farm which is of sandy loam soil and the test was conducted at about 32-35^o c temperature and 72-75 percent humidity. The details of physical parameters are placed in table 1 below.

Table 1: Physiological parameters of selected subjects (N=15)

Physical and Physiological Parameters	Range	Mean	Std. Deviation
Age, Years	15-45	31.1	8.06
Weight, Kg	45-59	51.7	4.91
Height, cm	142.1-163	152.3	7.61
HR rest, beats/min	65-76	70.3	3.17
HR max, beats/min	176-200	188.2	7.27
VO ₂ rest, l/min	0.16-0.24	0.19	0.02
VO ₂ max, l/min	1.56-1.81	1.71	0.08
BSA, m ²	1.37-1.69	1.52	0.12
BMI, Kg/m ²	20.5-23.25	22.32	0.82
Blood Lactate Accumulation (Mm/l of blood)	0.9-1.3	1.2	0.08

B. Calibration of subjects

The selected subjects are calibrated in laboratory before conducting the test. To know the maximum heart rate, maximum oxygen consumption, heart rate at rest the subjects were undergone treadmill test. The average value of fifteen subjects was taken as representing value for working duration. The heart rate was measured by Polar heart rate monitor and oxygen uptake was measured by Metamax-II. The Energy Expenditure was calculated by the formula

$$EER = VO_2 \text{ consumption} \times 23.96 \text{ (Varghese M.A.,1994)}$$

The detail of specifications of 2 row, 3-row and 4 row transplanter are placed in Table-2.

Table-2: Specification of different transplanters

Sl. No.	Details	Specifications		
		OUAT 2- row transplanter	OUAT 3-row transplanter	CRRI 4-row transplanter
1	Name	OUAT 2- row transplanter	OUAT 3-row transplanter	CRRI 4-row transplanter
2	Type	Manual using mat type seedling	Manual using mat type seedling	Manual using mat type seedling
3	Dimensions(L×W×H)	630×600×400	600×600×940	910×565×655
4	Weight ,Kg	16	18	24
5	No. of rows	2	3	4
6	Row spacing, cm	24	24	24
7	Planting depth	3-4	3-4	3-4
8	No. of hills per square meter	30-35	30-35	30-35
9	No. of seedlings per hill	2-5	2-5	2-5
10	Field capacity(ha/h)	0.008	0.01	0.02
11	Force Requirement	108 N(11 kgf)	145 N(14.8 kgf)	183 N(18.6 kgf)
12	Field efficiency	50-60%	50-60%	50-60%
13	Cost of transplanter	Rs.5500/-	Rs.7000/-	Rs.9000/-

III. Result And Discussion

A. Physical and Physiological characteristics of female subjects:

The mean heart rate of subjects at rest is found in the range 65 to 75 whereas the mean value was 70.28 and the corresponding oxygen consumption was 0.19 l/min. The maximum oxygen consumption of female subjects were found to be 1.71 l/min and lies in the range 1.55-1.80 .The mean body mass index was found to be 22.3kg/m² and body surface area was 1.52 m² which shows that the workers were of normal health.



Fig 1: Manual line transplanting

B. Comparative Ergonomical Evaluation of different transplanter with manual transplanting:

The ergonomical parameters of the female subjects changed according to the type of transplanting procedure from rest value after 30 minutes of work. These values were given in the Table-3.

Table 3: Variation of Ergonomical parameters

	Local Practices	2-row transplanter	3-row transplanter	4-row transplanter
HR _{rest} (beats/min)	70.3	70.2	70.6	70.7
HR _{work} (beats/min)	113.4	127.7	130.8	137.4
Work pulse (beats/min)	43.0	64.6	58.2	67.0
VO _{2 rest} (l/min)	0.19	0.20	0.20	0.20
VO _{2 work} (l/min)	0.5	0.9	1.02	1.10
EER,kJ/min	11.8	20.7	21.3	22.17
RCWL(% of VO ₂ max)	33.4	57.8	59.6	64.3
Area coverage, ha/day	0.03	0.065	0.08	0.10
Man days/ha	17	16.6	11.3	8.5
Continuous operating Time,min	56	32	28	17



Fig1: 2-row transplanter

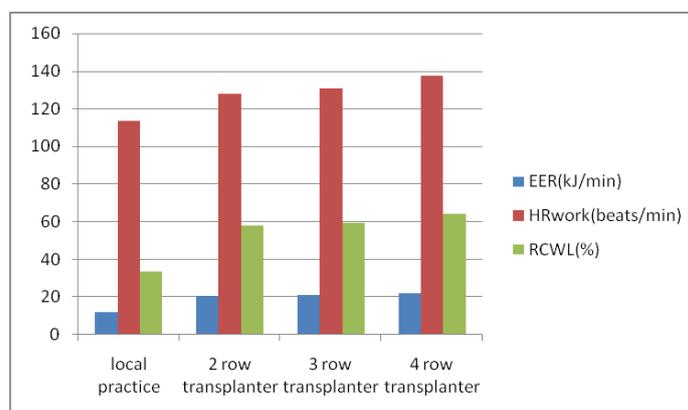


Fig2: 3 row transplanter



Fig3: 4 row transplanter

Physiological response parameters changed due to work represents the level of fatigue or comfortness in a comparative way and according to these how much the workers can work efficiently. The table shows that the heart rate during work increases successively from the resting value 70.28beats/min for local practices (113.4beats/min), 2-row transplanter(127.7 beats/min), 3-row transplanter (130beats/min) and for 4-row transplanter (137.4beats/min) .Likewise the volume of oxygen consumption during work increased to 0.5 l/min for local practice, 0.9 l/min for 2-row transplanter, 1.0l/min for 3-row transplanter, 1.1 l/min for 4-row transplanter from the resting value. The work pulse in local practice is minimum and in three row transplanter it's lower from two row transplanter. The variation in these values is represented in the graph.



From this graph it is visible that the energy expenditure rate for four row transplanter is the highest followed by 3 row, 2 row and manual practice . So the working heart rate is optimum in case of 4 row transplanter than the others. This higher energy expenditure results in fatigue after a small period of time where as lesser working heart rate results more effective time of work.

C. Economics of transplanting methods:

The annual fixed cost and variable costs were calculated by depreciation method by taking the purchase cost, annual uses of transplanter and life of machine. The daily wage of workers was taken to be Rs.150 with ten minutes break in every half an hour. The cost of operation per hectare were found to be Rs.2550 for local practice where as Rs.2484 for 2 row transplanter, Rs.2346 for 3 row transplanter and Rs.2237 for 4 row paddy transplanter. It was observed that while transplanting manually in bending posture the average area transplanted is 0.03 ha/day. But maximum 0.10 ha/day in case of 4 row paddy transplanter followed by 0.08 ha/day in 3 row and 0.065 ha/day in case of 2 row paddy transplanter.

IV. Conclusion

The ergo-economic analysis of different paddy transplanting methods revealed that the physiological response reduced in 2 row paddy transplanter from that of 3 row & 4 row paddy transplanter. The HR_{work} , ΔHR , OCR, RCWL were reduced from 137.4 beats/min to 127.7 beats/min, 67 beats/min to 58.2 beats/min, 1.10 l/min to 0.9 l/min, 64.3 percent to 57.8 percent from 4 row transplanter to 2 row transplanter. More force in pulling the transplanter in forward direction by female worker was obtained which was 183 N (18.6 kgf) in 4 row and lowest 104 N (11 kgf) in 2 row paddy transplanter. The average transplanting area was recorded minimum 0.03 ha/day in manual method of transplanting & 0.10 ha/day in 4 row transplanter. The continuous working time was recorded 17 minutes in 4 row transplanter, 28 minutes in 3 row and 32 minutes in 2 row transplanter. The cost of operation per hectare was calculated to be maximum Rs.2550 in manual transplanter and Rs. 2237 in 4 row transplanter. Keeping all the physiological and economical parameters into consideration the 3 row paddy transplanter was found to be the best among all transplanting methods.

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