

Physiological cost and drudgery in paddy transplanting

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■ **ABSTRACT** : The field experiment was conducted at agronomy field DBSKKV, Dapoli, on the traditional method of paddy transplanting and manual paddy transplanter. Eight male and seven female workers were participated in this activity. The mean working heart rate (WHR) during traditional method of paddy transplanting for male and female subject were 105.9 (± 4.01) and 106.97 (± 3.39) bpm, respectively, While mean WHR for male workers with manual paddy transplanter was 128.44 (± 12.38) bpm. The field capacity for traditional method of paddy transplanting for male and female workers were 0.0040 ha/h (40 m²/h) and 0.0038 ha/h (38 m²/h), respectively. The workloads for male and female workers was "Moderately heavy" for traditional method of paddy transplanting. The field capacity and field efficiency with manual paddy transplanter were 0.020 ha/h and 47.75 per cent, respectively, with 21(DAS) nursery. The workload was "heavy" for manual paddy transplanter. Hence, the field capacity with manual paddy transplanter was 5 times more as compared to traditional method of transplanting. The working heart rate (WHR) with manual paddy transplanter for male workers was 0.82 more as compared to traditional paddy transplanting.

■ **KEY WORDS** : Physiological cost, Drudgery, Paddy transplanting, Manual paddy transplanter, BPDS, ODR

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India is predominantly an agricultural country with rice as one of its main food crop. India has largest area under rice (43.90 million ha) with the production of about 106.5 million tones, it ranks second only to china with the productivity of about 2180 kg/ha during the year 2014-2015 (Anonymous, 2015). Industrialization has released millions of agricultural workers in the industrial sectors, which reduced level of manpower and increases the burdens on the worker. All current methods of producing rice depend largely on availability of manual labour.

Rice is dominantly grown by transplanting of seedlings. Transplanting refers to the planting of 20-22 days old seedlings of 12-15 cm height under wet land

condition. The seedlings are raised in nursery and uprooted for transplanting. Transplanting helps the plant to have better start over the weeds hence results in less growth of weeds. Also transplanting is having benefits like proper leveling of land, reduced weed problem, uniform plant population and better availability of most of the plant nutrients. Transplanting can be done manually or by using transplanters. In a traditional method person puts 2-3 seedlings per hill in the puddled soil at the depth of 3-5 cm. On an average, a worker dips finger 3,50,000 times to transplant one hectare of land and can transplant only 0.016 ha/day. Traditional Rice transplanting is tedious and very time consuming job requiring about 250 to 300 man-hour/ha, which is roughly 25 per cent of the overall

labour requirement for cultivation of paddy crop. Manually operated (stroke type) transplanter (CRRI, Cuttok and CIAE Design) requires mat type of nursery. The acceptability of stroke type transplanter is dogged by its unsatisfactory performance. In case of mat type of nursery farmers generally hesitate to go for the special type of nursery, with additional time and cost involved and apprehension about certainty of its success. Whereas, despite of satisfactory performance of power operated transplanters, their suitability is limited to big size plots with plain topography. Hence, power operated transplanters are not suitable as such considering the undulating topography, fragmentation of land, transportation issues, economic constraints of the farmers etc. One of the promising options for paddy transplanting in hilly region like Konkan is the hand cranking type transplanter which transplants root washed seedlings which are traditionally being grown by the farmers. Being traditionally carried out and performed with manually operated equipment, the physiological cost and drudgery involved in paddy transplanting is to be studied.

■ METHODOLOGY

Calibration of subjects and VO_2 max :

This study was carried out at Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth Dapoli, Dist. Ratnagiri (MS) during the year. Eight male and seven female (subjects) were participated in the study. All the subjects were at par as far as experience of paddy transplanting work is concerned. The details as age, stature and weight of each individual subject were noted and averaged. Accordingly, for male subjects the average age, weight and stature were 30.7 (± 7.34) years, 63 (± 9.07) kg and 167.5 (± 8.24) cm, respectively, whereas those values for the female subjects were 29 (± 8.18) years, 56.8 (± 7.61) kg and 158.8 (± 6.44) cm, respectively. The maximum strength or power can be expected from the age group 20 to 35 years (Gite and Singh, 1997). Hence, subjects were selected within this age group. The maximum heart rate (HR max) for each subject was calculated by using the following equation :

$$HR \text{ (max)} = 220 - \text{age in years} \quad \dots(1)$$

For determination of maximum aerobic capacity (VO_2 max) for male subjects, their laboratory calibration was carried out. It involved establishing the relationship

between, the (HR) and Oxygen Consumption Rate (OCR). Male subjects were asked operate the bicycle ergometer (839 E, Monark, Sweden). The HR and OCR are measured with mobile breath by breath metabolic system (K_4b^2 , COSMED, Rome Italy). All the participated subjects were asked to report in the laboratory 30 min before the actual calibration. It was confirmed that everyone had breakfast and good sleep in previous night. It was also ensured that everyone was free from the influence of stimulants such as alcoholic, drinks, cigarettes etc. and has no cardiac disease. After reporting, subjects were asked to take rest for 30 minute sitting on chair/stool in the laboratory. To allay the apprehension, the subjects were provided sufficient practice of breathing through the K_4b^2 mask. The average dry bulb temperature and relative humidity during the test were 26°C and 84 per cent, respectively. The saddle height of bicycle ergometer was kept such that the subject's leg was almost straight at knee when the pedal was at lowest position. The subject was asked to pedal the bicycle at a pedalling rate of 50 rpm. Pedalling speed was maintained using visual metronome on the bicycle which was continuously visible on the computer screen. The manual protocol was developed in which workload was automatically increased by 15 W at an interval of 2 min through software. In order to avoid any risk, each subject was asked to operate the ergometer upto his HR reaches to 75 per cent of HR max (target HR). If subject was willing to continue the test beyond target HR, he was allowed. The measured values of HR and OCR which were per breath for individual subject were averaged using software so as to convert the data of a minute interval. The calibration chart between HR and OCR for each individual were plotted. The correlations between heart rate and oxygen consumption rate for each subject were also developed. The VO_2 max was determined by extrapolating the calibration chart up to HR max. The calibration charts/correlation equations were used to predict the OCR for particular value of HR recorded during the field work. The Energy Expenditure Rate (EER) was calculated as,

$$EER = OCR \times 20.88 \text{ (20.88 kJ/l is calorific value of oxygen)} \quad \dots (2)$$

However, EER in case of in case of women subject, the equation developed by Varghese *et al.* (1994) was directly used as given below,

$$\text{EER (kJ/min)} = 0.159 \times \text{HR (beats/min)} - 8.72 \quad \dots (3)$$

The details of male subjects, their HR max and VO₂ max are given at Table A.

Physiological cost and drudgery in traditional method of paddy transplanting :

Traditionally, paddy transplanting is carried out by men and women workers in groups. The root washed seedlings are transplanted in the puddled field. It is very cumbersome work as performed in the bending posture. The seedlings are held in one hand and pushed in the puddle by the other hand. It is performed by the groups of workers standing in a straight line made by the string tied along the bunds. Once one row is completed, the group walk back to transplant the second row and so on. The photograph of traditional method of transplanting is shown at Fig. A and B. Hence, standing and walking (back) in the puddle, performing the task in the bending

posture increases the work stress. Ergonomic evaluation was conducted with male and female subjects. Heart rate monitor (Polar, RS 400™) was used for recording heart rate values in bpm. Standard protocol was followed for recording the heart rates. Each subject was given 30 minutes rest (sitting in shade) before starting of trial. Each trial was started taking 10 min resting heart rate data of the subject. The average resting heart rate (HR) was computed and recorded for each subject. After resting each subject was asked to perform planting operation for 15 minutes, during that period heart rate values were recorded. The recorded heart rate values were downloaded to the computer. The average heart rate from 6th to 15th min. of operation was used as working heart rate (WHR) for the further calculation and analysis. The same procedure was adapted to all the selected subjects.

The EER for male and female were calculated using

Table A : Subject details and VO ₂ max			
Sr. No.	Particulars	Male	Female
1.	No. of subjects	8	7
2.	Mean age, years	30.7 (±7.34)	29 (±8.18)
3.	Mean stature, cm	167.5 (±8.24)	158.85 (±6.44)
4.	Mean weight, kg	63 (±9.07)	56.83 (±7.61)
5.	Range of HR max, bpm	175 to 197	178 to 197
6.	Mean HR max, bpm	189.25 (±7.34)	191 (±8.18)
7.	Range of VO ₂ max, l/min	1.957 to 3.067	-
8.	Mean VO ₂ max, l/min	2.62 (±0.38)	-



Fig. A : Traditional method of paddy transplanting

equ. 2 and 3, respectively. The acceptable workload (AWL) for Indian workers was the work consuming 35 per cent of the VO_2 max (Saha *et al.*, 1979). Hence, the AWL determined for each subject. The increase in HR during working over that of during resting (WHR-RHR) is Δ HR also known as work pulse was calculated for each subject. Also, the work stress was quantified using the subject rating scales *viz.*, overall discomfort rating scale (ODR) *i.e.* a 10 point rating scale (0 - no discomfort, 10 extreme discomforts) was used. And for body part discomfort score (BPDS), the standard protocol as suggested by Corlett and Bishop (1976) was followed.

Physiological cost and drudgery paddy transplanting with manual transplanter :

The experiment was conducted in paddy field of Department of Agronomy, DBSKKV, Dapoli, during year 2015-2016. The manual paddy transplanter (hand cranking) was used for the present study. The details of which are given at Table B. The details about the available transplanter are as follows.

Initially, the manual paddy transplanter was tried with female subjects, but they were not even able to operate it. The reason was the high physiological demand of the transplanter. Hence, it was tested with only male eight subjects as, detailed at Table A. The resting heart rate (RHR), Working heart rate (WHR), was determined as explained earlier using and following the standard protocol for each subject using polar heart

Table B : Detailed specification of manual paddy transplanter (hand cranking)

Sr. No.	Particulars	Specifications
1.	Weight, kg	18 kg
2.	Length, mm	750
3.	Width, mm	450
4.	Height, mm	900
5.	Row to row distance, mm	250
6.	Float type	Wooden
7.	Power transmission	Chain and sprocket
8.	No. of rows	2

rate monitor. Oxygen Consumption rate (OCR), (Δ HR), and Limit of continuous performance (LCP) were predicted from calibration charts. Energy expenditure rate (EER), Overall discomfort rating (ODR), and Body Part Discomfort Score (BPDS), were determined as explained in the previous section. The Physiological parameters observed during traditional method of paddy transplanting for male and female are given at Table 1.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Physiological cost and drudgery in traditional method of paddy transplanting :

The mean working heart rate (WHR) during



Fig. B : Paddy transplanting using manual paddy transplanter

Table 1 : Comparative physiological cost and drudgery involved in paddy transplanting

Sr. No.	Parameter	Traditional method of paddy transplanting		Manual paddy transplanter (hand cranking)
		Male	Female	Male
I	Subject details			
II	Physiological parameters			
1.	Working heart rate (WHR), bpm	105.9 (± 4.01)	106.97 (± 3.39)	128.44 (± 12.38)
2.	Δ HR, bpm	27.56 (± 3.43)	24.23 (± 5.55)	37.81 (± 8.44)
3.	Working OCR, l/min	0.86 (± 0.14)	-	1.29 (± 0.24)
4.	Energy expenditure rate (EER), kJ/min	18.09 (± 2.98)	8.28 (± 0.5)	27.13 (± 5.16)
5.	Limit of continuous performance (LCP).	27.56 (± 3.43)	24.23 (± 5.55)	37.81 (± 8.44)
6.	Overall discomfort ratings (ODR).	6.75	8	6
7.	Body part discomfort score, (BPDS).	24.71	30.25	17.06
8.	Areas of discomfort	Mid back, lower back, left leg, right leg, right forearm, left thigh, right thigh.	Mid back, lower back, left leg, right leg, and right forearm.	Left leg, right leg, left forearm, right palm.
9.	Energy grade of work	Moderately heavy	Moderately heavy	heavy
III	Field performance parameters			
10.	Field capacity ha/hr	0.0040	0.0038	0.020
11.	Field efficiency (%)			47.7

traditional method of paddy transplanting were 105.9 (± 4.01) and 106.97 (± 3.39) bpm, respectively for male and female subject. The mean EER for male and female workers were 18.09 (± 2.98) and 8.28 (± 0.5) kJ/min, respectively. The work pulse (Δ HR) were 27.56 (± 3.43) and 24.23 (± 5.55) bpm, respectively for male and female workers. Similarly, the ODR for male and female workers were 6.75 and 8, respectively. The mean BPDS for male and female workers were 24.71 and 30.25, respectively. The field capacity for traditional method of paddy transplanting for male and female workers were 0.0040 ha/h (40 m²/h) and 0.0038 ha/h (38 m²/h), respectively. The workload was classified as in the category of “Moderately heavy” (Verghese *et al.*, 1994).

Physiological cost and drudgery in paddy transplanting with manual transplanter :

The mean WHR, EER and work pulse (Δ HR) for male workers during transplanting with manual paddy transplanter were 128.44 (± 12.38) bpm and 27.13 (± 5.16) kJ/min and 37.81 (± 8.44) bpm, respectively. The mean ODR and BPDS were 6 and 17.06, respectively. The field capacity and field efficiency for manual paddy transplanter were 0.020 ha/h and 47.75 per cent, respectively, with 21(DAS) nursery. The workload was classified as in the category of “heavy”.

The physiological parameters of the male and female subjects according to the type of transplanting, these

values are given in the Table 1.

Conclusion :

Considering the physiological response and drudgery in paddy transplanting it is revealed for the data that, energy grade of work was more for manual paddy transplanting and paddy transplanting using manual paddy transplanter *i.e.* “moderately heavy” and “heavy”, respectively. The Energy expenditure rate (EER) was about 50 per cent higher in paddy transplanter as compared to traditional method, whereas, the ODR and BPDS were about 13 per cent and 45 per cent less in paddy transplanter as compared to manual paddy transplanting. This finding catches the attention on despite of higher physiological data in paddy transplanter. The ODR and BPDS values were less. The reason was that, working posture. The continuous bending causes the undue stress on the spinal cord, lower back, legs and knees. The field capacity with manual paddy transplanter was 5 times more as compared to traditional method of transplanting. The working heart rate (WHR) with manual paddy transplanter for male workers was 0.82 more as compared to traditional paddy transplanting.

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