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Ergonomic evaluation of manually operated single row manual vegetable transplanter

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Abstract

India is the second largest producer of vegetables after China. In India, transplanting of the vegetable seedlings of different crops depend completely on human labour. In changing scenario of agricultural mechanization, ergonomics plays crucial role for effectiveness of the operation. Therefore the study was undertaken to evaluate the single row manual vegetable transplanter on three different types of vegetable crops i.e., brinjal, chilli and tomato at two different sites and compare it with traditional method of transplanting on ergonomic basis and to work out the energy expenditure rate involved in the operation. The activity of work load was classified as moderate with maximum heart rate (112 beats/min) and energy expenditure (9.1 kJ/min) with single row manual vegetable transplanter. The activity of work load was classified as heavy with maximum heart rate (125 beats/min) and energy expenditure (11.15 kJ/min) with traditional method of transplanting. Mean value of overall discomfort rating, musculo-skeletal problem, rating of perceived exertion were also very less in comparison with traditional method of transplanting.

Keywords: manual vegetable trans planter, anthropometry, body dimensions, heart rate, energy expenditure drudgery; ergonomics; posture and fatigue

1. Introduction

Ergonomics is the scientific study of the relationship between man & his working environment that includes ambient conditions, tools, methods of work and organization of work. The performance of the trans planter not only depends on the constructional features but also on the workers operating it (Gite, 1997). Availability of database on anthropometric dimensions of the user population, and its customization for target groups is thus important. More than 50% of the working population in Jammu and Kashmir region is engaged in agricultural operations involving traditional manual activities associated with lot of drudgery and low efficiency. Equipments have not been designed for majority of the user population due to insufficient anthropometric data, and are liable to cause operational difficulties, fatigue and lower performance. Anthropometric measures vary considerably with factors such as gender, race and age. Considerable difference has been found in Indian and Western anthropometric data (Gite and Yadav, 1989). Verma *et al.* (2015) ^[6] conducted an experiment for improving efficiency and reduction in drudgery of farm women in weeding activity by Twin Wheel Hoe. Kawat *et al.* (2014) conducted economical study on different paddy transplantation methods in north India to compare the economic cost and the rate of human drudgery among female farm workers, during manual hand transplanting. Yadav *et al.* (2007) ^[8] conducted an experiment on ergonomic evaluation of manually operated six row paddy transplanter to work out the energy expenditure. Pradhan *et al.* (2014) ^[5] carried out a study to calculate heart rate, oxygen consumption and relative cost of work load

2. Material and Methods

The ergonomic evaluation of vegetable transplanter in comparison with manual method of transplanting was conducted to work out energy expenditure rate, overall discomfort rating musculo-skeletal problems, work load and force required during the operation. The subjects were acclimatized with experimental protocol and asked to take sufficient rest before start of the operation. Transplanting operations were replicated thrice by the subjects to avoid the error in data recording for three different vegetable crops namely, brinjal, chilli and tomato. Different parameters were recorded to carry out experiment are as under:

2.1 Subjects

Three healthy male operators based on age and medical fitness were selected for the study. The strength or power is expected to be maximum in the age group of 25 to 35 years

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(Grandjean, 1982., Gite and Singh, 1997). Hence subjects were chosen from the age group of 25 to 35 years. The

physiological characteristics and basic anthropometric data of selected subjects is given in table 1.

Table 1: Physiological characteristics of participants

S. No	Variable	Subjects		
		1 st	2 nd	3 rd
1	Age, years	24	29	27
2	Body weight, kg	72	69	70
3	Height, m	1.74	1.65	1.68
4	Resting heart rate, beats min ⁻¹	69	72	69

2.2 Overall discomfort rate (ODR)

ODR was measured on a 10-point visual analogue scale (0- no discomfort, 10-extreme discomfort) that is an adoption of a technique developed by Corlett and Bishop (1976) [3]. A scale

of 70 cm length was fabricated having 0 to 10 digit marked on it equidistantly (Fig. 1). A movable pointer was provided to indicate the rating. At the end of each trial, the subjects were asked to indicate their overall discomfort rating on the scale.

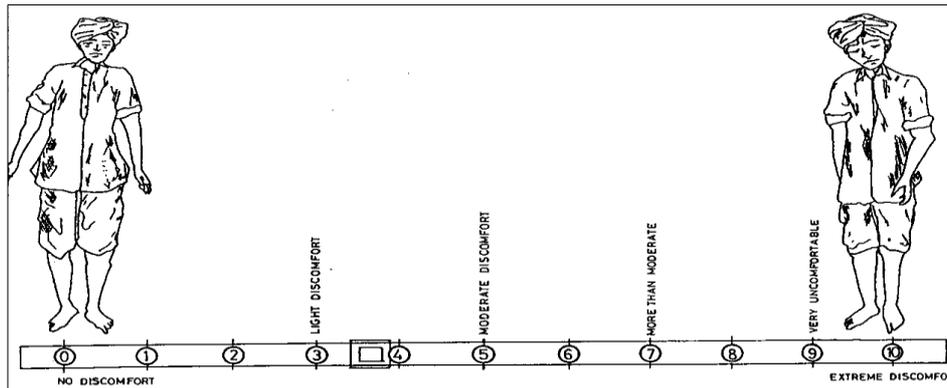


Fig 1: Visual analogue discomfort scale for assessment of overall body discomfort (Corlett and Bishop, 1976) [3].

2.3 Heart rate (beats min⁻¹)

Heart rate was recorded with the help of polar heart rate wrist watch before work at rest and during the work. The subjects were acclimatized with experimental protocol and asked to take sufficient rest before start of the operation and after 30 minutes of work with transplanting the heart rate was noted.

2.4 Energy expenditure rate (Kjmin⁻¹)

For calculation of Energy Expenditure Rate from heart rate, the Varghese (1994) [7] equation was used which is as follows:

$$\text{EER (kj/min)} = 0.159 \times \text{HR (beats/min)} - 8.72$$

2.5 Workload

The classification of workload during the transplanting period was done on the basis of average heart rate and average energy expenditure. Workload of activity was categorized as per the following classification of workload (Table 2) in different occupations proposed by Varghese *et al.* (1994) [7].

Table 2: Classification of workload.

Physical work load	Physiological variables	
	Energy expenditure (KJ/Min)	Heart beats (KJ/Min)
Very light	Up to 5.0	Up to 90
Light	5.0-7.5	91-105
Moderate	7.6-10.0	106-120
Heavy	10.0-12.5	121-135
Very heavy	12.6-15.0	136-150
Extremely heavy	< 15.0	Above 151

Source: Varghese *et al.* (1994) [7]

2.6 Musculo-skeletal problem (MSP)

Musculo-skeletal problems and posture were evaluated by asking the respondents as to where they felt pain in their body after transplanting with traditional method and vegetable transplanter.

3. Results and Discussions

3.1 Energy expenditure rate

Energy expenditure rate was calculated on the basis of maximum heart rate by using the Varghese (1994) [7]

equation. The maximum heart rate recorded was 112 and 125 beats min⁻¹ with traditional method and developed transplanter respectively. The energy expenditure calculated on the basis of maximum heart rate was found to be 9.1 and 11.15 kjmin⁻¹ with traditional method and developed transplanter respectively. Energy expenditure was higher in manual method of transplanting in comparison with vegetable transplanter as the continuous seating posture was eliminated with developed transplanter as shown in table 3.

Table 3: Basic anthropometric and physiological parameters of the subjects participated in studies

Subjects	Resting heart rate, beats min ⁻¹	Maximum heart rate(H _{Rmax}) beats min ⁻¹	Energy expenditure (KJ/Min)	Work load
Transplanter	70	112	9.1	Moderate
Manual	70	125	11.15	Heavy

3.2 Work Load

The activity was classified as moderate while using single row manual vegetable transplanter and heavy with traditional method of transplanting as the energy expenditure was reduced with developed transplanter. Farmers were comfortable while working with developed transplanter as they were relieved from back pain and standing posture added its advantage as shown in table 3.

3.3 Musculo-skeletal problems (MSP)

Musculo-skeletal problems and posture were evaluated by asking the respondents as to where they felt pain in their body after weeding with traditional and improved technology. Table 4 depicts that transplanting with traditional method in strenuous posture cause severe pain in shoulders, upper back, hands and fingers and the farmers perceived the task as heavy. On the contrary using single row manual vegetable

transplanter induced moderate discomfort and light pain in shoulders, hands and arms. They were relieved from back pain as standing posture eliminated continuous sitting posture and rating of perceived exertion was also reported as moderate with use the use of transplanter and heavy with tradition method of sowing.

3.4 Overall discomfort rating (ODR)

Transplanting is an activity where musculo-skeletal problems are very pronounced because the activity is time taking and performed continuously for prolonged hours. The traditional method employs continuous sitting posture which results in heavy work load and energy expenditure where as developed prototype was used in standing posture and thus resulted in less musculo-skeletal problem, energy expenditure and work load (Table 4).

Table 4: Overall discomfort rating (ODR), Responses on musculo-skeletal problems and perceived exertion experienced by respondents (RPE)

Transplanting method	ODR	MSP	RPE
Vegetable transplanter	4.0	Moderate to light pain in shoulder, upper and lower legs, and hands	Moderate
Manual method	8.0	Severe pain in shoulders, upper and lower back, hands neck and arms and fingers	Heavy

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