

Original Research Article

<https://doi.org/10.20546/ijcmas.2019.809.301>

Ergonomic and Workload Assessment in Weeding Operation Conducted for Wheat Crop for Male Respondents

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ABSTRACT

Keywords

Physiological variations, anthropometric dimensions, VO₂max

Article Info

Accepted:
24 August 2019
Available Online:
10 September 2019

The present findings focuses on the assessment of anthropometrical, physical and physiological characteristics undergone by male operators during weeding operation. The variations were measured prior to and after the commencement of weeding activity. The VO₂max and AWL was 27.59 mL/Kg min and 9.61 respectively. Assessment of physiological parameters includes average resting heart rate of the respondents which was reckoned as 101.33 bpm. The average working heart rate during weeding activity in case of hand hoe and wheel hoe was 112.33 and 108.83 (bpm) respectively. The average EER and OCR values were 8.19 kJ/min and 0.53 L/min in case of hand hoe and for wheel hoe it was 7.88 kJ/min and 0.51 L/min respectively. The average BPDS of subjects were ascertained as 25.4 and 21.4 for hand hoe and wheel hoe respectively. The subjects experienced light physical work in case of wheel hoe and moderately heavy physical work in hand hoe.

Introduction

Agriculture offers the basic means of income for majority of Indian farmers. The workers use various types of tools, equipment's and machinery for their day to day activities in the agricultural fields. Use of proper tools provides effective and sonorous results and hence it becomes utmost necessary to consider the human factor in the design of farm tools to enhance the operating efficiencies, working comfort and thereby improving the productivity of workers. Ergonomically designed equipment's/tools enhance the human operating efficiencies and comfort during its operation. The ergonomics being the branch of science is applied in every of field since it involves the aspects of man, machine and working environment. It, therefore plays a vital role in every workplace with the factor mainly focussing on the level of ease and safety to the subjects performing the desired operation in a particular work layout. Every field of science is somehow interconnected with the prospects of ergonomics and its related extent. Agriculture is also closely related to it since it constitutes a way to bring man (operator), machine (implement) and working environment (field). It is an imperative measure of operator's performance in carrying out any agricultural operation. It is regarded as the application of anatomical, physiological and psychological knowledge in the man, machine and environment. The workers use various types of tools, equipment's and machinery for their day to day activities in the agricultural fields. Use of proper tools provides promising and encouraging results and hence it becomes utmost necessary to consider the human factor in the design of farm tools to enhance the operating efficiencies, working comfort and thereby improving the productivity of workers. In keeping a view of this, the concern research deals with the ergonomic evaluation of male operators in weeding operation which

is performed by hand hoe (khurpa) and the wheel hoe. The performance of a weeder not only depends on the constructional features but also on the workers operating them. The performance of man-implement system may be poor, if ergonomics aspects are not given due attention. Tewari *et al.*, (1991) stated that the performance of the weeder is interpreted in terms of weeding efficiency and the grade of work relates to rating of workload while worker' comfort is the subjective assessment of operating posture. The physiological cost of work includes the heart rate (HR), oxygen consumption rate (OCR) and energy expenditure rate (EER). Ease of performing an operation affects the output of the worker.

Ergonomic evaluation is a tool to evaluate the energy expenditure of work, their physiological cost and suitability of the method for farm workers and how long they can work continue without getting fatigue (Kumar A. *et al.*,2013). Hence, to address these concerns of ergonomics in the field of agriculture to provide safe and comfort to the farmers and operators, the major thrust of the research findings is to assess the physical and physiological responses resulting in addition to the anthropometric dimensions and body part discomfort for the operators engaged in the farm operation.

Materials and Methods

The study was conducted at Agricultural farms, Department of Farm Machinery & Power Engineering, Vaugh Institute of Agricultural Engineering and Technology, Sam Higginbottom University of Agriculture, Science and Technology, Prayagraj (Allahabad).

The details of materials, procedures followed, and techniques adopted during the course of present investigation have been elaborated in this chapter under the following headings.

Experimental setup

Equipment employed for weeding activity which are taken into consideration

Hand hoe

Hand hoe used in weeding operation is khurpa. It is traditional weeding and inter-culture tool. It essentially consists of a blade attached to a ferrule. The blade is used to uproot the weeds. It consists of a wooden handle to manipulate it according to its necessity. It is usually operated by the rural labours to perform the weeding operation. The work rate of hand hoe is about 0.01ha/hr.

Wheel hoe

It is a manually operated weeder mostly used by both male and female operators owing to its high work rate of 0.05ha/h. It consists of a single sharp tyne blade and a single wheel to move hoe to a desired direction. It is operated in a standing posture which renders the operator more mobile.

Method – (In order to implement the experimental plan)

The ergonomic study was conducted in Agricultural farms, SHUATS, Prayagraj and its nearby villages. The anthropometric data of the selected operators was measured during the study. Weeding operation was carried out by hand hoe i.e. khurpa and wheel hoe at the desired site prescribed in the field of wheat crop with row to row spacing 0.95m.

Sixty male respondents in the age group of 25 to 50 years (i.e. 20-25, 25-30, 30-35, 35-40, 40-45 and 45-50) were selected. The mentioned age interval comprises 10 respondents. The operators were chosen at random to perform weeding operation by hand hoe and wheel hoe. Different replications (3

replications) were taken for the subjects during their performance by the listed hoes. These replications are performed on different days and each trial by each subject for each implement was 30min duration.

The subjects were selected on the basis of range of various age to conduct the evaluation of the performance from ergonomic point of view.

The past history of the respondents was considered with the intent to obtain the sonorous results in the present research study. The subject was made well acquainted with the experimental protocol to achieve their full co-operation and to maintain the uniformity in the measurement. Proper co-ordination and a sort of collaboration was achieved with the subject.

Firstly, all the anthropometric measurement is taken including height, weight and other body parameters of different ages of the subject. After words they were allowed to perform the weeding operation by employing the mentioned hoes for a duration of 20min. Before the commencement of the weeding operation.

The physiological parameters of the subject were taken such as heart rate (maximum and minimum) heart rate and resting and working blood pressure (both Systolic and Diastolic) were measured at one-minute intervals after five minutes from the beginning of work.

After that, other variables whose values depends on above enlisted parameters including OCR, EER and CCW were calculated.

The same procedure was repeated to get three sets of trials or replications and the average of the three sets was used to achieve the rigorous readings.

Physical, physiological and discomfort parameters involved in the concern study for the male subjects

BMI

The BMI is defined as the body mass divided by the square of the body height. The relation of BMI is given as:

$$\text{BMI} = \text{Weight} / (\text{Height})^2 - 2.1$$

LBM

Lean body mass is a component of body composition, calculated by subtracting body fat weight from total body weight.

$$\text{For male -LBM} = (0.32810 * w) + (0.33929 * H) - 29.5336 - 2.2$$

Estimation - LBM is usually estimated using the relation given by Hume, R (jul 1966).

Weight

The quantity of matter contained by the body is weight. Body weight of male and female subjects (in Kg) of different ages is measured by employing calibrated weighing scale.

Stature

Stature is the vertical distance (in cm) from the standing surface to the vertex of the head when the subject stands erect and looks straight forward.

BMR

Basal Metabolic Rate is the number of calories required to keep your body functioning at rest, also known as the metabolism. It is related to body mass, age, weight and height. It is also affected by gender. By Harris Benedict Equations,

BMR for male operators is represented by the following equations:

$$\text{For men - BMR} = 66.47 + (13.7 \times \text{Weight}) + (5 \times \text{Height}) - (6.8 \times \text{Age}) - 2.3$$

VO₂max

Also known as maximal oxygen consumption, maximal oxygen uptake, peak oxygen uptake or maximal aerobic capacity. It is the maximum rate of O₂ consumption measured during any physical operation (here implies to the weeding operation). The name is derived from V- volume, O₂- oxygen and max-maximum. VO₂max is expressed in litres of oxygen per minute (L/min). It can also be expressed in mL/kg min.

VO₂max is determined in the research study by utilizing the Uth- Sorensen- Overgaard- Pedersen estimation, the equation is based on maximum and resting heart rates and proposed by a group of researchers from Denmark. It is given by:

$$\text{VO}_2\text{max} \approx (\text{HRmax} / \text{HRrest}) \times 15.3 \text{ mL/kg minute} - 2.4$$

This equation for VO₂max is applicable only for the subjects having age between 21 to 51 only and it lies within the range of age taken in the present findings.

AWL

AWL stands for acceptable work load. It is equal to 35% of the VO₂max of the subjects (for young Indian worker).

Maximum heart rate

In the concerned research, it was determined by utilizing the formula derived by Maritz *et al.*, (1961).

$$\text{HRm} = 220 - \text{Age (years)} - 2.5$$

Energy Expenditure Rate (EER)

EER is determined and estimated using the following formula proposed by Verghese et al., (1944) in studying the EER of the workers.

$$\text{EER} = 0.159 \times \text{Average heart rate} - 8.72 \text{ (KJ/min)} - 2.6$$

Oxygen Consumption Rate (OCR)

Computed from the heart rate values (previously measured of the operator subject. OCR is represented by the equation (Singh et al., 2008) enumerated as follows:

$$\text{OCR (L/min)} = 0.0114 \times \text{HR} - 0.68 - 2.7$$

Cardiac cost of work (CCW)

CCW is determined by employing the following relation: $\text{CCW} = \text{AHR} \times \text{Duration of activity}$ AHR = Average Heart Rate (beats/min) Duration of activity = 30minutes (weeding activity was performed for duration of 30min in the present study work)

AHR = Average working heart rate - Average resting heart rate

$$\text{CCW} = \text{AHR} \times \text{Duration of activity} - 2.8$$

Body part discomfort score (BPDS)

Corlett and Bishop (1976) technique was used to measure confined discomfort. In this method, the body of respondents is divided into 27 regions. Each body region was numbered differently to avoid a subject marking on body region only. The subject was asked to mention to all body parts with discomfort, starting with the most painful, the next painful in descending order till no further areas are referred. In the present research, it

was examined by proper investigating the level of fatigue for the selected subjects and by means of relation enumerated below (Corlett and Bishop, 1976):

$$\text{BPDS} = \sum X_i \times S(3.40) - 2.9$$

where, X_i = number of body parts and S = discomfort score (6 to 1)

In the current research findings, the atmospheric conditions including average temperature, humidity and amount of sunshine was also assessed during the replications of the method taken in the month of February and March (as shown in the table 2.4).

The anthropometric data of the selected respondents was ascertained. The dimensions were measured by deploying anthropometer and measuring tape to maintain accuracy and preciseness in the results. Sixteen anthropometric measurements were taken, which were considered useful in utilizing the aforementioned tools. The corresponding strength data is enumerated in the table 2.5 given below:

Statistical analysis employed

The statistical analysis was considered to check the significant variation in the measured values with respect to ages of the respondents. The three replications were taken, and the values of average heart rate were deliberately examined by constructing the ANOVA in order to check the significance difference in the values with the mentioned ages. Split-plot design was employed during the research study. The coefficient of variance for the selected respondents was found to be 2.21. Since, the calculated variance ratio was slightly higher than its tabulated value, the alternative hypothesis was accepted which indicate that there is a significant variation in the working heart rate with different ages.

Results and Discussion

The results obtained from the present investigation has been summarized in this chapter. The factors taken under consideration in this concern research study are analysed and the inferences has been drawn pertinent to various physical and physiological parameters. The study focuses on its objectives by producing the results and its concise discussions are enumerated under following heads:

Regarding assessment of physical properties of male subjects

The BMI values calculated for the subject of ages 25, 30,35,40,45 and 50 were found as 19.86, 19.36, 20.29, 21.43, 19.33 and 21.95 respectively. The average value of BMI for the subjects of given ages were 20.37kg/m². The average value calculated was found normal and lies between the standard values 18.5-25(WHO 2006).

The average LBM value of the selected respondents was found to be 43.22 for different ages 25-50 years. The calculated value of LBM of various enumerated ages were 45.87, 40.49, 45.16, 44.47, 41.86, 41.45 and 43.22 respectively.

The values pertaining to BMR for the subjects of aforesaid ages were calculated and were found to be 1477.57, 1328.77, 1425.67, 1390.37, 1238.07 and 1251.27 respectively. The average value calculated for the subjects was 1351.95.

The VO₂max values of the respondents lies between the range 26-29 mL/Kg min (as indicated in the table 3.1). The lower values of VO₂max of male subjects were encountered(VO₂max< 38 for men of ages between 20-29 is considered low – Astrand-1960).

The acceptable work load for Indian worker is about 35% of VO₂max. Hence, for the mentioned values of VO₂max, the AWL of male respondents having age 25,30,35,40,45 and 50 were 9.76, 9.86, 9.97, 9.80, 8.95 and 9.3 respectively.

Regarding assessment of physiological parameters of the respondents

The average resting heart rate of the male respondents of age 25, 30,35,40,45 and 50 was found to be 104, 101, 98, 95,105 and 99 respectively. Therefore, the average value of resting heart rate of the subjects was 100.33 bpm before carrying out the operation(weeding) by hand hoe. In case of wheel hoe, it was 100.5 bpm as illustrated in the table 3.2.

Reason for the increase in resting heart rate for wheel hoe

An approximate increase in the average resting heart rate for wheel hoe might be due to initial weeding activity carried out by hand hoe for 20 minutes duration and then the subjects were allowed to take the required rest so that they could proceed for operation by wheel hoe.

This might be the reason for the enhancement of the resting heart rate when operation was conducted by wheel hoe.

The average working heart rate was measured for the respondents during accomplishment of work after 20 minutes duration. During the weeding operation conducted by hand hoe, the values of average working heart rate of male respondents of ages 25, 30, 35, 40, 45 and 50 were recorded as 116, 111, 110, 108, 119, and 110(bpm) respectively and 115, 107, 109, 104, 111 and 104(bpm) respectively in case of weeding activity performed by wheel hoe.

Comparison of average working heart rate for weeding operation conducted by hand and wheel hoe

The mean value calculated of average working heart rate for male subjects sustaining weeding activity by hand hoe and wheel hoe was 112.33 and 108.33(bpm) respectively.

By estimating the average heart rate value, the EER was calculated which is represented by the equation 3.6. For male respondents of the mentioned ages, the EER values when task was conducted by hand hoe were 8.77, 8.13, 7.82, 7.42, 9.09, 7.40 and 8.19 (kJ/ min) respectively. While the EER values calculated for wheel hoe were 8.83, 7.74, 7.58, 7.18, 8.61 and 7.34 (kJ/ min) respectively. Therefore, the average value of EER for male subjects during weeding operation conducted by hand and wheel hoe were 8.19 and 7.88 (kJ/ min) respectively.

The values of OCR were calculated as 0.57, 0.53, 0.51, 0.48, 0.60, 0.51 and 0.53 (L/ min) respectively when the subject accomplishes the weeding activity for the given duration of 20 minutes by hand hoe. However, in case of activity conducted by wheel hoe for the same subject of the above enlisting age, the readings were calculated as 0.58, 0.50, 0.49, 0.46, 0.56 and 0.47 (L/ min) respectively. The average OCR was 0.53 and 0.41 (L/ min) for hand hoe and wheel hoe respectively. The OCR was slightly enhanced when the subjects carried out the work by hand hoe than by wheel hoe.

The CCW values, when task was conducted by hand hoe were 240, 200, 240, 260, 280 and 220 (beats) respectively for the enumerated ages. While the CCW values calculated for wheel hoe were 180, 140, 260, 160, 80, and 120 (beats) respectively. Therefore, the average value of CCW of the respondents during weeding operation conducted by hand and wheel hoe were 240 and 156.67 (beats) respectively. The cardiac cost of work was

maximum when the subjects carried out the work by hand hoe rather than by wheel hoe. Similar results were observed in the study conducted by Verma S. *et al.*, (2011). The average BPDS values of selected subjects were ascertained as 25.4 and 21.4 for hand hoe and wheel hoe respectively as enumerated in the table. Similar results were investigated by Kumar *et al.*, 2002. The majority of body discomfort experienced were fatigue in knee and shoulder while it was arm, knee, wrist and shoulder in case of weeding operation conducted by hand hoe owing to the large effort required by the arms to uproot the weeds. However, for wheel hoe, the subjects undergoes lassitude which might be due to the high temperature of the surrounding ambience.

It was investigated that wheel hoe was efficiently designed and its sharp tynes offers little effort to remove the weeds. Thereby, it is concluded that wheel hoe offers easy adaptability and consistency in accomplishing the weeding activity in standing posture rather than the difficulty in manipulating the hand hoe in squatting position.

Regarding assessment of physical properties of male subjects

From the estimated values of LBM, the percentage of LBM in the body weights for male subjects of ages 25, 30, 35, 40, 45 and 50 was found to be 78%, 83%, 81%, 78%, 81% and 77%. The percentage of male subjects lies above 75%. So, it may be concluded that all male subjects of given ages were physically fit and healthy for performing the farm operation. They have perfect values of average LBM (as stated by National Academy of Sports Medicine 2006).

Reason for the declination of VO₂max in male subjects – Consumption of alcohol, smoking and chewing of tobacco might be the reason for the declination of VO₂max. Cardiac

efficiency is reduced as the VO₂max declines. Smoking reduces work capacity by reducing the oxygen carrying capacity of the blood. Before the research study, the past history of the respondents was taken into consideration.

Above all, it is concluded that VO₂max declines as the age progresses. Also in the presented findings, the average value of VO₂max of male respondents was found to be 30.16mL/Kg. min.

Table.1 The concise outlook of the experimental plan is enumerated in the mentioned table

Brief outlook of the experimental plan	
Farm operation	Weeding
Implements used	Hand hoe and wheel hoe
Total number of operators	60
Total number of replications	3
Duration of weeding activity	30 min
Area under weeding operation	30x40 m ²
Area of the row(strip) under weeding operation	0.5x30m ²
ANOVA – Type	Split plot design

Table.2 Enlistment of materials requirement for implementing the experimental plan

S. No	Characterstics	Variable	Equipments/ Tools
1.	Anthropometric dimensions	For measurement of small and large body dimensions	Anthropometer, steel scale, measuring tape
2.	Physical variables	Weight	Weighing balance
3.	Physiological responses	Pulse rate	Electronic sphygmomanometer, pulse oximeter
Implements for carrying out weeding operation- Hand hoe (khurpi) and Wheel hoe			

Table.3 illustrating the features of weeding implements

Specifications and working features of the mentioned weeding implements				
S.no	Hand hoe (khurpa)		Wheel hoe	
1	Overall length (mm)	320	Overall length (mm)	1680
2	Width of cutting edge (mm)	120	Width of cutting edge (mm)	110-180
3	Length of the blade (mm)	220	Length of the blade (mm)	150
4	Weight (kg)	1.1	Weight (kg)	7.4

Table.4 Enumeration of operating conditions

S. No	Operational parameters	Values
1.	Average temperature, °C	34
2.	Average humidity, %	52
3.	Average sunshine, hours	8.4

Table.5 The anthropometric data of the male respondents

S. No.	Anthropometric & Strength data	Age of male operators					
		25	30	35	40	45	50
1	Weight (kg)	53	49	56	57	48	54
2	Height	171	159	166	163	164	157
3	Elbow height	105	98	102	101	101	97
4	Olecranon height	99	95	97	94	95	93
5	Illicrystable height	91	89	90	85	90	87
6	Illiospiinal height	149	130	147	145	146	130
7	Knee height	50	45	47	46	46	43
8	Arm reach	81	76	77	76	75	73
9	Vertical reach	199	197	204	201	203	196
10	Hand length	19	16	18	18	17	16
11	Head length	20	19	20	19	19	18
12	Foot length	24	22	25	24	23	22
13	Biacromial breadth	40	38	39	38	39	37
14	Bideltoid breadth	46	44	45	45	44	43
15	Acromial height	141	136	138	137	140	132
16	Eye height	161	150	158	152	151	149

(Measurement taken in cm unless otherwise specified)

Table.6 Depicting the physical characteristics of the selected respondents

S.no	Physical characteristics	Age (years)						Average
		25	30	35	40	45	50	
1	Age (years)	25	30	35	40	45	50	
2	Height (cm)	171	159	166	163	164	157	163.33
3	Weight (kg)	58	49	56	57	52	54	54.33
4	BMI (kg/m ²)	19.86	19.36	20.29	21.43	19.33	21.95	20.37
5	LBM	45.87	40.49	45.16	44.47	41.86	41.45	43.22
6	BMR	1477.57	1328.77	1425.67	1390.37	1238.07	1251.27	1351.95
7	VO ₂ max (mL/Kg.min)	31.82	32.34	34.05	29.45	27.97	25.3	30.16
8	AWL	9.76	9.86	9.97	9.8	8.95	9.3	9.61

Table.7 The assessment of physiological responses of the male respondents conducting weeding operation by hand hoe and wheel hoe

I . By hand hoe (khurpa)								
S.n	Physiological parameters	Age (years)						Average
		25	30	35	40	45	50	
1	Average resting heart rate(bpm)	104	101	98	95	105	99	100.33
2	Average working heart rate (bpm)	116	111	110	108	119	110	112.33
3	Average heart rate(bpm)	12	10	12	13	14	11	12
4	Mean heart rate(bpm)	110	106	104	101.	112	104.	106.3
5	Maximum heart rate (bpm)	189	186	182	179	175	172	180.75
6	Energy Expenditure Rate (kJ/min)	8.77	8.13	7.82	7.42	9.09	7.4	8.19
7	Oxygen Consumption Rate	0.57	0.53	0.51	0.48	0.6	0.51	0.53
8	Cardiac Cost of Work(beats)	240	200	240	260	280	220	240
II . By wheel hoe								
S.n	Physiological parameters	Age (years)						Average
		25	30	35	40	45	50	
1	Average resting heart rate (bpm)	106	100	96	96	107	98	100.5
2	Average working heart rate(bpm)	115	107	109	104	111	104	108.33
3	Average heart rate(bpm)	9	7	13	8	4	6	7.83
4	Mean heart rate(bpm)	110.5	103.5	102.5	100	109	101	104.42
5	Maximum heart rate (bpm)	189.5	186	182.5	179	175.5	172	180.75
6	Energy Expenditure Rate (kJ/min)	8.85	7.74	7.58	7.18	8.61	7.34	7.88
7	Oxygen Consumption Rate	0.58	0.5	0.49	0.46	0.56	0.47	0.51
8	Cardiac Cost of Work(beats)	180	140	260	160	80	120	156.67

Table.8 Assessment of average BPDS of the female operators in various farm operations

S. No	Operations	Average body part discomfort score (BPBS)						
		25	30	35	40	45	50	Average
1.	Weeding by hand hoe	23.50	23.90	24.75	25.65	26.85	28.70	25.4
2.	Weeding by wheel hoe	20.25	20.90	21.15	21.75	22.35	22.50	21.4

Fig. 2(a) Hand hoe (khurpa)



Fig. 2(b) Wheel hoe



Fig.3-The operators undergoing weeding operation by hand hoe and wheel hoe



Fig: 4- Depicting the measurement of physical and physiological variables of operator



Regarding assessment of physiological parameters of the respondents

For the physiological responses, the male respondents were more comfortable physiologically in the standing posture i.e. in wheel hoe rather than by hand hoe from ergonomic point of view. The pulse rate was investigated high for the respondents employing hand hoe which might be due to the much effort required and prevailing operating conditions.

The health issues associated with the operators have their direct impact on their pulse rate while accomplishing the weeding activity.

The current findings investigate that the oxygen consumption rate was higher for the respondents employing hand hoe than by wheel hoe. As the fatigue rate was high among the respondents carrying out the task using the former implement, the oxygen consumption was slightly increased as the age of the operators progresses.

The energy expenditure rate was maximum when the subject carried out the work by hand hoe rather than by wheel hoe. This might be due to the inconvenience caused in continuing the work in squatting posture and the inconsistency while employing hand hoe.

Also, the prevailing conditions during the bright sunshine might be the reason for high energy consumption.

The present analysis

Regarding assessment of body part discomfort score of the respondents

The body discomfort arising were fatigue in knee and shoulder while it was arm, knee, wrist and shoulder in case of weeding operation conducted by hand hoe owing to the large effort required by the arms to uproot the weeds. It was investigated that wheel hoe was

efficiently designed and its sharp tynes offers little effort to remove the weeds. Thereby, it is concluded in the research findings that wheel hoe offers easy adaptability and consistency in accomplishing the weeding activity in standing posture rather than the difficulty in manipulating the hand hoe in squatting position.

The study regarding assessing of anthropometrical, physical and physiological parameters of the male respondents during weeding operation by hand hoe and wheel hoe was successfully accomplished. The variations in the physical and physiological characteristics were noticed. The physiological parameters including resting and working heart rates, blood pressure, energy expenditure rate, oxygen consumption rate and cardiac cost of work of the concerned subject were assessed and the respondents exhibit significant variations during their association in the operation conducted by hand hoe and wheel hoe.

The subjects undergo light physical work in case of wheel hoe and moderately heavy physical work in hand hoe. The subjects performed the activity more compatible by wheel hoe than by hand hoe which might be due to their consistency and easy adaptability with the former implement in hard soil conditions. The latter implement required more effort on the shoulders of the subjects in the prevailing soil conditions which resulted increase in body discomfort and physiological variations.

Acknowledgements

The authors acknowledge the productive support of the professors of the farm machinery and power engineering department who guided in every path of the concern research study. Special mention to the farmers who perfectly coordinated the study during the prescribed duration of time.

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How to cite this article:

Vishnu Ji Awasthi, Manpreet Singh, Rajat Mishra, Rahul Chaudhary, Mirtunjay Pandey, Dilwar Singh Parihar, Shubham Gautam and Dhiraj Kumar 2019. Ergonomic and Workload Assessment in Weeding Operation Conducted for Wheat Crop for Male Respondents. *Int.J.Curr.Microbiol.App.Sci*. 8(09): 2597-2609. doi: <https://doi.org/10.20546/ijcmas.2019.809.301>