Estimation of Physiological Cost of Female Agricultural Workers for Weeding Operation

Premkumari*, Ravindra Yaranal, M. Veerangouda and Devanand Maski

Department of Farm Machinery and Power Engineering, College of Agricultural Engineering, University of Agricultural Sciences, Raichur, Karnataka India

*Corresponding author

A B S T R A C T

Agriculture is the primary source of employment for women in most of the developing countries. In India 27 crore of women are engaged in agriculture in rural sector. The present study was conducted in UAS campus Raichur on a sample of 10 agricultural workers for estimation of physiological cost selected subject for three types of weeders. Anthropometric kit was used for measuring body dimensions and strength parameter, physiological cost estimation done by measuring heart rate, oxygen consumption rate and energy expenditure rate. The mean stature and weight of female subjects ranged 150.85 cm and 52.6 kg respectively. The mean work pulse (ΔHR) of all subject for khurpi, CIAE wheel hoe and CAE weeder were 39.59 beats/min, 32.04 beats/min and 23.45 beats/min, respectively. Mean working Oxygen consumption rate for khurpi, CIAE wheel hoe and CAE weeder were 0.664 l/min, 0.586 l/min and 0.525 l/min respectively. The energy expenditure rate was highest for khurpi (13.86 kJ/min) followed by CIAE wheel hoe (11.34 kJ/min) and CAE weeder (10.95 kJ/min). The HR, OCR and EER during weeding were more for khurpi and CIAE wheel hoe followed by CAE weeder. CAE weeder is ergonomically designed it reduces the fatigue and increases the efficiency.

Introduction

Female agricultural workers in India play dominant role in increasing production and productivity. About seventy per cent of the Indian women are engaged in agricultural work either in their own fields or as hired laborers. If eight hours of work is considered as one man-day, the Indian rural women work more than two man-day everyday both in home and farm together. Still women are considered as secondary workers in the economic scenario. The farm women perform almost each and every agricultural activity right from land preparation and sowing to the harvesting and storage of the agricultural produce.

Hand tools and manually operated equipments are extensively used for digging, weeding and harvesting operations in agriculture. Weeding is one of the most important farm operations in crop production system. The most commonly used hand tools and equipments by
the farmers for manual operations are spade, weeder, thresher, sprayer, plough, sickle, paddy puller, straw puller, hoe, hand power tiller etc. Manual weeding requires a huge labour force and accounts for about 25 per cent of the total labour requirement (Nag and Datt, 1979). So manually operated weeders are remained first priority of the researchers.

Weeding is one of the maximum drudgery involved activity performed for highest number of days in a year. These women do the back breaking agricultural activities without any protections from sun, soil or shower with the traditional tools. To increase the productivity of the women’s work there is a greater need for the ergonomic analysis of the activities performed by women and to study the circulatory stress and the physiological cost of each agricultural activity (Hasalkar, 2004).

Ergonomical evaluation is necessary to assess the energy expenditure of agricultural workers their physiological cost and body discomfort suitable for female workers. How long they can work continuously without getting fatigue. Ergonomical evaluation along with mechanical evaluation helps us to make comparison between traditional method and improved methods. The method which gives better field capacity, less power consumption, low energy expenditure rate and more safety will be recommended for the agricultural operation.

When a person does any physical work, she uses her muscle power (energy) and skeletal tissues. During the muscular activity her physiological responses i.e., energy expenditure rate, oxygen consumption rate and heart rate increases. This increase in physiological responses is related to the type, intensity and duration of work and thus sets limits to the performance of heavy work. In the present study oxygen consumption rate and heart rate was used for physiological cost estimation.

**Materials and Methods**

The study was carried out on farm women workers in age group 25-45 years were randomly chosen. Thirty body dimensions including strength parameters involved in manual weeding operations of 10 female (S₁ to S₁₀) of UAS Campus Raichur were measured by using anthropometric kit and mean values of body dimensions and strength parameters of the subjects were calculated. They were screened for normal health with medical investigations. These subjects were used in the field trials for manual weeding each subject was replicated three times. Physiological cost estimation of the selected subjects were carried out to evaluate the performance of the three types of manual weeder viz., Khurpi (Traditional), Wheel hand hoe (CIAE model), Standing khurpi (CAE model) (Table 1).

**Physiological cost of the selected subjects during weeding operation**

Field experiments were carried out to assess heart rate and oxygen consumption rate response during weeding operation with three types of weeders. The operation was performed in linseed crop (variety VT NL 115) having a row to row spacing of 30 cm.

Heart rate (HR), measured by polar heart rate monitor. The polar coded transmitter which measures the heart’s electrical activity was fitted around the subject’s chest with an elastic strap. A receiver worn as a wrist watch recorded the heart rate responses at the field testing sessions. Before fixing heart rate monitor to subject, setting should be made that age, sex, weight should be added in a watch. Before the start of the operation the subject was asked to take rest for 10 minutes
and her resting heart rate was recorded. One of the subjects was asked to operate khurpi observations were taken for 15 minutes working and 10 minutes resting shown in Plate 1. Heart rate was recorded for each 4 second interval and 15 readings were averaged to get the mean heart rate. This gave the mean steady state HR. This procedure is repeated for CIAE wheel hoe to find heart rate shown in Plate 2, for CAE weeder the heart rate evaluated shown in Plate 3.

After recording heart rate, the oxygen consumption rate (OCR) was calculated by Astrand and Rhyming nomogram graph, for each heart rate readings oxygen consumption rate is calculated 15 reading were recorded and averaged to get mean oxygen consumption rate. Analysis will be made by the nomogram having scale of body weight which is based on the assumption that every person having the same weight, when carrying out a similar stepping exercise, will have identical mechanical efficiency. This allows reading horizontally from the body weight scale to the oxygen uptake scale and with this assumed VO2 value, to proceed as explained before this gives the mean steady state OCR.

The energy expenditure rate (EER) was estimated by multiplying the working OCR with the calorific value of oxygen taken as 20.88 kJ/l (Nag and Dutt, 1980). The increase in HR for an area covered (ΔHR) by the subject was calculated. Steps were repeated for next 9 female subjects and repeated with 3 implements viz., khurpi, wheel hand hoe (CIAE wheel hoe) and Standing khurpi (CAE wheel).

**Results and Discussion**

Thirty body dimensions including strength parameters involved in manual weeding operations of 10 female (S1 to S10) of UAS Campus Raichur were measured. The consolidated data on selected body dimensions and strength parameters are presented in Table 2.

Experiments were carried out to assess the physiological cost of the subjects in terms of heart rate (HR), oxygen consumption rate (OCR) and energy expenditure rate (EER). The stature and weight of female subjects ranged from 138 cm to 161.00 cm (mean = 150.85 cm) and 44 kg to 66 kg (mean = 52.6 kg) respectively. The mean maximum atmospheric temperature, relative humidity and wind velocity varied between 24˚C to 27.5˚C, 35 to 50 per cent and 1.6 to 3.2 km/h respectively during the experiments.

The mean rest heart rate of subject during weeding operation ranged from 68.8 to 80 (beats/min), 71.3 to 75.4 (beats/min) and 67.6 to 79.3 (beats/min) for khurpi, CIAE wheel hoe and CAE weeder respectively. The mean rate of ten subject before operation of khurpi, CIAE wheel hoe and CAE weeder were 76.54 beats/min 74.14 (beats/min) and 74.19 beats/min respectively. Heart rate measured for ten female subjects while operating three types of weeder in field. The mean working heart rate of the subject during weeding operation ranged from 110.7 to 125.7 beats/min, 100.6 to 112.1 beats/min and 94.9 to 100.2 beats/min for khurpi, CIAE wheel hoe and CAE weeder respectively. The mean working heart rate for khurpi, CIAE wheel hoe and CAE weeder were 97.63 beats/min, 116.13 beats/min and 106.18 beats/min respectively were presented in Table 3. The work heart rate of CAE weeder was less than khurpi and CIAE wheel hoe.

Mean work pulse (ΔHR) for all subjects ranged from 32.3 to 47.8 beats/min, 25.8 to 38.6 beats/min and 16 to 32.6 beats/min for weeding with khurpi, CIAE wheel hoe and CAE weeder respectively. The mean work
pulse (ΔHR) of all subject for khurpi, CIAE wheel hoe and CAE weeder were 39.59 beats/min, 32.04 beats/min and 23.45 beats/min respectively. The increasing in heart rate during weeding was more for khurpi and CIAE wheel hoe followed by CAE weeder presented in Figure 1. The mean rest oxygen consumption rate of subject during weeding operation ranged from 0.139 to 0.167 l/min, 0.136 to 0.165 l/min and 0.141 to 0.163 l/min for khurpi, CIAE wheel hoe and CAE weeder respectively. The mean rest oxygen consumption rate of ten subjects before operation of khurpi, CIAE wheel hoe and CAE weeder were 0.151 l/min, 0.153 l/min and 0.152 l/min respectively. The mean working oxygen consumption rate of the subject during weeding operation ranged from, 0.618 to 0.723 l/min, 0.509 to 0.620 l/min and 0.497 to 0.553 l/min for khurpi, CIAE wheel hoe and CAE weeder respectively. The mean working oxygen consumption rate of ten subjects before operation of khurpi, CIAE wheel hoe and CAE weeder were 0.151 l/min, 0.153 l/min and 0.152 l/min respectively. The mean (ΔOCR) for all subjects ranged from, 0.469 to 0.568 l/min, 0.367 to 0.48 l/min and 0.356 to 0.392 l/min for weeding with khurpi, CIAE wheel hoe and CAE weeder respectively. The mean (ΔOCR) of all subject for khurpi, CIAE wheel hoe and CAE weeder were 0.512 l/min, 0.433 l/min and 0.373 l/min respectively. The increasing in Oxygen consumption rate during weeding was more for khurpi wheel hoe followed by CIAE wheel hoe and CAE weeder presented in Figure 2.

Mean (ΔOCR) for all subjects ranged from, 0.469 to 0.568 l/min, 0.367 to 0.48 l/min and 0.356 to 0.392 l/min for weeding with khurpi, CIAE wheel hoe and CAE weeder respectively. The mean (ΔOCR) of all subject for khurpi, CIAE wheel hoe and CAE weeder were 0.512 l/min, 0.433 l/min and 0.373 l/min respectively. The increasing in Oxygen consumption rate during weeding was more for khurpi wheel hoe followed by CIAE wheel hoe and CAE weeder presented in Figure 2.

Mean Energy expenditure rate in weeding operation ranged from 12.90 to 15.10 kJ/min, 10.76 to 11.98 kJ/min and 10.38 to 11.55 kJ/min for weeding with khurpi, CIAE wheel hoe and CAE weeder respectively. The mean energy expenditure rate for all subjects is presented in Table 5. The energy expenditure rate was highest for khurpi (13.86 kJ/min) followed by CIAE wheel hoe (11.34 kJ/min) and CAE weeder (10.95 kJ/min) presented in Figure 3. The energy expenditure rate for weeding CIAE wheel hoe and CAE weeder was almost same which implies that work load for both the wheel hoes is nearly same.

In Table 4 shows the mean working Oxygen consumption rate for khurpi, CIAE wheel hoe and CAE weeder were 0.664 l/min, 0.586 l/min and 0.525 l/min respectively. The work Oxygen consumption rate of CAE weeder was less than khurpi and CIAE wheel hoe. CIAE weeder and CAE weeder was lesser compared to other method. This may be due to application of more continuous push and pull force as compared to other methods.

Mean Energy expenditure rate in weeding operation ranged from 12.90 to 15.10 kJ/min, 10.76 to 11.98 kJ/min and 10.38 to 11.55 kJ/min for weeding with khurpi, CIAE wheel hoe and CAE weeder respectively. The mean energy expenditure rate for all subjects is presented in Table 5. The energy expenditure rate was highest for khurpi (13.86 kJ/min) followed by CIAE wheel hoe (11.34 kJ/min) and CAE weeder (10.95 kJ/min) presented in Figure 3. The energy expenditure rate for weeding CIAE wheel hoe and CAE weeder was almost same which implies that work load for both the wheel hoes is nearly same.

| Specification                      | Khurpi | Standing khurpi (CAE model) | Wheel hand hoe (CIAE model) |
|------------------------------------|--------|----------------------------|----------------------------|
| Height of handle from the ground level | 18.5 cm | 84 cm                      | 169 cm                     |
| Handle width                       | -      | 42 cm                      | 41 cm                      |
| Width of cut                       | 11.5 cm | 18 cm                      | 20 cm                      |
| Diameter of hand grip              | 3 cm   | 2.5 cm                     | 2.5 cm                     |
| Diameter of ground wheel           | -      | 15.5 cm                    | 20 cm                      |
| Type of blade                      | -      | flat type                  | V type                     |
Table 2: Anthropometric and strength measurements of 10 randomly selected female agricultural workers of age group of 25-45 years

| Body Dimensions               | S1  | S2  | S3  | S4  | S5  | S6  | S7  | S8  | S9  | S10 | Mean |
|------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|
| **A. Measurements in standing posture** |     |     |     |     |     |     |     |     |     |     |      |
| Weight (Kg)                  | 58  | 60  | 50  | 44  | 47  | 45  | 66  | 54  | 45  |      | 52.6 |
| Stature                      | 161 | 138 | 152 | 148 | 151.5 | 152 | 149 | 149 | 159 |      | 150.85 |
| Eye height                   | 147 | 127 | 136 | 142 | 140 | 142 | 132 | 141 | 133 | 144 |      | 138.4 |
| Shoulder height              | 137 | 116 | 126 | 131 | 122 | 129 | 119 | 125 | 122 | 132 |      | 125.9 |
| Elbow height                 | 102 | 87  | 96  | 97  | 90  | 97  | 86  | 91  | 91  | 98  |      | 93.5 |
| Olecranon height             | 103 | 90  | 94  | 91  | 93  | 96  | 87  | 95  | 92  | 96  |      | 93.7 |
| Waist height                 | 105 | 86  | 93  | 94  | 95  | 98  | 90  | 93  | 90  | 100 |      | 94.4 |
| Knee height                  | 48  | 43  | 44  | 42  | 44  | 40  | 43  | 43  | 37  | 47  |      | 43.1 |
| Arm reach from the wall      | 85  | 80  | 68  | 94  | 86  | 79  | 79  | 75  | 93  |      | 82.3 |
| Forearm hand length          | 43.5| 39  | 40  | 38  | 41  | 43  | 39  | 41  | 38  | 44  |      | 40.65 |
| Span                         | 163.5| 144 | 153 | 148 | 153 | 156 | 149 | 151 | 137 | 161 |      | 151.55 |
| Span akimbo                  | 83  | 77  | 74  | 76  | 76  | 78  | 76  | 79  | 74  | 78  |      | 77.1 |
| Thumb tip reach              | 68  | 61  | 62  | 65  | 61  | 67.5| 68  | 71  | 62  | 75  |      | 66.05 |
| Shoulder grip length         | 66  | 55  | 69  | 52  | 61  | 63  | 63  | 61  | 55  | 68  |      | 61.3 |
| **B. Measurements in sitting posture** |     |     |     |     |     |     |     |     |     |     |      |
| Sitting height               | 77  | 70  | 76  | 73  | 73  | 72  | 82  | 84  | 75  | 89  |      | 77.1 |
| Eye height                   | 68  | 60  | 64  | 66  | 64  | 68  | 70  | 69  | 69  |      | 66.4 |
| Popliteal height             | 41  | 41  | 39  | 42  | 37  | 45  | 45  | 42  | 39  | 44  |      | 41.7 |
| Elbow rest height            | 21  | 21  | 19  | 20  | 21  | 22  | 18  | 23  | 20  | 23  |      | 20.8 |
| **C. Miscellaneous measurements** |     |     |     |     |     |     |     |     |     |     |      |
| Hand length                  | 17.5| 17  | 16  | 17  | 16  | 17  | 16  | 16  | 17  | 16  |      | 16.75 |
| Hand breadth                 | 8   | 9   | 10  | 9   | 9   | 9   | 9   | 8.5 | 9   |      | 8.95 |
| Palm length                  | 10  | 10  | 10  | 10  | 10  | 9.5 | 10  | 9.5 | 10  | 9   |      | 9.55 |
| Grip diameter (inside)       | 4.35| 4.054| 3.33| 3.484| 3.55| 3.696| 3.715| 3.269| 3.28| 3.806|      | 3.33 |
| Grip span                    | 8.5 | 10.5| 13  | 11  | 9   | 11  | 8.5 | 13  | 12  | 10  |      | 10.65 |
| Maximum grip length          | 12  | 10.3| 12.5| 13.4| 14.5| 14  | 14  | 13  | 12.5| 13  |      | 12.92 |

D. Strength Measurements
| Methods of weeding                                           | Khurpi | CIAE wheel hoe | CAE weeder |
|-------------------------------------------------------------|--------|----------------|------------|
| Subjects                                                   | HR (beats/min) | ΔHR (beats/min) | HR (beats/min) | ΔHR (beats/min) | HR (beats/min) | ΔHR (beats/min) |
| S1                                                        | 111.8  | 38.4           | 101.0      | 27.3           | 99.5           | 25.1           |
| S2                                                        | 111.6  | 32.8           | 111.7      | 38.4           | 100.2          | 32.6           |
| S3                                                        | 110.7  | 32.3           | 107.9      | 33.1           | 98.5           | 25.1           |
| S4                                                        | 113.6  | 35             | 109.9      | 38.6           | 97.3           | 19.6           |
| S5                                                        | 114.6  | 37.8           | 112.1      | 36.7           | 98.8           | 25.1           |
| S6                                                        | 124.1  | 44.1           | 100.6      | 25.8           | 96.6           | 24             |
| S7                                                        | 112.2  | 43.4           | 107.0      | 32.2           | 98.5           | 27.1           |
| S8                                                        | 125.7  | 47.8           | 105.2      | 29.9           | 96.7           | 20.3           |
| S9                                                        | 121.5  | 42.1           | 104.4      | 29.7           | 95.3           | 16             |
| S10                                                       | 115.5  | 42.2           | 102.0      | 28.7           | 94.9           | 19.63          |
| Mean                                                      | **116.13** | **39.59**       | **106.18** | **32.04**      | **97.63**      | **23.45**      |

All dimensions are in cm, unless specified.

**Table 3** Mean HR and ΔHR response during manual weeding
### Table 4 Mean working oxygen consumption rate during manual weeding

| Methods of weeding | Khurpi | CIAE Wheel hoe | CAE weeder |
|-------------------|--------|----------------|------------|
|                   | OCR (l/min) | ΔOCR (l/min) | OCR (l/min) | Δ OCR (l/min) | OCR (l/min) | Δ OCR (l/min) |
| S₁                | 0.619   | 0.469         | 0.563      | 0.404         | 0.515     | 0.374         |
| S₂                | 0.666   | 0.513         | 0.576      | 0.423         | 0.530     | 0.374         |
| S₃                | 0.618   | 0.479         | 0.612      | 0.48          | 0.513     | 0.366         |
| S₄                | 0.682   | 0.536         | 0.620      | 0.475         | 0.535     | 0.377         |
| S₅                | 0.670   | 0.517         | 0.578      | 0.416         | 0.513     | 0.367         |
| S₆                | 0.719   | 0.558         | 0.611      | 0.45          | 0.550     | 0.387         |
| S₇                | 0.653   | 0.486         | 0.589      | 0.435         | 0.519     | 0.368         |
| S₈                | 0.723   | 0.568         | 0.602      | 0.444         | 0.553     | 0.392         |
| S₉                | 0.655   | 0.508         | 0.604      | 0.438         | 0.520     | 0.366         |
| S₁₀               | 0.631   | 0.488         | 0.509      | 0.367         | 0.497     | 0.356         |
| Mean              | 0.664   | **0.512**     | **0.586** | **0.433**     | **0.525** | **0.373**     |

### Table 5 Mean energy expenditure rate during manual weeding

| Methods of weeding | Khurpi | CIAE model Wheel hoe | CAE Model |
|-------------------|--------|----------------------|-----------|
|                   | EER(kJ/min) | EER(kJ/min) | EER(kJ/min) |
| S₁                | 12.92    | 10.95        | 10.75      |
| S₂                | 13.91    | 11.00        | 11.07      |
| S₃                | 12.90    | 11.65        | 10.71      |
| S₄                | 14.24    | 10.87        | 11.17      |
| S₅                | 13.99    | 11.98        | 10.71      |
| S₆                | 15.01    | 10.76        | 11.48      |
| S₇                | 13.63    | 11.65        | 10.84      |
| S₈                | 15.10    | 11.77        | 11.55      |
| S₉                | 13.68    | 11.43        | 10.86      |
| S₁₀               | 13.18    | 11.32        | 10.38      |
| Mean              | **13.86** | **11.34**    | **10.95**  |
**Fig. 1** Heart rate in manual weeding operation

**Fig. 2** Oxygen consumption rate during manual weeding operation

**Fig. 3** Energy expenditure rate in Manual Weeding operation
Plate.1 Physiological cost estimations for khurpi
Plate.2 Physiological cost estimations for CIAE wheel hoe
Plate.3 Physiological cost estimations for CAE weeder
In conclusion, CAE weeder CIAE weeder khurpi were evaluated with 10 subject to their physiological cost while weeding operation. The mean HR, OCR and EER during weeding with khurpi, CIAE wheel hoe and CAE weeder was 116.13 beats/min 106.18 beats/min, 97.63 beats/min, 0.664 l/min, 0.586 l/min, 0.525 l/min and 13.86 kJ/min, 11.34 kJ/min and 10.95 kJ/min, respectively. The minimum mean ΔHR and ΔOCR for subjects was observed during weeding with CAE weeder, followed by CIAE wheel hoe, whereas maximum value was observed for khurpi. Agricultural tools/implements are not designed ergonomically and this leads to increase in fatigue, health hazards and even accidents to agricultural workers. CAE weeder, which can increase their efficiency and work output and reduce the circulatory stress, physiological cost of work.

References

Agarwal, M., Gandotra, V. and Gite, L. P., 2007, Physiological stress of women farmers involved in organic farming in India. Paper presented at Int. Ergonomics Conf. on Humanizing Work and Work Envir., CIAE, Bhopal, December 10-12, pp: 96-99.

Agrawal, K. N., Tiwari, P. S., Gite, L. P. and Bhushanababu, V., 2010, Isometric push/pull strength of agricultural workers of central India. Agril. Engg. Int., 12: 38-39.

Badiger, C., Hasalkar, S. and Huilgol, S., 2004, Drudgery of farm women in agriculture and animal husbandry operations. kar. J. Agric. Sci., 17(4): 787-790.

Behera, B. K., Swain, S. and Mohanty, S. K., 2007, Ergonomic evaluation of push-pull type weeder with women operators. J. Agril. Engg., 44: 39-43.

Dewangan, K. N., Owary, C. and Datta, R. K., 2008, Anthropometric data of female farm workers from north eastern India and design of hand tools of the hilly region. Int. J. Ind. Erg., 38: 90-100.

Fernandez, J. A. and Uppugonduri, K. G., 1992, Anthropometry of south India industrial workmen. Ergonomics, 35: 1393-1398.

Geetha, S. P. and Tewari, V. K., 2000, Anthropometry of Indian agricultural workers and implication on tool design. AMA., 31: 63-66.

Gite, L.P., 1999, Heart rate responses of women workers during soybean harvesting by using local sickle, improved sickle and self propelled reaper. NRCWA. Annual report, 34.

Gite, L. P. and Agarwal, N., 2000, Ergonomical comparison of local and improved sickle for wheat harvesting by women workers, Agril. Engg. Today, 24: 7-12.

Hasalkar, S. M., Shivalli, R. C., Budihal, R. Y. and Biradar, N. P., 2004, Assessment of work load of weeding activity in crop production through heart rate. J. Human Ergology, 14: 165-167.

Kar, S. K., Ghosh, S., Manna, I., Banerjee, S. and Dhara, P., 2003, An investigation of hand anthropometry of agricultural workers. J. Hum. Ecol., 14(1): 57-62.

Karunanithi, R. and Tajuddin, R., 2003, Physiological response of agricultural workers in rice farming operations. J. Agril. Engg., 40: 33-40.

Kathirvel, K., Thambidurai, S., Ramesh, D. and Jesudas, D.M., 2007c, Ergonomical evaluation of available finger type rotary weeder in terms of physiological stresses and work output. Paper presented at Int. Ergonomics Conf. on Humanizing Work and Work Envir., CIAE, Bhopal, December 10-12, pp: 92-96.

Kaur, N., Dhillon, M. K., Sidhu, M. and Sandhu, P., 2007a, Physiological responses during cotton-picking activity performed by rural women of Bathinda district - comparison of conventional and improved method. Paper presented at Int. Ergonomics Conference on Humanizing Work and Work Envir., CIAE, Bhopal, December 10-12, pp: 11-16.

Kaur, H., Oberoi, K., Sharma, S. and Kaur, H., 2007b, An ergonomic study on the potato picking activity performed by farm women of Punjab. Paper presented at Int.
Ergonomics Conf. on Humanizing Work and Work Envir. CIAE, Bhopal, December 10-12, pp: 23-27.

Khogare, D. T. and Borkar, S., 2012, Ergonomical evaluation of manually operated weeder. Electronic Int. Interdisciplinary Res. J., 42: 56-59.

Maheshwari, T. K. and Devendra Kumar, 2007, Manually operated equipment for women farm workers-An ergonomic study. Paper presented at Int. Ergonomics Conf. on Humanizing Work and Work Envir., CIAE, Bhopal, December 10-12, pp: 62-67.

Nag, P. K. and Dutt, P., 1979, Effectiveness of some simple agricultural weeder with reference to physiological responses. J. Hum. Ecol. 8: 13-21.

Nag, P. K. and Dutt, P., 1980, Cardiorespiratory efficiency in some agricultural work. Appli. Erg., 11: 81-84.

Nag, A., Nag, P. K. and Desai, H., 2003, Hand anthropometry of Indian women Indian. J Med Res 117, pp: 260-269.

Philip, G. S. and Tewari, V. K., 2000, Anthropometry of Indian agricultural workers and implication on tool design. AMA., 31: 63-66.

Sen, R. N., 1964, Some anthropometric studies on Indian in tropical climate. Proceedings of the symposium on environmental physiology and psychology in arid conditions, UNESCO, Paris. 163-174.

Singh, S. P., 2012, Physiological workload of farm women while evaluating sickles for paddy harvesting. Agric. Engg. Int., 14(1): 54-62.

Singh, S. P., Gite, L. P. and Agarwal, N., 2006, Ergonomical assessment of manually operated seed drills for farm women. J. Agril. Engg. 43: 42-48.

Singh, S., Sinwal, N., Rathore, H. and Sinwal, S., 2011, Assessment of physiological workload related to selected manual material handling tasks. Anthropologist, 13(4): 293-298.

Tewari, V. K. and Philip, G.S., 2003, occupational stress on Indian female agricultural Workers. Proceeding 37 Convention of ISAE, pp: 365-360.

Vinay, D. and Sharma, S., 2005, Physiological stress on women at work: ergonomic consideration. International ergonomics association press.

Vyavahare, R. T. and Kallurkar, S. P, 2012, Anthropometric and strength data of Indian agricultural workers for equipment design: a review. Agric. Engg. Int., 14 (4): 102-114.

Yadav, R., Kaur, N., Gite, L. P. and Randhawa, J., 2000, An anthropometry of Indian female agricultural workers. AMA., 31: 56-60.

Yadav, R., Pund, S., Patel, N. C. and Gite, L. P., 2010, Analytical study of strength parameters of indian farm workers and its implication in equipment design. Agril. Engg. Int., 12: 54-57.

Yadav, R., Tewari, V. K. and Prasad, N., 1997, An anthropometric data of Indian farm workers – a module analysis. Appl. Erg., 28: 69-71.

How to cite this article:

Premkumari, Ravindra Yaranal, M. Veerangouda and Devanand Maski. 2018. Estimation of Physiological Cost of Female Agricultural Workers for Weeding Operation. Int.J.Curr.Microbiol.App.Sci. 7(08): 2364-2374. doi: https://doi.org/10.20546/ijcmas.2018.708.238