Figure 4: Photographic view of Power weeder (Model II)

3.3. Acceptable Workload (AWL)

To ascertain whether the operations selected for the trails were within the acceptable workload (AWL), the oxygen uptake in terms of VO_2 max (%) was computed. Saha et al. (1979) reported that 35% of maximum oxygen uptake (also called maximum aerobic capacity or VO_2 max) can be taken as the acceptable work load (AWL) for Indian workers which is endorsed by Nag et al, 1980 and Nag and Chatterjee, 1981. The oxygen uptake corresponding to the computed maximum heart rate in the calibration chart gives the maximum aerobic capacity (VO_2 max).

Each subject's maximum heart rate was estimated by the following relationship (Bridger, 1995).

Maximum heart rate (beats min^{-1}) = 200 - 0.65× Age in years

The mean oxygen uptake in terms of maximum aerobic capacity was calculated and it was 47 % and 48% respectively for the models tested and the value was above the acceptable limit of 35% of VO_2 max indicating that the micro tillers were could not be operated continuously for 8 hours without frequent rest-pauses.

3.4. Overall Discomfort Rating (ODR)

Mean overall discomfort rating on a 10 point visual analogue discomfort scale (0- no discomfort, 10- extreme discomfort) was 2.0 and scaled as " light discomfort" during weeding for model I while it was 4.0 and scaled as " more than light discomfort" for second model.

3.5. Body Part Discomfort Score (BPDS)

The majority of discomfort was experienced in the left shoulder and right shoulder for all the subjects and the body part discomfort score of subjects during weeding with micro tiller model I was 23.08. For model II, the majority of discomfort was experienced in the left shoulder and right shoulder, upper back, left and right palm for all the subjects and the body part discomfort score of subjects was 24.97.

3.6. Limit of Continuous Performance (LCP)

The work pulse (Δ HR) was 38 beats min^{-1} and it was well within the limit of continuous performance of 40 beats min^{1} for model I while the work pulse was 40 beats min^{-1} for model II and was within the limit.

3.7. Work Rest Cycle

For every strenuous work in any field requires adequate rest to have an optimum work out put. Better performance results can be expected from both the operator and the worker only when proper attention is given for the work rest schedule for different operations.

The actual rest times taken for each subject were found from the heart rate response curves of respective operations. The rest time was measured from the cease of the operation till the heart rate of the subject reaches resting level. The rest time taken was averaged to arrive at the mean value for each selected implement.

The rest pause to the subject was calculated using the following formula as given by Pheasant (1991)

$$R = \frac{T\,(E-A)}{E-B}$$

Where.

R = Resting time (min)
T = Total working time/day (min)
E = Energy expenditure during working task (kcal/min)
A = Average level of energy expenditure considered acceptable (kcal/min)
B = Energy expenditure during rest (kcal/min)

Average level of energy expenditure considered acceptable was 4 kcal min^{-1}(Murrel, 1965).

Rest pause was calculated using the above formula as all the subjects operated continuously for the 30 min period and it was found that 8 min rest for model 1 and 9 min rest for model II could be provided to operator who was engaged in operating the equipment. The rest period calculated was also in agreement to the recovery heart rate of operator. If two operators are engaged with a machine in shift, it could be operated for day-long work.

4. Conclusions

An ergonomic evaluation of two models of micro tillers were carried out at Farming Systems Research Station, Sadanandapuram, Kottarakkara, Kerala for weeding/ interculture in upland field . The physiological cost was found out and the mean working heart rate of operator was 109 beats min^{-1} for model I while it was 111 beats min^{-1} for model II. The operation was graded as "moderately heavy". The work pulse of the micro tillers are well within the limit of continuous performance of 40 beats min^{-1}. The oxygen uptake in terms of VO_2 max was above the acceptable limit of 35% of VO_2 max indicating that the micro tillers were

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could not be operated continuously for 8 hours without frequent rest-pauses. It is suggested that two operators may be engaged in shift for a day long work with micro tillers. The first model was best suited to sandy loam soil however the second model was suited to both sandy loam soil and laterite soil. The weeding index was found to be 79% and the area covered by the first model was 0.5acre/day while the weeding index was found to be 85% and the area covered was 0.75acre/day for the second model. Mean overall discomfort rating on a 10 point visual analogue discomfort scale (0- no discomfort, 10- extreme discomfort) was 2.0 and scaled as " light discomfort" during weeding for model I while it was 4.0 and scaled as " more than light discomfort" for second model. Shoulder and arm wrist regions are concerned areas of discomfort for operating micro tillers.

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