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Development and Evaluation of Self-Propelled Cono Weeder for Rice Cultivation in *Vertisol*

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ABSTRACT

Weeding is one of the important agricultural operation. 30 to 60 per cent of crop yield is affected due to improper weeding. Intercultural/weeding operation in paddy crop is very important operation where the worker in bending position used to uproot the weeds that might affect their health therefore it is quite necessary to have suitable agricultural implements which farmers can use and also allow them to use for custom hiring. A self-propelled cono weeder was developed and tested ergonomically and mechanically. The frame of the developed self-propelled cono weeder was fabricated from hollow square pipe of 25 x 25 mm having a thickness of 2 mm. The supporting drive wheel of weeder (600 mm diameter) was fabricated from mild steel rod of 8 mm. A 1kW (1.3HP) petrol engine is used as its power source. The travel speed, weeding efficiency, field capacity and fuel consumption od developed powered cono weeder were found to be 2.28 km/h, 68.77 %, 0.0323 ha/h and 6.77 l/ha respectively. The peak heart rate, oxygen consumption rate and energy expenditure rate for operating self-propelled cono weeder by women workers were found to be 11.34 beats/min, 0.668 l/min and 13.94 KJ/min respectively.

1. Introduction

Rice (*Oryza sativa L.)* is the staple food for more than 60% of the world population and rigorous efforts are being made under several research programmed by scientist around the world to evolve different strategies for improving yield of rice. Weed is a plant which is judged by many to be not of use and undesirable at a place where it flourishes (Patil *et al.,* 2010). Weeding is an important and labor intensive agricultural unit operation and *kharif* crops are highly affected due to weed infestation.

Weeding accounts for about 25 % of the total labor requirement (900–1200 man-hours/hectare) during a cultivation season (Nag and Dutta, 1979). The share has progressively decreased over the years from 48% in 1950s to the current 17% and food production has quadrupled in the last 50 years from a mere 51 Mt in 1950 to 232 Mt in 2011. Obnoxious weeds like *Carthamus oxycantha*, *Cyperus rotundus, Saccharum spontaneum, Cynodon dactylon, Avena fatua, Phalaris minor, Parthenium hysterophorus*, *etc.* have infested large areas in various states of India (Biswas *et al.,* 1993). According to (Rangaswamy *et al.,* 1993), one third of the cost of cultivation is being spent for weeding alone. Still in India the weeding operation is carried out by indigenous hand tools like *'Khurapi'* and spade. However, for weeding purpose many improved hand tools have been developed and introduced.

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The cost for manual weeding are higher and according to (Rao *et al.,* 2007), out of the total losses due to various biotic factors weeds alone account one-third. Despite the good efforts made in research and extension in the field of weed science, the farmers still continue to face heavy losses in crop yield due to weed interference. Weed removal by mechanical method is one the methods frequently used to remove weeds from the agricultural fields. In spite of tool available, the farm farmers usually prefer manual weeding which is time consuming as well as costly. Many small portable manually operated weeder are available in the market, however the farmers still not prefer. Various types of cutting blades are used for manual weeding, where they are continually pushed, V–shape sweep is preferred and tool geometry of these cutting blades is based on soil-tool-plant interactions (Bernacki *et al.*, 1972). Mechanical weeder does not only uproots the weeds between the row crop it also loosens soil surface ensuring better soil aeration and water intake capacity.

The performance of man-implement system may be poor if ergonomics aspects don't give due attention. (Kathirvel *et al.,* 2004) ergonomically evaluated cono-weeder with farm women in assessing its suitability to farm women laborers and reported that the mean heart rate was 149.59 beats/min and corresponding oxygen consumption rate was 0.690 l/min. Energy expenditure for cono weeding was 13.42 kJ/min and the work was classified as “heavy”. The performance of weeders is interpreted in terms of weeding efficiency and the grade of work relates to the rating of the workload while worker’s comfort is a subjective assessment of operating posture (Tewari *et al.,* 1991). Weeding in squatting and bending posture with traditional hand tools *khurpi* consume more energy and its energy consumption for a given load is 30-50% more as compared to standing/sitting posture (Grandjean, 1988) and may lead to musculoskeletal disorders (Rainbird and O’Neill, 1955). All the designs of tools and implements are region specific to meet the requirements of soil type, crop grown, cropping pattern and availability of local resources. An effort has been made to develop a cono weeder (self-propelled) to meet the demand of farmers in Madhya Pradesh and it was tested in the field through mechanical and ergonomics point of view for its efficiency.

2. Methods

2.1 Participants

Three physically fit female workers served as the participants in this experiment. All the participants were examined for any past or current musculoskeletal disorder or lower-back pain before experiment. Each of the participants were informed about the purpose of study.

2.2 Design and Development

The supporting drive wheel of the developed self-propelled cono weeder was made from Mild Steel (MS) rod of 8 mm. The diameter of the ground wheel was 600 mm and it has a hub of 25 mm diameter made from MS rod of 30 mm. 12 numbers of equally spaced spokes made from 8 mm MS rod each having 28.75 mm length connected radially the central hub and outer rim of driving wheel. Mild steel rod 8 mm, 80 mm long and 12 in numbers were welded on the outer periphery of the rim at equal spacing. Petrol engine having 1 kW (1.3 HP) was selected as prime mover. The engine speed (5500 rated RPM) at no load condition was reduced to 20 RPM using chain and sprocket arrangement in two steps.

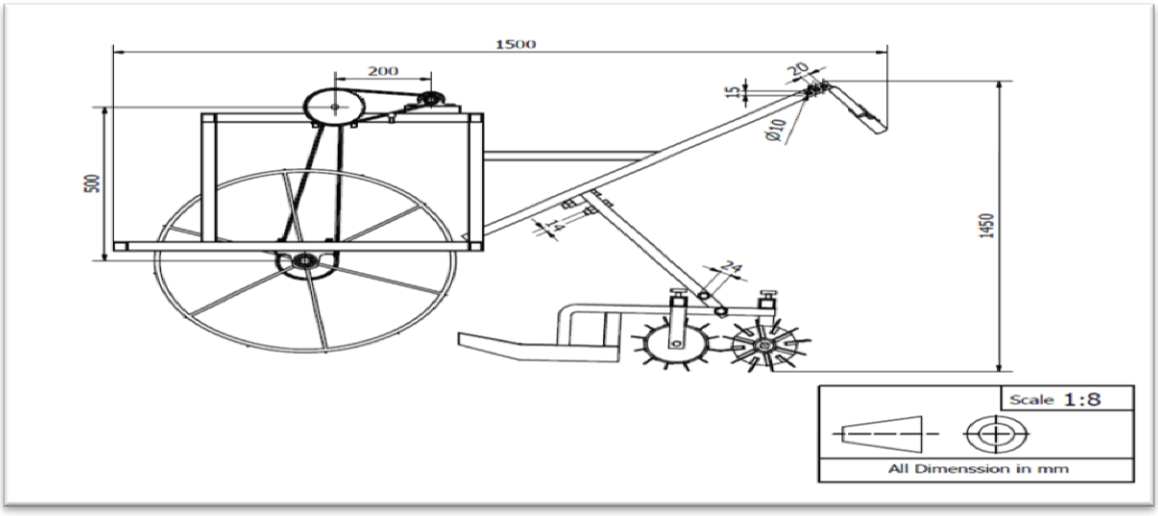

Figure 1. Orthographic view of developed weeder

The engine was mounted on the frame made up of MS hollow square pipe (25 x 25 mm, 2 mm thickness) having 200 mm width, 720 mm length, 400 mm height. The design was done using software Autodesk Inventor 2012 as shown in (Figure 1). The cono weeder developed by CIAE Bhopal was used for the performance evaluation. The pictorial view of the developed self-propelled weeeder is shown in (Figure 2).

2.3 Measurement of basic physical and physiological characteristics of the subjects at field operation.

For conducting the experiment the test field was divided 9 plots of 30 x 1 (L x B m). Three healthy experienced female workers were chosen for the experiment purposed. Selected subjects are conversant with the equipment and field operation. All the trial was conducted in between 8:00 to 12:00 hrs and 16:00 to 17:00 hrs in the field where the temperature 30.3^{0}C. A minimum gap of two hours was maintained between food intake and start of trial. Before the actual experiment each subjects operated the weeder for 10 min for warm up exercise and then asked to take rest for 5 to 10 minutes, so that her physiological responses attained the resting level. In the field the heart rate was measured with the help of a stethoscope. A total of 3 readings for each operators for each equipment (manually operated cono weeder and self-propelled cono weeder) were taken during each replication.

2.4 Field Evaluation

The test was carried out in the 3 series of test with 3 replications. The test conditions such as soil moisture content, soil type, bulk density, depth of the root zone and the density of weed population were taken into consideration. The draft of the developed weeder was calculated using equation (1), actual field capacity (ha/h) was calculated by using equation (2), field efficiency (%) was also calculated by fixing and an area of 30 m^2 (30 x 1 m) by using equation (3), the weeding efficiency was also calculated by fixing an area of 1 m^2 (1 x 1 m) by using the equation (4) respectively.

Formulae

Draft of the developed weeder

$$D = W \times d_w \times R_s \quad \text{…….. (1)}$$

where , D = draft of the weeder, kg

W = width of cut, cm

$d_{w=}$ depth of cut, cm

R_s = soil resistance, kg/cm^2

Actual field capacity (ha/h) =

$$\frac{\text{Actual width of field coverage (m)} \times \text{Length of field coverage (m)}}{\text{Time for covering total area (h)} \times 10000} \quad \text{…(2)}$$

$$\text{Field efficiency (\%} = \frac{\text{Actual field capacity (ha/h)}}{\text{Theoretical field capacity (ha/h)}} \quad \text{…(3)}$$

Weeding efficiency (%)

$$= \frac{N1-N2}{N1} \times 100 \quad \text{…(4)}$$

Where,

N_1 = Number of weeds before weeding and

N_2 = Number of weeds after weeding.

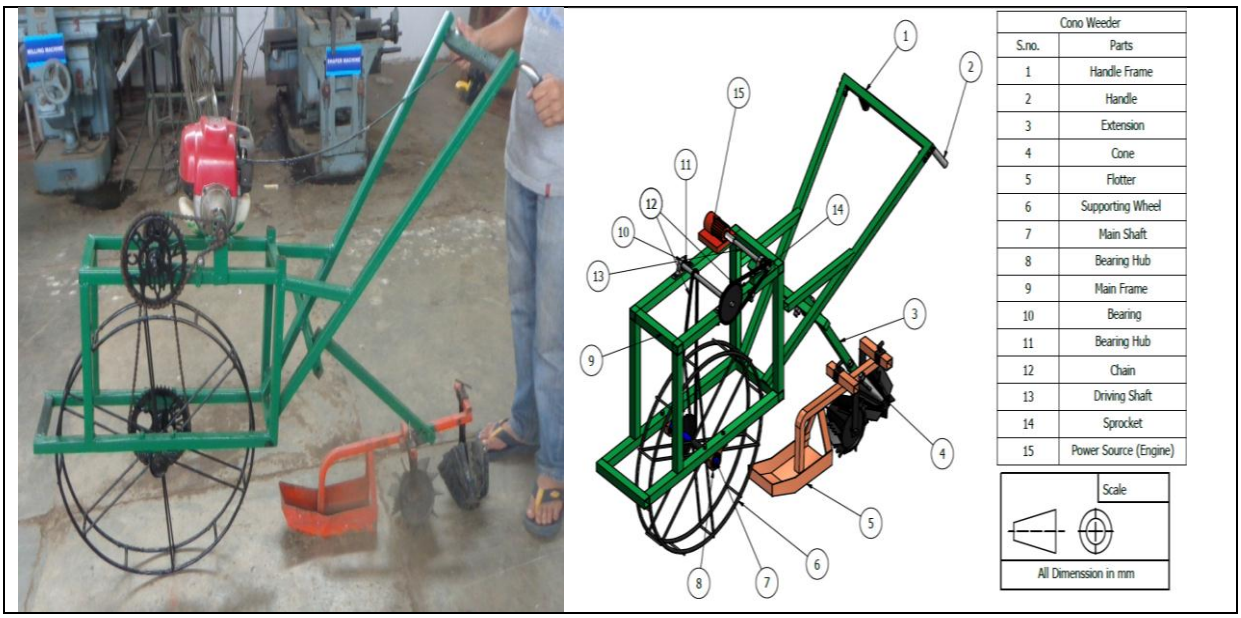

Figure 2. Developed self-propelled cono weeder

3. Results and Discussion

3.1. Relationship between Stature and other Body dimensions of female workers at standing posture

The (Figure 3) shows the relationship between stature and the other body dimensions of female workers in standing posture. For the female workers, a linear relationship was found between the stature and body diemnsions (vertical reach, span, eye height, acromial height, grip diameter) in standing posture. The strength parameter such as right and left hand grip were found to be non-linear with stature.

3.2 Response of Heart Rate during field operation

The heart beat responses of the female participants under two different weeding operations were observed at field. The heart rate was observed for duration of 24 minutes at an interval of 4 minutes. For a particular workload, the heart rate showed a sudden increase in the first few minutes and then it was decreased and stabilized. The peak heart rate was found to be 133, 134 and 138 beats /min for subjects S1, S2 and S3 in manually operated cono weeder and 119, 115 and 120 for self-propelled cono weeder respectively as shown in (Figure 4 & 5). It was also found that the peak heart rate was observed after 16 minutes of operation. Analysis of t stat indicates that heart rate was significantly affected for the weeder, but it was found to be nonsignificant for the subjects as shown in Table 1.

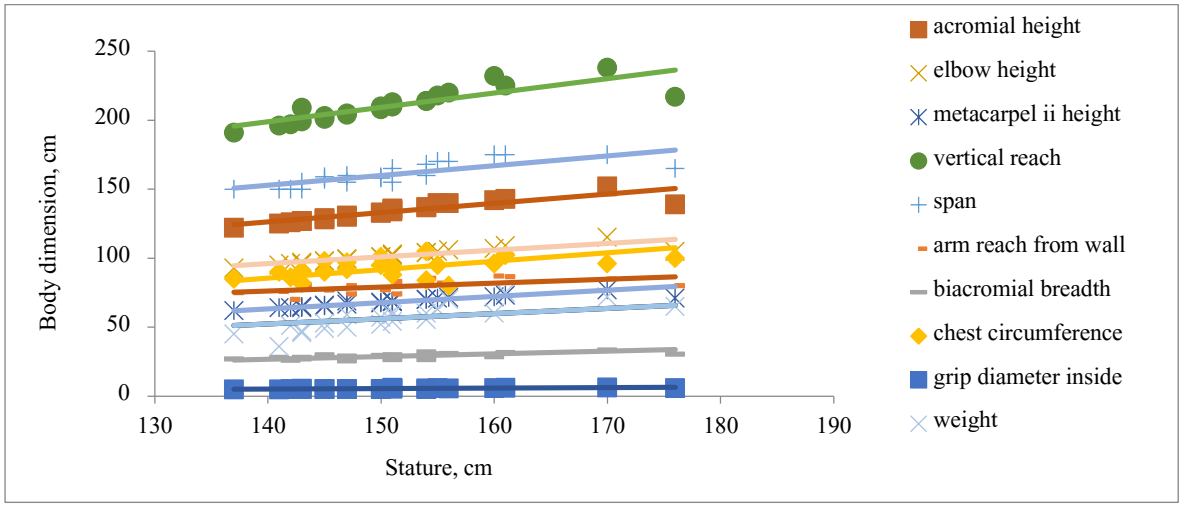

Figure 3. Relationship between stature and other body dimensions of female worker at standing posture

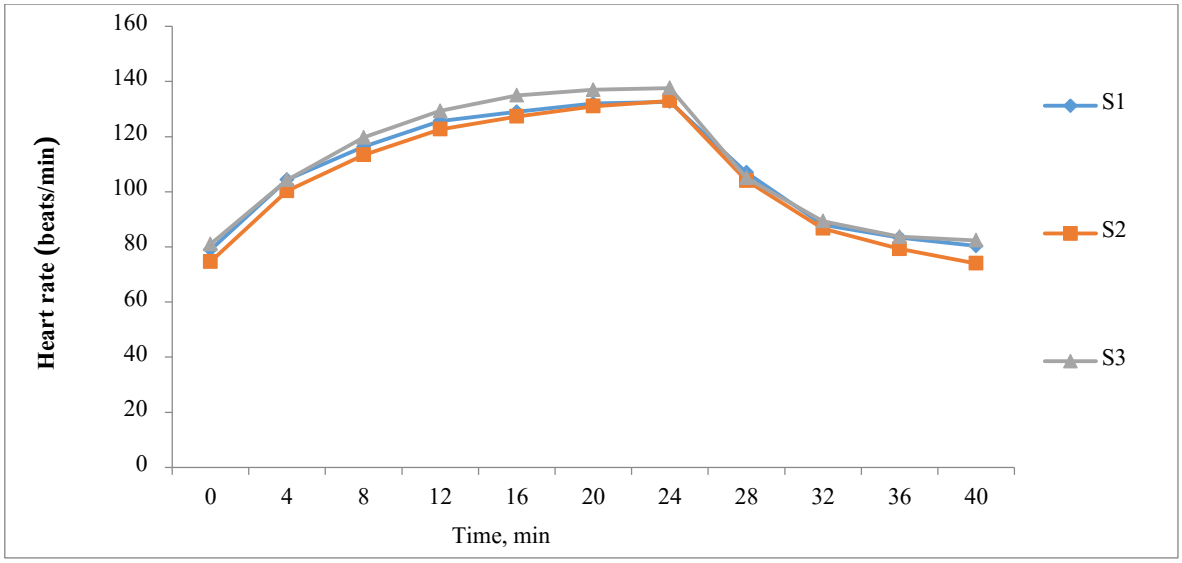

Figure 4. Physiological evaluations in term of heart rate of subjects S1, S2 and S3 (manually operated) during operation and rest pause

The increase in heart beat rate was higher during the initial 0-8 minute and became stable after 20-24 minute of operation as shown in (Figure 6). Average increase in heart rate of different age groups of female operators at two different operations were 56.67 and 37.33 beats/min.

3.3 Response of Oxygen Consumption Rate (OCR) during field operation

The peak oxygen consumption rate of different age group of female workers while operating manual cono weeder and self-propelled cono weeder were 0.893 and 0.688 l/min respectively. It was found that the peak consumption rate of oxygen was observed during 20-24 minute after start of operation. This is because the oxygen consumption rate is directly proportional to the heart beat rate of the operators. The average rate of oxygen consumption was obtained to be 0.852 and 0.649 l/min for manually operated and self-propelled cono weeder.

Analysis of t stat indicates that the oxygen consumption rate was significantly affected for the weeder as well as subjects shown in Table 1.

3.4 Response of Energy Expenditure Rate (EER) during field operation

The energy expenditure rate responses of the female subject under two different weeding operations were calculated using corresponding OCR which was obtained in the field. The maximum energy expenditure rate of 18.62 and 14.35 kJ/min was found in manually operated and self-propelled cono weeder after 20-24 minute of operation. The more the oxygen consumption rate, the higher is the EER. The average EER for the manually operated and self-propelled cono weeder were 17.83 and 13.54 kJ/min respectively. Analysis of t stat indicates that energy expenditure rate was significantly affected for the weeder, but found to be nonsignificant for the subjects as shown in Table 1.

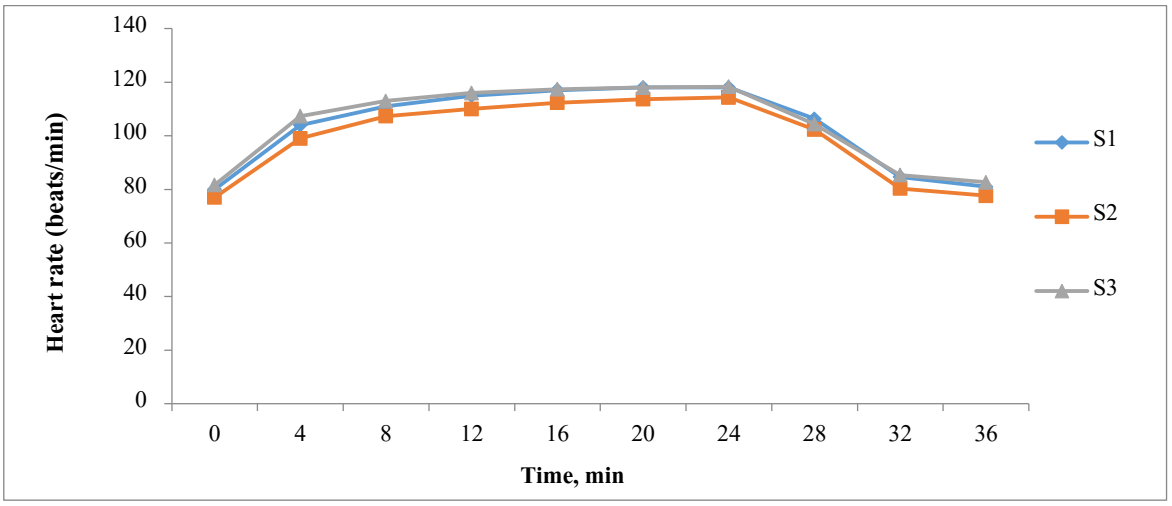

Figure 5. Physiological evaluations in term of heart rate of subjects S1, S2 and S3 (self-propelled) during operation and rest pause

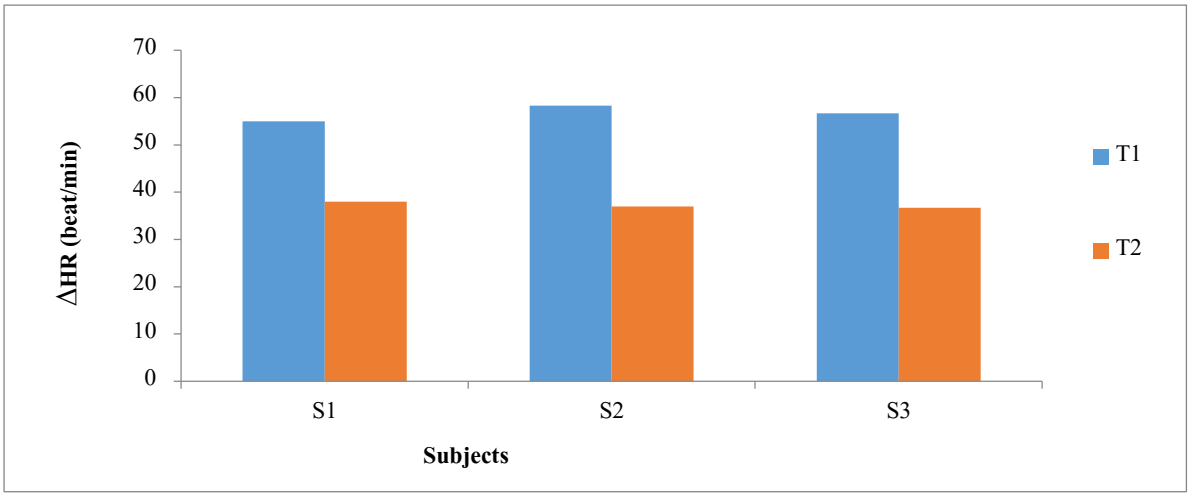

Figure 6. Increase in heart beat rate after 20 minutes of operation.

3.5Field Capacity and Field Efficiency

The mean value of the actual field capacity of manual cono weeder (T_1) and self-propelled cono weeder (T_2) were 0.0207 and 0.0323ha/h respectively. Among the two weeders the maximum field capacity (0.0323ha h^{-1}) was obtained with T_2 treatment followed by T_1 which gave field capacity of (0.0207 hah^{-1}). In case of self-propelled cono weeder (T_2) the operational speed is more than manually operated weeding methods

3.6 Weeding Efficiency

Amongst the two weeders (T_1 and T_2), the highest weeding efficiency 74.44% were found in T_1 and lower weeding efficiency of 68.77% was obtained in T_2. The highest weeding efficiency with T_1 may be due to the repeated operation of cono weeder in the same area (pull and push) in a pass.

Table 1. Statistics analysis with Student's T-Test

Response of Heart Rate during field operation

Particulars	**T1**	**T2**
Observation	9	9
Pool Variance	5.38889	
t Stat	15.9409	
P(T<=t) one-tail	1.5E-11	
t Critical one-tail	1.74588	
P(T<=t) two-tail	3.1E-11	
t Critical two-tail	2.12	

Response of Oxygen Consumption Rate during field operation

Particulars	**T1**	**T2**
Observation	9	9
Pool Variance	0.000847	
t Stat	14.7676	
P(T<=t) one-tail	4.83E-11	
t Critical one-tail	1.745884	
P(T<=t) two-tail	9.65E-11	
t Critical two-tail	2.119	

Response of Energy Expenditure Rate during field operation

Particulars	**T1**	**T2**
Observation	9	9
Pool Variance	0.344826	
t Stat	15.4815	
P(T<=t) one-tail	2.38-11	
t Critical one-tail	1.745884	
P(T<=t) two-tail	4.75E-11	
t Critical two-tail	2.119	

Conclusions

Operating with the Self-propelled cono weeder had a heart rate of 116.89 beats and oxygen consumption rate of 0.649 l/min. The energy expenditure rate was also obtained as 13.54 kJ/min. The field capacity and field efficiency was found to be 0.032 ha/h and 94.49% with weeding efficiency of 68.77%. The minimum man hour required for controlling the weed with self-propelled cono weeder is 25 man-h/ha at the operating speed of 2.28 km/h with fuel consumption of 6.77 l/ha. The developed machine is efficient in operation, but there is little instability as the power source is mounted on one side. This can be avoided if we mounted the power source above the ground wheel.

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References

Agarwal KN, Tiwari PS, Pharade S, Majumdar J, and V Bhushanababu (2011). Anthropometry of Agricultural Workers of Madhya Pradesh. *J Agric Eng,* 48(4): 1-9.

Agriculture research data book, 2011, 2012 and 2013.

Bernacki H, Haman J, and G Kanafajoki (1972). Agricultural Machines–Theory and Construction, Vol. I. National Science Foundation, Washington, D.C.

Biswas HS, Ingle GS, and TP Ojha (1993). Performance evaluation and optimization of straight blades for shallow tillage and weeding in black soils. 24(4): 19-22.

Biswas HS (1990). Soil tool interaction for mechanical control of weeds in black soils. Unpublished Ph.D. thesis, Indian Institute of Technology, Kharagpur.

Biswass HS, Ojha TP, and GS Ingle (1990). Development of animal drawn weeders in India. *Agricultural Mechanization in Asia Africa & Latin America*, 30(4): 57-62.

Ghanshyam D (2012). Rotary weeder for drudgery reduction of women during weeding in rice field. *Indian J Weed Sci,* 44(2): 132–134.

Gite LP, and BG Yadav (1989). Optimum handle height for a push pull type manually operated dryland weeder. *Ergonomics* 33: 1 487–94.

Goel AK, Behera D, Behera BK, Mohanty SK, and SK Nanda (2008). Development and ergonomic evaluation of manually operated weeder for dry land crops. *Agricultural Engineering International: the CIGR Ejournal. Manuscript, PM* 08 009. Vol. X.

Gopinath R (2014). Design of Silent Chain Drive. Middle-East *J Sci Res,* 20(5): 667-670.

Grandjean E (1988). Fitting the task to the man. Taylor and francis, London, 4 ed. 363 p.

Kathirvel K, Sirisha D, and R Manian (2004). Ergonomical evaluation of cono weeder with farm women. All India Coordinated Research Project on Human Engineering and Safety in Agri-culture. Progress Report (1996–2000), TNAU, Coimbatore. 97-105.

Kumar VJF, Durairaj CD, and VM Salokhe (2000). Ergonomic evaluation of hand weeder operation using simulated actuary motion. *International Agric Eng J,* 9(1): 29-39.

Nag PK, and P Dutt (1979). Effectives of some simple agricultural weeders with reference to physiological responses, *J Hum Ergon*, 13-21.

Parida BC (2002). Development and evaluation of star-cum cono weeder for rice. *Agric. Mechanization in Asia, Afr. Latin Am.*, 33(3): 21-22.

Patil PS, Ahirrao YA, Dusing YA, Aher VP, and DA Patil (2010). Role of crop weeds in traditional medicines in Buldhana district (MH). *Life sciences leaflets,* 10: 261 – 272.

Rainbird G and DH O'Neill (1955). Occupational disorders affecting agricultural workers in tropical developing countries. *Applied Ergonomics*, 26:185–7.

Rajvir Y, and P Sahastrarashmi (2007). Development and ergonomic evaluation of manual weeder. *Agricultural Engineering International: the CIGR Ejournal. Manuscript, PM* 07 022. Vol. IX.

Rao AN, Johnson DE, Sivaprasad B, Ladha JK, and AM Moritmer (2007). Weed management in direct seeded rice. *Advance in Agronomy,* 93: 153–255.

Remesan R, Roopesh MS, Remya N, and PS Preman (2007). Wet Land Paddy Weeding- A Comprehensive Comparative Study from South India. *The CIGR journal. Manuscript PM* 07011, 9: 1-21.

Singh SP (2010). Ergonomical Evaluation of Cono-Weeder with Farm Women. Sub-centre of Directorate of Research on Women in Agriculture, CIAE, 34(3): 31-36.

Singh G (1992). Ergonomic considerations in development and fabrication of manual wheel hoe weeder. *Indian J Agric Eng 2*(4): 234-243

Sridhar HS (2013). Development of Single wheel multi use manually operated weed remover. *International J Mod Eng Res (IJMER)* 3(6): 3836-3840.

Tewari VK, Datta R K, and ASR Murtyh (1991). Evaluation of three manually operated weeding devices. *ppl. Ergonomics,* 22(2): 111-116.