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Ergonomics Evaluation of Single Row Power Weeder for Rice

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A B S T R A C T

Weed control is one of the most difficult tasks on an agricultural farm. Mechanical weed control not only uproots the weeds between the crop rows but also keeps the soil surface loose, ensuring better soil aeration and water intake capacity. The developed weeder should have the following features: 2.0 hp, 2-stroke petrol engine. It is compact light low weight equipment, self-propelled with durable floating system. It is centrally driven with worm gear box for transmission. The working width of the developed machine could be adjusted between 140mm to 250mm. It is equipped with rotating blades with 176 rpm and is centrally driven. The cardiac cost involved in the operation of power paddy weeder was found out and the mean working heart rate value of the subject was 108 beats min-1. The energy expended during operation of a power paddy weeder was 19.50 kJ min^{-1}. The oxygen uptake in terms of VO2 max was 46% which was above the acceptable limit of 35% of VO2 max. Mean overall discomfort rating on a 10 point visual analogue discomfort scale (0- no discomfort, 10- extreme discomfort) was 3.0 and scaled as "light discomfort".

Introduction

Weeding out of unwanted plants is a very difficult task in Indian agriculture manually as well as using bullock operated equipment's and consumes 15% of total energy spent in crop production. If there is a delay and negligence in weeding operation crop yield is affected up to 30 to 60% (Singh, 1988). Weeds waste excessive proportions of farmers' time, thereby acting as a brake on development. Weeding operation is performed generally manually which involves highly labour input and time consuming. 16-42% reduction in crop yield is estimated due to weed alone and involves one-third of total cost of cultivation (Rangasamy *et al.*, 1993). Mechanical weed control reduces the drudgery involved in uprooting of the weeds. The engine-powered implements have a strong, direct impact over operational drudgery, saving its operator (or more than one) from an otherwise very tiring process.

An ergonomic dimension corresponds best to the orientation of the designed machine which are worked in different positions and postures should be different as per the region to meet

the requirement of soil type, crop grown, anthropometric measurement's. Hence the effort has been made to develop a weeder to meets the demand of the farmers and achieve the better efficiency, human comfort and safety. The performance of any machine especially manually operated ones could be considerably improved if ergonomic aspects are given due weightage (Gite, 1993). Measurement of physiological parameters of the operator are also important from the safety point of view because whenever the physical capacity of a person is exceeded, it is bound to cause considerable fatigue and large reduction in the alertness of the person making the operation unsafe.

Materials and Methods

Development of single row active power weeder (rice) for weeding is designed with the ergonomics point of view such that agriculture workers can work effectively with less drudgery. The various design parameters have consider for developing machine. Adjustability to change the width of working, it varied from 140 mm to 240 mm. light weight be developed to lessen fatigue/workload on the operator and easy to operate, low maintenance thereby facilitating them to walk comfortably behind the weeder.

It is best suited for rice crop weeding having row spacing between 170 mm to 240 mm. The developed weeder should have the following features: 2.0 hp, 2-stroke petrol engine. It is compact light low weight equipment, self-propelled with durable floating system. It is centrally driven with worm gear box for transmission. The working width of the developed machine could be adjusted between 140 mm to 250 mm. It is equipped with rotating blades with 176 rpm. Due to compactness and low weight it is easily manoeuvrable. The technical specifications of the power tiller are given in Table 1.

Design consideration

A manually operated power weeder was designed for weeding of mechanical and manual transplanting of rice. From the design point of view- power source (engine), cutting blades shaft were the important components of single row power weeder for rice. Conceptual design of power weeder was prepared with Solid Works software it is shown in Fig.1.

Ergonomic evaluation

The subjects were in the age group of 26 to 42 years. Nineteen anthropometric measurements were taken, which were considered useful for designing of power weeder. Table 2 shows the body dimensions.

Field layout experiments

The experiment was conducted in farmer's field in different district of Chhattisgarh. Power weeder is a manually operated implement and designed to work in between the rows of 14-25 cm spacing in wet lands. All the operators were equally trained in the operation of the power paddy weeder. The subjects were given information about the experimental requirements so as to enlist their full cooperation. The physiological parameter was measured and recorded using stethoscope, pulse oximeter, B.P monitor machine, BMI machine and fitness band. Each trial started with taking five minutes data for physiological responses of the subjects while resting on a stool under shade.

Data Analysis

The stabilized values of heart rate for each subject during operation after every 7^{th} to 15^{th} min as per operator condition were used to calculate the mean value for power paddy weeder. From the mean values of heart rate (HR) observed during the trials, the

corresponding values of oxygen consumption rate (VO_2) of the subjects were predicted from the calibration curves of the subjects. The energy costs of the operations were computed by multiplying the value of oxygen consumption (mean of the values of three subjects) by the calorific value of oxygen as 20.88 kJ lit^{-1}.

Body part discomfort score (BPDS)

The body part discomfort score of each subject was the rating multiplied by the number of body parts corresponding to each category. The subjects were asked to locate the body parts with respect to degree of discomfort in the order as extremely heavy, very heavy, moderately heavy, heavy, light and very light. The body part discomfort was determined by the following formula (Corlett and Bishop, 1976):

$BPDS = S\ X_i * S$ (3.40)

Where,

BPDS = Body parts discomfort score
X_i = Number ofbody parts
S = Discomfort score (6 to 1)

Results and Discussion

Physiological evaluation

Heart rate

Initially heart rate was different for each different group ranging between 60 to 66 beats per min. For a particular workload the heart rate showed a sudden increase in starting periods of work and then established throughout the work. After the completion of the work, heart rate decreases drastically. Average heart rate of different age groups after the commencement of weeding operation was found as 109, 116, 111 and 114 beats /min. The detailed observed data of heart rate, of a particular subject with time duration shown in fig 4.

Energy cost of operation

The average working heart rate of the operator was 109.55beats min^{-1} and the corresponding value of oxygen consumption rate was 0.57 l min^{-1}. The corresponding energy expenditure was 12.60 $kJmin^{-1}$. Based on the mean energy expenditure, the operation was graded as "Moderately Heavy"

Fig.1 Conceptual design of power weeder prepared with Solid Works software

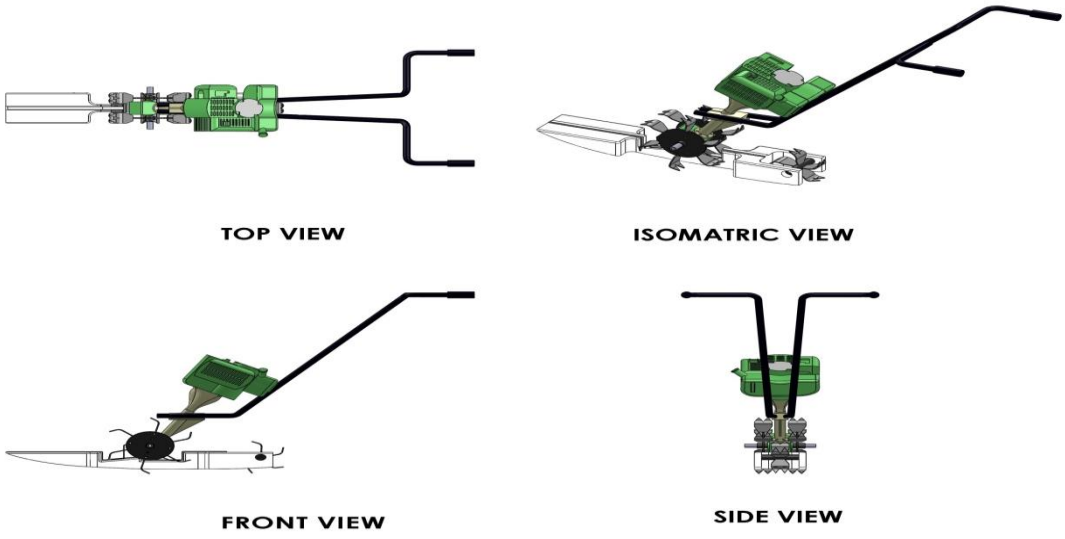

Fig.2 Heart Rate caliberation during operation with the help of fitness band

Fig.3 Field testing of power weeder at Research Farm IGKV, Raipur

Fig.4 Stress stabilization for power weeder

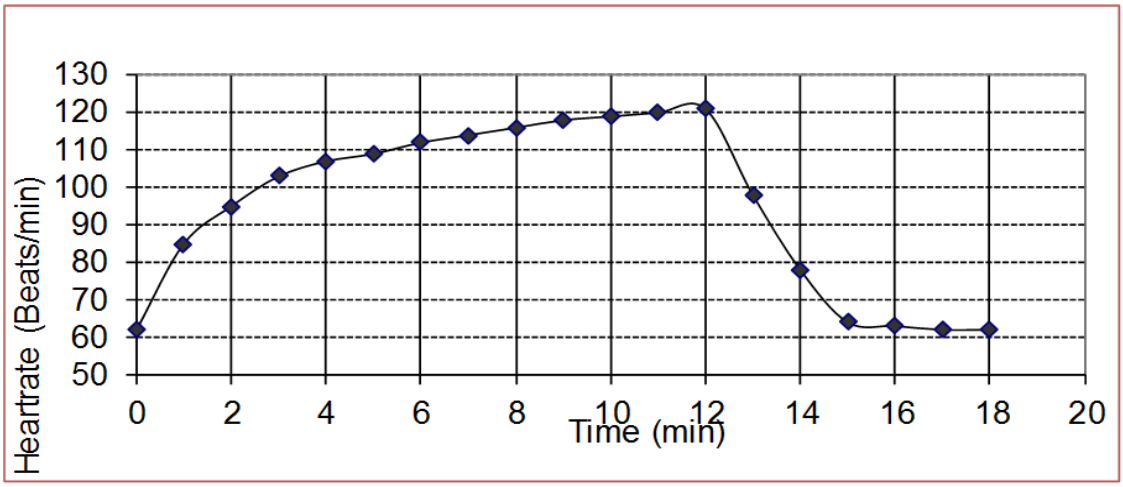

Table.1 Technical specification of power weeder

Specification	Value
Number of cylinder	1
Engine maximum power at 6000 rpm	2 hp
Weeding width	140 mm to 250 mm
No. of Blades	8
Rotavator speed	176 rpm
Overall dimension (LxWxH)	890x325x580mm
Total weight	14.5 kg

Table.2 Selected Body Dimensions of Subject's taken for study

Sl. No.	Dimensional Element (mm)	Subjects				
		1	2	3	4	5
1	Height	1720	1650	1670	1590	1640
2	Eye Height Standing	1610	1535	1542	1495	1550
3	Eye Height Sitting	1214	1189	1196	1059	1170
4	Sitting height	910	900	904	890	830
5	Shoulder Breadth	425	410	414	395	405
6	Chest Depth	220	217	218	205	220
7	Hip Breadth; standing	315	309	311	315	305
8	Hip Breadth; Sitting	580	570	572	561	570
9	Shoulder Elbow	397	385	389	365	375
10	Forearm – hand	421	419	419	388	422
11	Arm reach	692	688	688	652	685
12	Elbow height: sitting	195	187	188	172	170
13	Buttock knee	562	559	560	530	552
14	Seat length	467	460	461	448	458
15	Knee height: sitting	521	520	524	503	523
16	Seat height	439	425	426	407	422
17	Foot length	259	250	252	239	248
18	Foot breath	874	900	892	860	875
19	Age (years)	26	30	35	42	24

(Measuring unit: mm unless otherwise specified)

Body part discomfort score (BPDS)

The majority of discomfort was experienced in the left shoulder, right shoulder, left wrist, right wrist, left thigh and right thigh region for all the subjects during weeding and the body part discomfort score of subjects during weeding with power rice weeder was 24.12.

Work rest cycle

Rest pause was calculated, as all the subjects

operated continuously for the 25 min period and it was found that 7 min rest could be provided to operator who was engaged in operating the equipment.

The performance of rice weeder was found excellently on wet condition and is easy to operate. The developed weeder could work upto the depth of 4-8 cm with the field capacity of 33.33 h/ha. Fuel consumption of the weeder was 2 l/h. The operating cost of the rotary rice weeder was Rs.980/ha compared to Rs. 2300/ha for manual weeding.

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