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CONTENTS

Drudgery reduction of farm women involved in weeding of soybean crop

SHALINI CHAKRABORTY

ICAR Krishi Vigyan Kendra, Rajgarh, R.V.S. Agriculture University, Gwalior, Madhya Pradesh

ABSTRACT: Weeding is the most important farm operations in crop production system.It is one of the most drudgery prone operation performed by the farm women. Majority of the farm women do weed control using hand tools like sickle or khurpi in squatting and bending position which decreases the work efficiency and involves a lot of drudgery and time. The main purpose of the present study is to demonstrate weeding implements (Single Wheel Hoe and Twin Wheel Hoe) for weeding in soybean crop with the objective to reduce drudgery with muscular stress and fatigue. Twenty five farm women were selected randomly from different villages of Rajgarh district for the study. The study measured the changes in heart rate (ΔHR), area covered during weeding and cardiac cost of work (CCW) of the subjects in traditional methods of weeding (squatting and using a sickle or khurpi) vis-a-vis weeding implements (Single Wheel Hoe and Twin Wheel Hoe). It is evident from the results of the demonstration that usage of weeding implements led to significant ($p<0.05$) decrease in ΔHR and CCW, while the weeding area registered a significant increase ($p<0.05$). Drudgery reduction was recorded as 52 and 58 per cent for single wheel hoe and twin wheel hoe, respectively. The results underscored the importance of weeding implements usage by farm women for intercultural operations leading to reduced exhaustion and fatigue.

Key words: Cardiac cost of work, drudgery, energy expenditure, weeding, wheel hoe

Weeding is one of the most important but equally labour intensive farm operations in crop production system. Weed growth is a major problem for dry land crops particularly in oilseed crops like groundnut and soybean causing a considerable lower yield. As oilseeds constitute the second major agricultural crops in India next to food grains in terms of quantity and cost, Delay and negligence in weeding operation affect the crop yield vary from 40-60% and in many cases cause complete crop failure (Singh, 1988). In India soybean is an established major Kharif crop. Madhya Pradesh has the major share in the area (70%) and production (65%) of soybean in India. In this crop, weeding operation is mostly performed requires higher labour input and also very tedious and time consuming process.

Weeding accounts for about 25 % of the total labour requirement (900–1200 man hours/hectare) during a cultivation season (Yadav and Pund, 2007). Moreover, the labour requirement for weeding depends on weed flora, weed intensity, time of weeding and soil moisture at the time of weeding and efficiency of worker. There is an increasing concern over the intra row weeder because of environmental degradation and growing demand for the food. Today the agricultural sector requires non-chemical weed control that ensures food safety. Consumers demand high quality food products and pay special attention to food safety.

The most common methods of weed control are mechanical, chemical, biological and cultural methods. Out of these four methods, mechanical weeding either by hand tools or weeders are most effective (Manjunatha *et al*., 2014; Tewari *et al*., 2014; Chandel *et al*., 2021) and are being practiced in many regions of India. Women performed this activity is in bending and squatting posture for longer time. This posture increases the fatigue and drudgery of farm women while weeding which leads to aches and pains in the back, knee and cervical region (Vinay and Sharma,2005). The unnatural body posture adopted during this activity results in an increase in the physiological workload causing a lot of muscular-skeletal problems, all this leads to a decrease in the efficiency of women. Using mechanical weeders which perform simultaneous job of weeding and hoeing can reduce the time spent on weeding (man hours), cost of weeding and drudgery involved in manual weeding (Goel *et al.*,

2008). The present study was conducted with the objective to observe and compare the performance of traditional weeding tool with mechanical weeders, like single wheel hoe and twin wheel hoe through different drudgery related performance parameters.

MATERIALS AND METHODS

Locale and subjects of the study

The study was conducted on farm women involved in weeding in soybean fields (24°00'32"N, 76°44'21"E) in Rajgarh district of Madhya Pradesh, India.The farm women were in the age group of 25 to 45 years having normal blood pressure and free of any physical deformity. Experiments were conducted in the month of August. Well prepared interview questionnaire was carried out for collecting the data; as regards to their physical fitness and prevalence of any serious health hazard. The anthropometer and weighing balance were used to measure the physical characteristics like height and weight. The grading of health status of women was done on the basis of Body Mass Index (BMI). The BMI scores were interpreted as per the classification given by Garrow (1987).

Tools of the study

Locally available *khurpi* was considered for traditional weeding in this study. Single wheel hoe and twin wheel hoe was provided by ICAR-CIAE, Bhopal; the same was adopted in this study as the mechanical weeding operation. The wheel hoe comprised single / twin wheel, frame, V-blade with tyne, U clamp, scrapper and handle. Cutting and uprooting of weeds are done through push and pull action.

Figure 1:Heart rate monitoring with a sphygmomanometer

Parameters

The parameters studied during the experiments were, output in terms of weeded area (m^2/hr), ergonomic cost of weeding activity in terms of heart rate (beats/min) and cardiac cost of work (beats/m^2), economics in terms of reduction of man power (labourer/ha) and labour cost (Rs/ha) and musculo skeletal problems. These parameters were studied for traditional method of weeding (using *khurpi*) and weeding using the single wheel hoe and twin wheel hoe.

Heart Rate (HR, beats/min) of the respondent was recorded by using the digital heart rate monitor sphygmomanometer(Make: Omron HEM 6111) (Figure 1).

Resting heart rate (RHR), heart rate at rest before activity.

Working heart rate (WHR), heart rate after completion of the activity.

Output (m^2/h) = Weeding area per unit time

Cardiac Cost of Work (CCW):Pertinent evidence of the degree of physiological stress induced by work can be easily obtained from the cardiac cost of work when the experiment is over.

$$CCW(beats/m^2) = \frac{\Delta HR \times duration}{Output} \quad (1)$$

$$\Delta HR = WHR - RHR \quad (2)$$

Drudgery reduction (DR), is defined as the per cent reduction in the physiological stress induced by work.

$$DR = \frac{CCW_1 \times CCW_2}{CCW_1} \times 100 \quad (3)$$

Where, CCW_1 is cardiac cost of work with traditional

tool, CCW_2 is cardiac cost of work with improved tool.

Energy Expenditure Rate- Energy expenditure is the amount of energy that a person needs to carry out physical function. Average heat rate was used to calculate this energy expenditure rate (EER,kJ/min) (Varghese,1994)

$$EER = (0.159 \times HR) - 8.72 \quad (4)$$

The results were statistically analysed using test of significance (t- test at 5 per cent level of probability) and simple regression (r) by the method proposed by Snedecor and Cochran (1987).

Musculo-skeletal problems

Bodily discomfort in terms of musculo-skeletal problems was identified using the body map (Figure 2) indicating pain in different parts of the body before and just after the completion of the activity. Intensity of pain was scaled by a Five-point scale: 5, very severe; 4, severe;3, moderate;2, mild;1, very mild.

RESULTS AND DISCUSSION

Physical characteristics of the respondents

Respondents in the age group between 25-45 years were selected at random and average age was counted as 36.6± 6.24 years. The mean body mass index (*BMI*) was calculated using standard formula using the body weight (*W*, kg) and height (*H*, m). All the physical parameters are reported in Table 1.

Table 1: Physical characteristics of selected respondents (N=25)

Physical features	Mean ± S.D.
Age (yr)	36.6± 6.24
Height (cm)	152.84±3.59
Weight (kg)	48.46± 4.35
Body Mass Index (BMI)	20.73± 1.37

$$BMI = \frac{W}{H^2} \quad (5)$$

Physiological workload of weeding

Data in Table 2 reveals the performance parameters (Physiological workload) of farm women while weeding with different weeding tools. Generally heart rate is used as an ergonomic measure to evaluate the physiological or functional demands of work on the individual workers (Hasalkar *et al.,* 2004). The physiological point of view, the job demand or work load refers to the demands placed on the cardio-respiratory system and is determined by the energy cost and cardiac cost of work. Average change in heart rate (ΔHR) denotes average

Table 2:Mean(N=25) values of performance parameters for farm women while weeding using different methods

Parameters	Khurpi	Single wheel hoe	Twin wheel hoe
Average working heart rate beats/min	85.20±5.11	81.88±4.22	81.32±4.64
Average resting heart rate (beats/min)	76.76±5.40	74.00±4.30	73.16±4.44
"HR (beats/min)	8.44 ±1.80	7.92±1.47	8.16±2.10
Output (m^2/hr)	72.16±6.14	149.84±13.16	173.12±17.01
Cardiac cost of work (beats/m^2)	7.05±1.43	3.21±0.74	2.86±0.81
Energy expended during work (kJ/min)	4.83±0.83	4.30±0.67	4.21±0.74
Energy expended during rest (kJ/min)	3.48±0.86	3.04±0.68	2.91±0.71
Drudgery reduction (per cent)	-	53.04 ±13.21	57.44±16.86

Table 3: Interrelationship between methods of weeding

Responses	Cardiac cost (beats/m^2)	Area covered (m^2/hr)	Energy expenditure during work (EEW)	Energy expenditure during rest (EER)
Traditional weeding	7.05^a	72.16^a	4.83^a	3.48^a
Single Wheel hoe weeding	3.21^b	149.84^b	4.30^{ab}	3.04^b
Twin Wheel hoe weeding	2.86^b	173.12^c	4.21^b	2.91^b
Error Mean Square	1.23	166.82	0.593	0.59
LSD	0.63	7.28	0.43	0.42

Degrees of freedom= 72, $T_{critical}$ = 1.99, Means with the same letters are not significantly different at $p<0.05$

Table 4: Correlation between experimental factors and weeding tools

		AGE	WEIGHT	HEIGHT	WHR	RHR	ЛЬ Iw	OUTPUT	CCW	EEw	EER
Khurpi	AGE	1									
SWH		1									
TWH		1									
Khurpi	WEIGHT	0.422	1								
SWH		0.422	1								
TWH		0.422	1								
Khurpi	HEIGHT	0.526	0.797	1							
SWH		0.526	0.797	1							
TWH		0.526	0.797	1							
Khurpi	WHR	0.264	0.359	0.196	1						
SWH		0.341	0.359	0.161	1						
TWH		0.069	0.263	-0.030	1						
Khurpi	RHR	0.376	0.365	0.299	0.935	1					
SWH		0.349	0.268	0.146	0.950	1					
TWH		0.090	0.144	-0.092	0.899	1					
Khurpi	ЛЬ Iw	-0.270	0.025	-0.255	0.290	-0.067	1				
SWH		-0.066	0.249	0.028	0.045	-0.269	1				
TWH		-0.041	0.282	0.132	0.306	-0.142	1				
Khurpi	OUTPUT	-0.158	-0.165	-0.119	0.294	0.168	0.375	1			
SWH		-0.223	-0.220	-0.274	0.066	0.214	-0.481	1			
TWH		0.032	-0.334	-0.077	-0.294	-0.288	-0.039	1			
Khurpi	CCW	-0.251	0.077	-0.240	0.196	-0.142	0.937	0.033	1		
SWH		0.047	0.253	0.124	0.004	-0.289	0.938	-0.741	1		
TWH		-0.084	0.372	0.139	0.392	-0.020	0.928	-0.399	1		
Khurpi	EEw	0.264	0.359	0.196	1.000	0.935	0.290	0.294	0.196	1	
SWH		0.341	0.359	0.161	1.000	0.950	0.045	0.066	0.004	1	
TWH		0.069	0.263	-0.030	1.000	0.899	0.306	-0.294	0.392	1	
Khurpi	EER	0.376	0.365	0.299	0.935	1.000	-0.067	0.168	-0.142	0.935	1
SWH		0.349	0.268	0.146	0.950	1.000	-0.269	0.214	-0.289	0.950	1
TWH		0.090	0.144	-0.092	0.899	1.000	-0.142	-0.288	-0.020	0.899	1

Table 5: Responses on musculo-skeletal problems and perceived exertion experienced by respondents

Weeding method	Musculo- skeletal problems	Rating of perceived exertion (RPE)
Traditional	Severe pain in shoulders, upper and lower back and upper arms	Very heavy
Single Wheel hoe	Moderate to light pain in shoulders, hands and arms	Moderately heavy
Twin Wheel Hoe	Moderate to light pain in shoulders, hands and arms	Moderately heavy

Table 6: Economical analysis of using wheel hoe

Parameters	Weeding using Khurpi	Weeding using Single wheel hoe	Weeding using Twin wheel hoe
Area covered (m^2/day)	577	1199	1385
Manpower required for weeding(man/day/ha)	17.33	8.34	7.22
Labour cost (Rs/ha) Rs. 300/labour	5199	2502	2166
Labour Saving (per cent)	-	51.87	58.33

difference of working heart rate and the heart rate during rest. Table 2 indicates that average ΔHR in traditional method of weeding is 8.44 beats/min and in weeding with single wheel hoe and twin wheel hoe is 7.92 and 8.16 beats/minute respectively.There was no significant difference observed between average working heart rate of all the three activity i.e. traditional weeding as well as weeding with wheel hoe. Only 72.16±6.14 m^2 area was weeded per hour in traditional weeding whereas using single wheel hoe and twin wheel hoe 149.84±13.16 and 173.12±17.01 weeded area m^2 area overed per hour respectively. In other words the output in terms of weeded area using both type of wheel hoe is almost double than that of traditional method of weeding. The energy expenditure was 4.83 kJ/min during traditional weeding and 4.30 and 4.21 kJ/min during weeding with single wheel hoe method and twin whell hoe respectively. The cardiac cost of work for traditional method of weeding is 7.05 beats/

m^2,where as it is 3.21and 2.78 beats/m^2 in weeding with single wheel hoe and twin wheel hoe. So, there is saving of cardiac cost of up to 53 to 58 Per cent when weeding activity is done with both the wheel hoe, which depicts that wheel hoe enhances the efficiency up to double of than that of traditional method of weeding.It was clearly depicted that twin wheel hoe has proved more efficient on time and output as compared with traditional khurpi and single heel hoe.

The interrelation between the measures of drudgery and different weeding methods is shown in the Table 3. It can be observed that there is a significant difference between all the drudgery measures for traditional weeding and twin wheel hoe. Non-significant difference was observed in energy expenditure during the weeding operation carried out traditionally or by a single wheel hoe. There is a significant difference in terms of area covered between all the weeding methods. Indications are that weeding carried out by twin wheel hoe has a distinct advantage over the traditional and single wheel hoe. Other than the area covered there was non-significant difference in terms of the vital drudgery measures between the single wheel hoe and twin wheel hoe. Similar findings were also reported by other researchers (Tripathi *et al.*, 2016;Chakrabortyand Chakraborty, 2019)using different weeding tools for drudgery reduction.

Correlation between experimental factors in relation to different weeding tools

The correlation coefficient between the experimental parameters in relation to different methods of the weeding is presented in this Table 4. The correlation depicted by the physiological parameters (age, weight and height) are obvious as expected. It is worth noting that increase in height resulted in decrease of working heart rate for twin wheel hoe. May be that having more height eased the weeding operation. A recommendation can be that a provision for length adjustment in twin wheel hoe height help in reducing Working heart rate (WHR). Height of the operator also offered an advantage in terms of energy expanded while using twin wheel hoe (TWH). The negative correlation between height and for TWH is an indicator of the above fact. WHR and Output had a negative correlation for twin wheel hoe, reflecting the drudgery advantage associated with twin Wheel hoe as compared to single wheel hoe and traditional weeding. Cardiac Cost of Work (CCW) and output had a negative correlation, while it was otherwise for traditional weeding. Across all the weeding operations the CCW and Energy Expenditure depicted a positive correlation. Twin wheel hoe reflecting the drudgery advantage associated with TWH as compared to Single wheel hoe and.

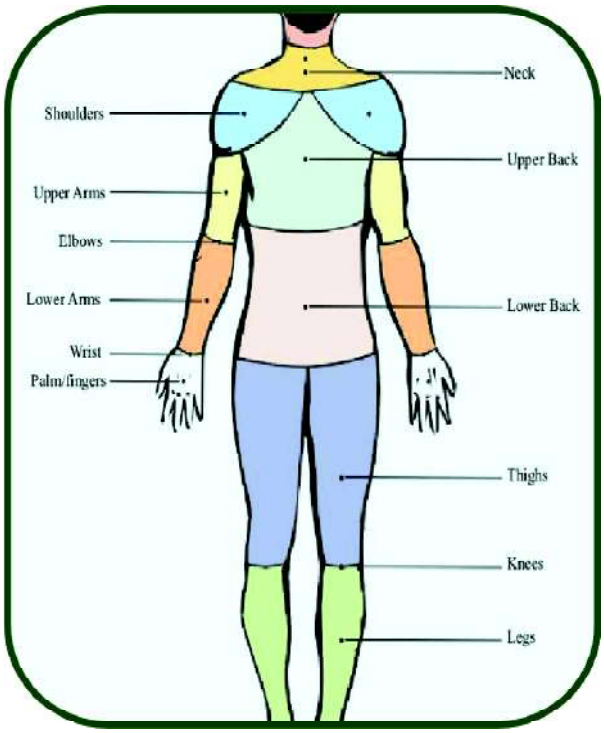

Figure 2: Body map indicating the different parts of the body in terms of musculo-skeletal problems

Musculo skeletal problems

Weeding is an activity where musculo-skeletal problems are very pronounced. The reason being the activity is time bound and performed continuously for prolonged hours. The traditional method employs bending and squatting posture while pulling out weeds either with bare hands orusing *Khurpi*.Musculo-skeletal problems and posture were evaluated by asking the respondents as to where they felt pain in theirbody after weeding with traditional and improved technology. Table 5 depicts that

weeding with traditional tools in strenuous posture caused severe pain in shoulders, upper and mid back and upper arms. The women perceived the task as very heavy. On the contrary using improved weeding tool induced moderate to light discomfort/pain in shoulders, arms, wrist and neck. They were relieved from back pain as improved tool employed standing posture and eliminated back breaking bending and squatting posture. The rating of perceived exertion was also reported as moderately heavy with use of both the improved tool.

Economics of labour

The economics associated with using wheel hoe is exhibited in Table 6. It can be inferred from the said table that 17.33 men/day/ha are required for weeding by the traditional method. When Single wheel hoe and Twin wheel hoe was used for weeding, the number of men/day/ha required decreased to 8.34 and 7.22 respectively. Thus, use of both type of wheel hoe for weeding purposes led to a massive decrease in number of required labourers(by more than 50 Per cent approximately). Labour cost involved in weeding one hectare of land with traditional method wasRs. 5199 (labour @300 Rs/ day) whereas with single wheel hoe and twin wheel hoe, it wasRs.2502and 2166 per ha, resulting in a saving of about 51.87 and 58.33 Per cent in labour cost respectively.

CONCLUSION

Weeding of soybean by traditional tool (*khurpi*) is a time consuming and tedious operation. It was observed that single and twin wheel hoe reduced the drudgery 53 and 57 per cent, respectively thus "increase" the efficiency of workers:"reduce" the labour cost up to 52 and 58 per cent, respectively. It can be concluded that the same amount of weeding can be performed by only with half the number of farmwomen (or double the area can be covered by same number of farmwomen). The added advantage of the technology is that twin wheel hoe will improve posture and efficiency of the worker thus reducing drudgery - while weeding done by women the "rating of perceived exertion" where using wheel hoe was rated as "moderately heavy" as compared to traditional weeding rated as "very heavy". Popularization of these tools among farm women is essentially required to reduce their burden in weeding activity and enhance their efficiency.

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