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Evaluation of Improved Sickle for Paddy Harvesting in Central India

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ABSTRACT

Improved and local sickle were evaluated ergonomically for harvesting paddy crop with 10 farm women (Subjects) aged 22-45 years from Kachhi-berkheda village, Bhopal (Madhya Pradesh). Improved sickle was tested on farm women to improve work efficiency and to reduce the drudgery of farm women. The performance in respect to heart rate, cardiac cost, overall discomfort, body part discomfort and output were evaluated and data of improved and local sickle were compared. The results revealed that mean HRwork and oxygen consumption rate was 112 beats/min and 0.5 l/min with improved sickle, whereas it was 109 beats/min and 0.6 l/min with local sickle during paddy harvesting, respectively. The corresponding work pulse (Δ HR) was 34 beats/min. It was observed that there was 5.3 per cent increase in output with improved sickle. The total cardiac cost of work and physiological cost of work in improved sickle was recorded as 1251 and 42, respectively. About 28 per cent reduction in drudgery was observed with improved sickle in comparison with local sickle.

Keywords: Drudgery, heart rate, improved sickles, paddy harvesting, women workers

INTRODUCTION

Agriculture has an important place in the Indian economy and main workforce in it is human power. Farm women play a significant and crucial role in agricultural operations almost each and every field activity right from sowing to harvesting. In India, nearly 50-60 per cent of women workforce is engaged in agriculture. In India, rice is the major cereal crop and ranked 2nd in production in the world with a share of 21.6 per cent of the total world rice production grown in an area of 39.47 million ha with a production of 87.10 million tonnes, and yield of 2207 kg/ha (Agricultural Statistics, 2012). In Madhya Pradesh rice grown in an area of 160.029 lakh ha with production of 17.721 lakh tonnes and yield of 1106 kg/ha (Directorate of Rice Development, 2011).

The sequence of manual harvesting, field drying, bundling and stacking in traditional systems can cause losses of between 2 per cent and 7 per cent (Toquero and Duff, 1974). The serrated edged blades of improved sickle facilitate self-sharpening and better quality of cut. The handle has lightweight with a better grip to improve the operators comfort and do not receive hand injury. Singh and Singh (1978) reported that serrated surface gives better performance than a plain one with shearing force at the cutting edge. Nag *et al.*, (1980) reported that for wheat and paddy crop harvesting about 8 per cent of the total human-h involved in their production.

Harvesting paddy crop from the field is traditionally done by manually with sickle which involves drudgery and takes longer time to accomplish the operation. With local sickle, about 170 to 200 man-h takes to harvest one hectare of paddy crop. However, with improved sickle about 80 to 150 man-h required for harvesting one hectare of paddy crop depending upon the crop stand and skill of the operator. Proper harvesting and handling method can considerably reduce losses. The improved sickle reduced drudgery of farm women by about 16.5 per cent as compared to local sickle for harvesting wheat crop (Gite and Agarwal, 2000). Karunanithi and Tajuddin (2003) reported that for paddy harvesting with local sickle, average heart rate of women workers of Coimbatore region was 120 beats/min. In manually paddy harvesting activity, women usually working in squatting posture and they continue to work in this posture due to which they reported severe body pain in lower back, knee and cervical region (Jyotsna et al., 2005). Singh (2012) observed mean heart rate during work, in operation with

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Naveen, Vaibhav and local sickles were 103 beats/min, 107 beats/min and 106 beats/min respectively. Correspondingly, average output with these sickles was 47.3, 60.7 and 65.4 m2/h. Alka *et al.,* (2014) concluded that with improved sickle average working heart rate and energy expenditure of women were found to be 110 beats/min and 12 kJ/s respectively and working efficiency was increased 19.5 per cent by using improved sickle over local sickle. Saving in cardiac cost of farm women per unit of output was found to be 19 per cent compared to local sickle. The field performance evaluation of sickles for paddy crop harvesting is being felt important in order to reduce the drudgery during harvesting. Hence, evaluation of paddy harvesting with improved sickle with farm women of Central India was carried out and comparison was done with local sickle.

METHODOLOGY

In this study, the performance of improved sickle in respect of cardiac cost, overall discomfort, body part discomfort and output were evaluated with farm women and comparison was done with local sickle for harvesting of paddy crop. The field experiment was carried out with 10 farm women, among physically fit, without any major illness involved in paddy harvesting operation, each women falling between the age group of 22-45 years. Before starting the experiment, recorded physically measurements like age, height and weight of all selected women and working environment parameters were also recorded. Each subject operated both the sickles for 60 min. At the beginning and at the end of each experiment, the subjects were given 15 minutes for rest so that all the physiological parameters regained to their normal level. The detail specification of the sickles used in the study is given in Table 1.

Table 1: Dimensions of improved and local sickle against standards (Singh, 2012)

Particulars	Dimensions of studied sickle, mm		
	BIS (1967)	Improved sickle	Local sickle
Base plate for blade of sickle	12 ± 2	55	9
Maximum width of blade	28 ± 3	23	40
Blade thickness	4 ± 0.5	1.5	4
Cutting surface	-	252	225
Outer length of blade	-	285	340
Concavity of blade	59	30	52
Sickle length	-	364	350
Maximum handle length	125	122	123
Effective handle length	-	109	115
Maximum handle diameter	-	37	33.5
Length of ferrule	> 20	15	-
Size of sickle	224 ± 3	238	191

The heart rate of farm women during the course of study was recorded by using the polar heart rate monitor. The polar transmitter detects the HR and transmits it to the wristwatch type receiver. It is generally considered that the heart rate gets stable after 3-5th minute of the work thereby heart rate during work and the OCR was measured between 6th to 60th minute of each subject. Data for resting, working and recovery were taken for period of 15 min, 60 min and 15 min respectively. The average HR and OCR were taken for computational work. The work pulse value calculated on the basis of subtracting mean heart rate during work minus mean heart rate during rest. The energy expenditure rate was calculated by multiplying the OCR (l/min) with 20.93 kJ (One lire O2 = 20.93 kJ). The oxygen consumption of subject on their measured heart rate was determined by the following formula (Singh et al., 2008).

$$Y = 0.0114 X - 0.68 \quad \text{..... (1)}$$

Where,

Y = oxygen consumption, l/min
X = heart rate, beat/min

The energy expenditure rate was calculated as,

$$EER = OCR \times 20.93 \quad \text{..... (2)}$$

Where, EER = Energy expenditure rate, kJ/min
OCR = Oxygen consumption rate, l/min

To determine the total cardiac cost of the work (TCCW), added cardiac cost of work to the cardiac cost of recovery. The cardiac cost of work can be calculated by multiplying work pulse (Δ HR) to duration of activity. When this total cardiac cost of work is divided by duration for which this activity carried out, it gives physiological cost of work. Following formulae were used to calculate the TCCW and physiological cost of work (PCW) (Singh et al., 2007).

$$CCW = \Delta HR. tA \quad \text{..... (3)}$$

Where, CCW = Cardiac cost of work

Δ HR = Mean working heart rate – Mean resting heart rate

tA = duration of activity

$$CCR = (AHR\ recovery - AHR\ rest). tR \quad \text{.....(4)}$$

Where, CCR = Cardiac cost of recovery

AHR recovery = Average recovery HR

AHR rest = Average resting HR
tR = duration of recovery

TCCW = CCW + CCR …….. (5)

Where, TCCW = Total cardiac cost of work

PCW = TCCW/tA ...……. (6)

Where, PCW = Physiological cost of work

To measure body part discomfort score (BPDS), a score based technique was followed (Corlett and Bishop, 1976). In this technique, the subject's body is divided into 12 regions. The overall discomfort rating (ODR) of the farm women were measured by using a 10-point Visual Analogue Scale (VAS). The scale having 0 to 10 digit marked from left to right on it (0-no discomfort, 10-extreme discomfort). At end of each experiment, farm woman verbally reported their painful regions and score from 0-10 point scale. The ODR given by each of the 10 farm women were averaged to get the mean rating.

RESULTS AND DISCUSSION

Physical and Physiological Characteristics of Farm Women

It was observed that mean heart rate during work of farm women while operating improved and local sickles was 112 beats/min and 109 beats/min with range of 95-130 beats/min and 91-126 beats/min respectively. The mean work pulse (ΔHR) was 34beats/min and 31beats/min with improved and local sickles respectively and corresponding oxygen consumption rate (OCR) of these sickles was 0.5 l/min and 0.6 l/min. Generally, it was found that more oxygen consumption is by younger than older women.

During paddy harvesting with improved sickle, the energy expenditure was found high i.e. 12.4 kJ/min, while with local sickle it was about 11.8 kJ/min. The higher energy expenditure with improved sickle as compared to local sickle one was only due to their habits of using the local sickle since long time and less friendly with improved sickle. The mean body mass index (BMI) was 21.21 kg/m2 with range of 18.55-24.65 kg/m2 which showed that all the farm women were physically fit as per the classification given by WHO (1995, 2000 and 2004). Maximum heart rate of subjects was determined by using the equation "220-age (in years)".The physical and physiological characteristics of farm women participated in trial are given in Table 2. Table 3 shows the performance characteristics of improved and local sickle for harvesting paddy crop.

Table 2: Physical characteristics of selected farm women n=10

Particulars	Range	Mean ±S.D
Age, years	22 - 45	36 ± 8.27
Weight, kg	43 - 54	47.5 ± 3.95
Height, cm	141 - 155	150 ± 0.05
BMI, kg/m2	18.5- 24.6	21.2 ± 2.68
Av. Predicted HRmax(beats/min)	175 -198	184 ± 8.27

Table 3: Performance data improved and local sickle for paddy harvesting n=10

Particulars	Mean ± S.D	
	Improved sickle	Local sickle
Average working heart rate (beats/min)	112 ± 12.8	109 ± 13.5
Average heart rate during rest (beats/min)	78 ± 12	78 ± 12
Work pulse, beats/min	34 ± 4.4	31 ± 8
Oxygen consumption, l/min	0.5± 0.15	0.6± 0.15
Energy expenditure, kJ/min	12.4 ± 3.1	11.8± 3.2
Total cardiac cost of work (TCCW)	1251.0	1054.2
Physiological cost of work (PCW)	42.0	35.0
Overall Discomfort Rating	5 ± 0.53	6.9± 0.7
Body Parts Discomfort Score	61 ± 3.76	76 ± 4.98
Area covered, (m^2/h)	79 ± 4.78	75 ± 4.69
Increase inefficiency (%)	5.3	-

Output Capacity

The cutting edge of improved sickle is serrated instead of being plain, it combines slicing and sawing action while local sickle working on principle of impact force for harvesting. The output capacity of the improved sickle recorded to be 79 m2/h whereas it was 75 m2/h with local sickle for paddy harvesting. It was observed that there was 5.3 per cent increase in output with improved sickle. Mishra *et al.*, (2013) also reported that higher field capacity with improved sickle over local sickle due to less pushing force required for operating the sickle, which resulted in higher cutting speed and also found higher output with better efficiency and reduced drudgery by using improved sickle.

Overall Discomfort Rate (ODR) and Body Part discomfort Score (BPDS)

During paddy harvesting with improved sickle, there was 28 per cent drudgery reduction in ODR as compared to local sickle. The reduction in drudgery with BPDS as compared to local sickle was found 20 per cent with serrated sickle. The body parts having discomfort expressed by subject were low back pain, neck ache and shoulder ache due to bending working body posture during paddy harvesting with local sickle. Dilbaghi *et al.*, (2008) reported that maximum output with improved sickle and reduction in total cardiac cost of worker with improved sickle over local sickle.

CONCLUSION

Feedbacks of farm women using both sickles were also recorded. The improved sickles are very much appreciated by farm women especially by the lower age group farm workers as it did not require regular sharpening and also due to the less force requirement than local sickle.

The ergonomic evaluation of paddy harvesting activity concluded that the physiological responses and physiological cost of work reduced significantly by using improved sickle. The serrated sickle is a women-friendly farm tool because the assessment of technology reduces drudgery. Due to better construction of serrated sickle provides safety to workers and also able to reduces cutting stubble height of cutting crop. The serrated sickle does not require sharpening of cutting edge frequently. The OCR was 0.5 l/min and 0.6 l/min with improved and local sickle respectively and corresponding energy expenditure was recorded as 12.4 kJ/min and 11.8 kJ/min.

Improved sickle reduces 27.5 per cent drudgery in ODR and 19.7 per cent in drudgery with BPDS as compared to local sickle. It was found that output increases by 5.3 per cent with improved sickle as compared to local sickle.

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