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## Development of farm women friendly sickle for reducing drudgery and saving energy

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### Abstract

Bokaro district of Jharkhand has mono cropping type of cropping pattern in which paddy is the main and most important crop. Harvesting of paddy crop is very tedious, monotonous and back breaking activity which is performed solely by farm women through small, traditional and iron made sickle due to which harvesting became the activity of full drudgery and energy intensive. Therefore, an OFT was conducted to develop farm women friendly sickle for reducing drudgery and energy expenditure. The present OFT was of four year experiment. In first year, three treatments were taken i.e. Local sickle as farmer practice, Vaibhav sickle as technological option-1 and Naveen sickle as technological option-II. Total numbers of replications were 10. On the basis of first year findings and given feedback by farm women, a newly designed sickle was developed. In second time, four treatments were taken i.e. Local sickle as farmer practice, Vaibhav sickle as technological option-1, Naveen sickle as technological option-II and Bokaro refined sickle (newly designed) as technological option-III. At first baseline information was collected in which age range of farm women were from 20 to 45 years. Farm women had mean age as 34.5 years, mean body weight as 45.4 kg, mean body height as 150.6 cm and mean value of body mass index as 20 kg/m<sup>2</sup>. Man-h requirement/ha were 216, 201, 190 and 160 for Local, Vaibhav, Naveen and Bokaro refined sickle respectively. It was also found that number of labour/ha needed was 27 for Local sickle, 25 for Vaibhav sickle, 24 for Naveen sickle and 20 for Bokaro refined sickle. Cost of harvesting/ha was found as Rs. 6411 by Local sickle, Rs 5936 by Vaibhav sickle, Rs. 5698 by Naveen sickle and Rs. 4749 by Bokaro refined sickle. Result had shown that Bokaro refined sickle was helpful to save approximate 26 per cent each in man-h requirement, labour and cost of harvesting per hectare. So it can be concluded that Bokaro refined sickle is most suitable newly designed sickle for farm women of Bokaro district, which is cost effective, efficient in operation and helpful in drudgery reeducation.

**Keywords:** Cropping pattern, Drudgery, Sickle, Body Mass Index, Effective field capacity

### 1. Introduction

In India, more than 70% of total population are actively engaged in agriculture. Agriculture is not just only a profession, but it is a way of life for the farming community of Bokaro district. Farm women play a vital role in agricultural system and approximate 40% of the farming activity is carried out by farm women. But most of the tasks in farming system are done manually and by using the traditional tools. Singh *et al.* (2006) <sup>[8]</sup> reported that maximum drudgery of farm women were in rice transplanting and harvesting activities. Oberoi and Singh (2001) <sup>[5]</sup> have identified the harvesting operation as the most prone tasks for drudgery. Harvesting of paddy crop is solely performed by farm women by small, traditional and iron made implements known as sickle.

Sickle being an oldest tool has curved blade with handle used to cut paddy crops. Normally, sickle has two types of cutting edges i.e. plain edge and serrated edge. The plain edge sickle perform cutting by shear force, while the serrated edge sickle perform cutting by frictional force. Singh and Singh (1978) <sup>[6]</sup> found that sickle with serrated surface gives better performance than plain one with shearing force at the cutting edge. Patel and Singh (2013) <sup>[3]</sup> have recommended that the improved serrated sickles should be used by the farm women, as it reduces the drudgery and more productive by saving time and money.

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Harvesting of paddy crop is done in bending position and started in early morning and continued up to late evening i.e. for hours and hours. Due to working in bending condition for long hours and by doing the work with small and traditional sickle, which lead to severe pain in shoulder, upper back, lower back, thigh, upper arm, lower arm and palm of hand. In this way, harvesting became very drudgerous and energy intensive activity for farm women. By observing these problems an On Farm Trial (OFT) was conducted to develop a farm women friendly sickle to reduce drudgerous and energy expenditure in harvesting operation.

**Materials and Methods:** A series of activities were done in methodology which is as follows:

- 1. Selection of villages:** Four places were selected as study site in the present OFT. First site was farm of KVK, Bokaro, second was Tundra village of Jaridih block, third was Ambadih village of Petarwar block and fourth was Durgapur village of Kasmar block. All four places were selected on the basis of accessibility.
- 2. Selection of Respondents (Farm women):** Total 10 farm women were selected randomly to conduct the study. Age range of farm women were between 20 to 45 years. Farm women were free from any kind of disease. By appearance wise they were healthy without any sign and symptoms of morbidity. After taking their verbal consent, they were given all instructions related to the study. All precautions were discussed with them as essential for the study.
- 3. Study Period:** The study was conducted for four years. In first year, a comparative study was conducted by taking Local sickle as farmer practice, Vaibhav sickle as Technological option – I, Naveen sickle as Technological - II. On the basis of the findings and feedback given by farm women, a new sickle known as Bokaro refined sickle was developed. Again second time, comparative study was conducted by taking local sickle as farmer practice, Vaibhav sickle as Technological option–I, Naveen sickle as Technological option –II and Bokaro refined sickle as Technological option –III. Again as per findings and given feedback by the farm women refinements in newly designed (Bokaro refined sickle) sickle were done.
- 4. Selection of Sickle:** By considering the drudgerous problem of farm women to develop location specific newly designed sickle i.e. all three type of sickle Local, Vaibhav and Naveen sickle were studied. Improved sickle i.e. Naveen and Vaibhav were purchased from Central Institute of Agricultural Engineering (CIAE) Bhopal.
- 5. Mode of Experiment:** Experiment was conducted from 9 AM to 1 PM and 2 PM to 5 PM each day in harvesting period. Each farm woman operated sickle for one hour and then take rest for 10 minutes. One round experiment was completed in 4 days. All four sickles were used one by one by the farm woman in sequence i.e. Local, Vaibhav, Naveen and Bokaro refined sickle.
- 6. Measurement of Body Mass Index (BMI):** Body Mass Index was calculated by the equation given by Garrow (1981)

$$\text{Body Mass Index (BMI)} = \frac{\text{Weight (kg)}}{\text{Height}^2 (\text{m}^2)}$$

- 7. (Measurement of Heart Rate:** Heart Rate of farm women were measured with the help of stethoscope before and after harvesting operation (Figure – 1).



**Fig 1:** Measurement of Heart Rate during experiment.

- 8. Measurement of Oxygen Consumption:** Heart rate of farm woman was recorded by using a stethoscope. The oxygen consumption of the subject was estimated on their measured heart rate, based on general equation as given by Singh *et al* (2008) <sup>[10]</sup>  
 $Y = 0.0114 X - 0.68$   
 Where Y = Oxygen consumption l/min  
 X = Heart rate (bpm)
- 9. Measurement of Energy Expenditure:** Energy expenditure in harvesting was also calculated by average heart rate (AHR) by using the equation given by Varghese *et al* (1994)  
 $\text{Energy expenditure (KJ/min)} = 0.159 X \text{ AHR (bpm)} - 8.72$
- 10. Effective field capacity:** The Effective field capacity (EFC) of a machine in the field can be calculated by dividing the area in hectares completed by the hours of actual field time.
- 11. Man-h and labour requirement:** - Man-h requirement and labour per hectare were also calculated by the formula

$$\text{Man-hr requirement / ha} = \frac{1}{\text{Effective field capacity}}$$

- 12. Labour required/ha =**  $\frac{\text{Man-h requirement per ha}}{8}$

**Results and Discussion:-**The primary objective of the present study was to develop a farm women friendly sickle to reduce drudgerous and energy expenditure in harvesting of paddy crops. For achieving this objective, a comparative study was done among Local, Vaibhav and Naveen sickle. Both sickle, Vaibhav and Naveen were purchased from C.I.A.E, Bhopal. Bokaro refined sickle was designed and developed on the basis of findings of first year experiment and given feedback by farm women. Dimensions of the Bokaro Refined Sickle is shown in Figure.2 and harvesting by Bokaro Refined Sickle is shown in Figure.3

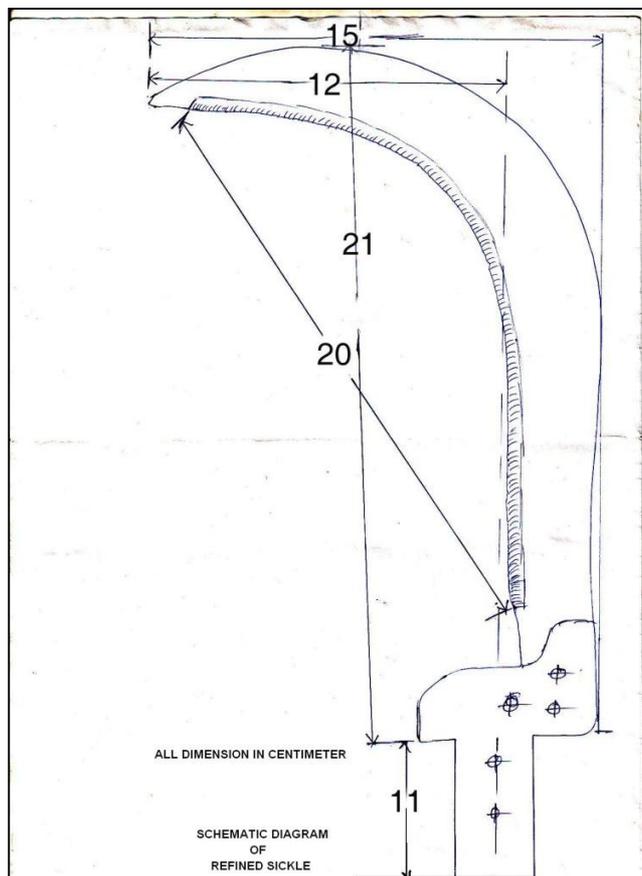


Fig 2: Dimension of Bokaro Refined Sickle



Fig 3: Harvesting of Paddy with Bokaro Refined Sickle

General information regarding all farm women is given in Table.1.

Table 1: General information of farm women engaged in paddy harvesting.

Parameter	Age(Yr)	Weight (kg)	Height (cm)	BMI (kg/m <sup>2</sup> )
Mean Value	34.5±11	45.4±7.0	150.6±10	20±2.1

Farm women had mean age as 34.5 years, mean weight as 45.4 kg, mean height as 150.6 cm, and mean value of BMI as 20 kg/m<sup>2</sup>. As per the study of Mishra and Satapathy, (2018) [4] the average age, average weight and average Body Mass Index (BMI) of all selected 10 farm women were found to be 32.6 years, 55.9 Kg and 0.0022 Kg/m<sup>2</sup> respectively. Information regarding drudgery related technical parameters is given in Table.2.

Table 2: Drudgery related technical parameter of farm women during paddy harvesting

Treatment	Mean Heart Rate at rest (bpm)	Mean Heart Rate in working (bpm)	Mean Oxygen Commutation at rest (l/min)	Mean Oxygen Communion in working (l/min)	Mean Energy Consumption at rest (kj/min)	Mean Energy Commutation in working (kj/min)
Local sickle (FD)	76	91	0.1864	0.3574	3.364	5.749
Vaibhar Sickle (T-1)	76	86	0.1864	0.3004	3.364	4.954
Naveen Sickle (T-2)	76	85	0.1864	0.2890	3.364	4.795
Bokaro Refinal Sickle (T-3)	76	82	0.1864	0.2548	3.364	4.318

**Mean Heart Rate:** Heart rate was measured with the help of stethoscope both in rest condition and in working condition. Harvesting was done with all four sickles Local, Vaibhav, Naveen and Bokaro Refined Sickle by same farm women. It was found that maximum rise in heart rate was observed in case of local sickle and minimum in Bokaro Refined Sickle. According to the study of Dilbaghi *et al.* (2008) [10] average working heart 107 (bpm) was found minimum for Falcon wooden handle based sickle.

**Mean Oxygen Consumption:** Similarly as rise in heart rate, change in oxygen consumption was observed before and after the harvesting and it was found that 0.1710, 0.1140, 0.1026 and 0.0684 Litre/min by using Local, Vaibhav, Naveen and Bokaro refined sickle respectively. From the above finding it is clear that maximum oxygen was consumed in case of local sickle and in case of Bokaro refined Sickle comparatively lower amount of oxygen was consumed.

**Mean Energy Consumption:** Like, rise in heart rate and oxygen consumption, change in energy expenditure was also observed. It was found that 2.385, 1.590, 1.431 and 0.954 kj/min energy was expenditure in case of local Vaibhav, Naveen and Bokaro refined sickle respectively. The result shown that need of higher amount of energy while Local sickle was used but when Bokaro refined sickle was used comparatively lower amount of energy was needed with respect to other three sickle. Singh and Sharma (2007) [9] found that heart rate (bpm), energy expenditure (kcal/min) and total cardiac cost of harvesting recorded were highly significant for traditional sickle, Naveen sickle as well as Pantnagar sickle. The data revealed that values found to less for Pantnagar sickle but yield was low in the treatment. It was not compatible to carry out the activity.

The feedback of the farm women regarding the special features of all four sickle regarding the use and performance i.e. of Local, Vaibhav, Naveen and Bokaro refined sickle during paddy harvesting is given in Table-3.

**Table 3:** Special features of all four sickle on scale basis (maximum score - 10)

Treatment	Handle	Curviness of blade	Sharpness of blade	Tool Compatibility	Suitability for field	Total	Remarks
Max. Score	10	10	10	10	10	50	
Local Sickle (FP)	5	8	9	7.0	7.0	36.0(72%)	Acceptable
Vaibhav Sickle (T1)	7	9	7	8.0	8.5	39.5(79%)	More acceptable
Naveen Sickle (T2)	9	6	7	8.5	8.0	38.5(77%)	More acceptable
Bokaro Refined Sickle (T3)	9	9	9	9.0	9.0	45.0(90%)	Highly acceptable

As per given feedback of farm women it was found that overall Local sickle obtained 72%, Vaibhav Sickle 79%, Naveen sickle 77% and Bokaro refined sickle was 90% score. Hence based on the percentage of score it can be said that the Bokaro refined sickle was highly acceptable tool, whereas Vaibhav and Naveen Sickle was more acceptable tool and Local sickle was acceptable respectively. Mishra & Satapathy (2018) [4] observed that the total percentage of score obtained for plain sickle was 68%, for existing serrated sickle was 80% and for improved serrated sickle was 86%. Hence

based on the percentage of score values, the improved serrated sickle falls in the category of 'highly acceptable' tool, the existing serrated sickles in the category of 'more acceptable' tool and the plain sickles in 'acceptable' category respectively.

Acceptance of any agricultural implements depends upon so many things in which its specification is important one. All information regarding details of specification of all four sickles are given in Table-4

**Table 4:** Details of specification of all four sickles under study.

Type of sickle	Material of Handle	Length of handle (cm)	Material of blade	Length of curve of blade (cm)	Width of curve of blade (cm)	Diagonal distance of serrated (cm)	No. of teeth per cm	Total Weight of sickle (gm)
Local Sickle	Iron/mild steel	11	Iron/mild steel	15	11	14	9	165
Vaibhav Sickle	Plastic	11	High carbon steel	21	15	20	7	172
Naveen Sickle	Wooden	11	High carbon steel	22	12	20	7	240
Refined sickle	Wooden	11	High carbon steel	21	15	20	9	220

**Handle of Sickle:** Handle of Local sickle was made up of mild steel/iron and Vaibhav sickle of plastic. Whereas handle of both sickle, Naveen and Bokaro refined were made up of wooden. Length of handle of all four sickles was 11 cm.

**Blade of Sickle:** Blade of Local sickle was made up of mild steel/iron and other three sickle was made up of high steel carbon. In the study of Dilbaghi *et al* (2008) [1] blades of all the improved sickles were made up of high carbon steel except for conventional sickle that was made up of iron/mild steel.

**Length of Blade:** Length of curve of blade was 15 cm, 22 cm and 21 cm for Local, Naveen and both for Vaibhav, and Bokaro refined sickle respectively.

**Width of blade:** Width of blade was 11 cm, 12 cm, and 15 cm of Local, Naveen and both for Vaibhav and Bokaro refined sickle respectively. Width of curve of the blade is deciding factor of how many number of paddy plants will be covered in one stroke. More the width of curve of blade more number of plant will be covered in one lot.

**Diagonal Distance of Serrated Part of Blade:** In the present study, the diagonal distance of serrated part of blade was calculated also, which was 14 cm for Local sickle and 20 cm for each Vaibhav, Naveen and Bokaro refined sickle respectively.

**Number of Teeth:** In the present study, number of teeth was counted. It was 9 per cm both in Local and Bokaro refined

sickle whereas in Vaibhav and Naveen sickle 7 per cm each. In case of sickle, number of teeth per cm is deciding factor and responsible for how speedily paddy plants would cut. More number of teeth per cm less time will be required for cutting paddy plants and vice versa.

**Weight of Sickle:** Total weight of all four sickle was as Local sickle ((165 gm), Vaibhav sickle (172 gm), Naveen sickle (240 gm), and Bokaro refined sickle (220 gm), respectively. Singh (2012) [11] found the weight of Naveen, Vaibhav and Local sickle was 247, 194g and 299 g respectively.

In the present study, comparative study was conducted by taking four sickle i.e. local, Vaibhav, Naveen and Bokaro refined sickle All information regarding the assessment of performance of all four sickle (Figure-4) is given in Table. 5.

**Fig 4:** Local, Vaibhav, Naveen and Bokaro Refined Sickle used in the study.

**Table 5:** Assessment of performance of all four sickles under study

Treatments	Area covered (m <sup>2</sup> /h)	Effective Field capacity (ha/h)	Man-h requirement per ha	No of labour per ha	Cost of harvesting Rs per ha
Local Sickle (FP)	46.30	0.00463	216	27	6411.00
Vaibhav Sickle (T1)	49.75	0.00497	201	25	5936.00
Naveen Sickle (T2)	52.50	0.00525	190	24	5698.00
Bokaro Refined Sickle (T3)	62.40	0.00624	160	20	4749.00

Ways @ Rs. 237.44/man days.

**Area covered:** It was found that area covered by Local, Vaibhav, Naveen and Bokaro refined sickle was 46.30, 49.75, 52.50 and 62.40 m<sup>2</sup>/h respectively. Singh (2012) [11] studied that area covered by Naveen, Vaibhav and Local sickle was 47.3, 60.7 and 65.4 m<sup>2</sup>/h respectively.

**Effective Field Capacity:** The pattern of Effective field capacity (ha/h) was similar as of area covered (m<sup>2</sup>/h). Effective field capacity of Local sickle was minimum (0.00463) whereas Bokaro refined sickle was maximum (0.00624).

**Man-h requirement and number of labour per ha:** It was found in the present study that maximum man-h requirement per ha and number of labour per ha was needed in case of Local sickle i.e. 216 and 27 but minimum man-h requirement per ha and number of labour per ha in case of Bokaro refined sickle i.e. 160 and 20 respectively. Whereas in case of Vaibhav and Naveen sickle it was 201 & 25 and 190 & 24 respectively. So it is clear that in one hectare of land, Bokaro refined sickle required approximately 56 man-h/ha and 7 no. of labour more as compared to Local sickle, which is used in Local situation. Ultimately it will help to save both time and labour needed for harvesting of paddy crops. So it is clear that Man-h requirement per ha and number of labour required per ha was just reverse in nature as compared to area covered and effective field capacity.

**Cost of Harvesting:** Cost of harvesting is an important aspect in making farming occupation more profitable. So, it was calculated and observed that in case of Local, Vaibhav, Naveen and Bokaro refined sickle, cost of harvesting were as 6411, 5936, 5698 and 4749 Rs/ha respectively. Result shown that by the use of Bokaro refined sickle approximately 1662 Rs/ha was saved with respect to Local sickle.

Through statistical analysis it was found that performance of Bokaro refined sickle and Naveen sickle were highly significant with CV 17 per cent. Cost of harvesting was found minimum of Rs.4749/-per ha for Bokaro refined sickle and maximum Rs.6411 per ha for Local sickle. When Pearson correlation was used then it was found that Bokaro refined sickle was better than all three other sickles. As per t-test Naveen sickle (2.57) and Bokaro refined sickle (354.40) were highly significant. Whereas Local sickle (0.356) and Vaibhav (0.660) were non-significant. On the basis of above findings it is concluded that Bokaro Refined Sickle is superior among all sickles. Therefore, when harvesting will be performed in big plot then huge amount of money will be saved. This will be very important effort for making farming a profitable operation.

### Conclusions

Bokaro District has mono cropping type of cropping pattern in which paddy crop in main and most important crop. Harvesting of paddy crop was solely performed by farm women. So Location specific refined sickle was developed known as Bokaro refined sickle to reduce drudgery, pain and energy expenditure as per feedback of farm women of different districts of Jharkhand state. Bokaro refined sickle is comfortable cost effective and best suited for harvesting

purpose for farm women.

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