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RESEARCH ARTICLE :

Modifications in serrated sickle for increasing field capacity and reducing drudgery

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SUMMARY : The Vaibhav Sickle developed by Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli was modified based on users feedback, anthropometric data and available scientific literature. The cutting surface length, chord length of available Vaibhav sickle was 200 and 180 mm respectively, hence the CS/CL ratio was 1.11. The blade concavity was 39. The average diameter and length of the handle were 32 mm and 136 mm, respectively. The angle of blade with handle was 130 deg. In modified Vaibhav sickle, the cutting surface length, chord length were 225 mm and 210 mm, respectively, hence the CS/CL ratio was 1:07 and blade concavity was 30. The effective serration pitch and angle between blade and handle were 0.2 cm and 160 deg, for both sickles. The comparative ergonomic evaluation of existing and modified sickles was carried out. The field capacity of improved Vaibhav sickle was found to be 112 m^2/h which was 13.1 per cent higher than existing Vaibhav sickle (99 m^2/h). The working heart rates of female workers while using improved and existing Vaibhav sickles were 120.3 and 128.5 beats/min, respectively while the work pulse for those sickles were 36.15 and 46 beats/min. The center of mass was located at distance of 7.3 cm away from the line of action in case of Vaibhav sickle and in case of improved sickle it was located very close to the line of action. This improved the balance of sickle and there is no lateral twisting to the wrist. The performance of improved Vaibhav sickle is better in terms of its field capacity, ergonomic design and balancing.

KEY WORDS :
Serrated sickle, Drudgery

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BACKGROUND AND OBJECTIVES

Konkan is a coastal part of Maharashtra between western ghat and Arabian Sea. It is characterized by hilly terrain, lateritic soil and heavy rainfall about 2500 to 4000 mm during June to October. The most of farmers of this region are small and marginal. Due to small and fragmented land holding pattern of region and hilly terrain, farmers are cultivating fields either manually or with bullocks using small tools and implements. The topographical limitations, merge overall investment capacity of farmers, non-availability of proper farm roads are some of the constraints which plagued the extent of farm mechanization in the Konkan region. Rice is staple food of Konkan region of Maharashtra. It is grown on 4.136 lakh hectare with production of 10.42

lakh tones and productivity is 2.56 tones/ha. In konkan region harvesting of paddy is carried out predominantly by sickles. Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli developed the serrated sickle popularly known as 'Vaibhav sickle' which was manufactured and sold with subsidized rate. It tool is in use since long about 15-20 years back. There were certain feed backs from users as well as observations regarding the material and geometry of sickle blade. On the basis of the scientific references available, the material and geometry of the blade were required to be modified for enhancing the durability, performance and reducing the efforts. The incorporation of anthropometric and strength data in design results the efficient and safe tool reducing the work stress to the great extent. Hence, considering the above things in view the work on refinements and ergonomic evaluation in serrated sickle was under taken.

RESOURCES AND METHODS

Existing Vaibhav sickle :

The detailed specification of the Vaibhav sickle were taken which are given in Table A, whereas the photograph is shown in Plate A.

The weight of existing Vaibhav sickle was 201.7 g. The cutting edge (CS) and chord length were 200 and 180 mm, respectively hence the CS/CL ratio was 1.11. The blade concavity was 39. The average diameter and length of the handle were 32 mm and 136 mm, respectively. The angle of blade with handle was 130 deg. The different dimensions are illustrated in PlateA.

Refinements in Vaibhav sickle :

It was necessary to incorporate refinement in the existing Vaibhav sickle based on the scientific literature. Also, as being manually operated tool, the anthropometric dimensions of users were required to be considered. The available anthropometric data on agricultural female workers was used for deciding some dimensions of sickle. The optimized dimensions of sickle are explained as below.

Table A : The specifications of serrated sickles

Sr. No.	Parameters	Values
1.	Weight, g	201.7
2.	Length of cutting edge, CS (mm)	200
3.	Maximum width of cutting edge (mm)	26
4.	Chord length, CL (mm)	180
5.	Blade concavity (mm)	39
6.	Pitch (mm)	2
7.	Angle of teeth	60^0
8.	Length of handle (mm)	136
9.	CS- CL ratio	1.11
10.	Average diameter of handle (mm)	32
11.	Angle of blade with handle, deg	130

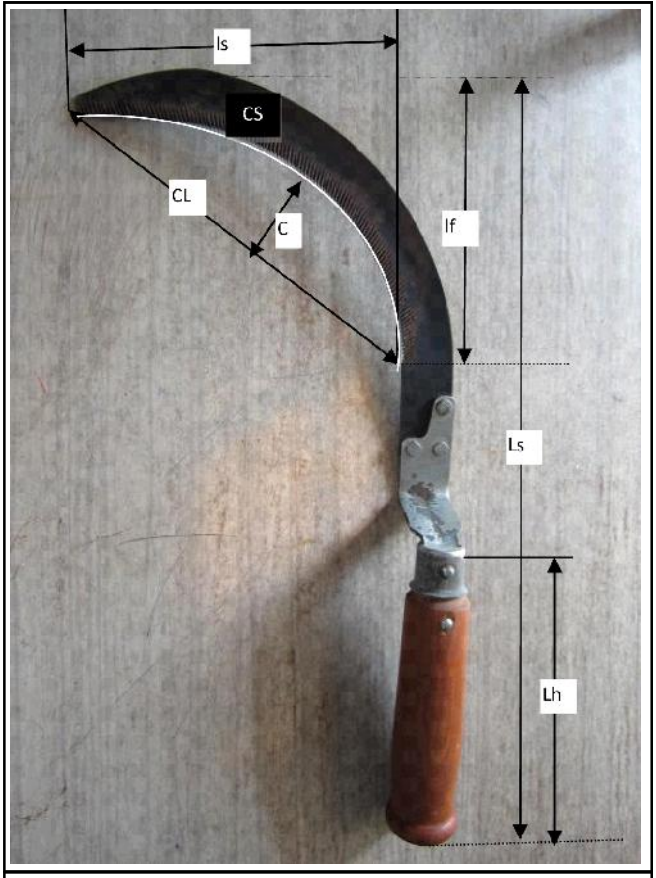

Plate A : Vaibhav sickle

Blade :

As per Pandey and Devnani (1988), the values of ls/CS and lf/CS ratios for serrated sickles should be 0.4 and 0.8, respectively. Accordingly, the length of cutting surface and chord length were optimized as 225 mm and 210 mm, respectively. Hence, the CS/CL ratio was 1.07. Also, according to Kawashima (1954), the most effective serration pitch and angle between blade and handle were 0.2 cm and 160 deg, respectively. Those parameters were kept as it were.

Basically, cutting of crop by serrated sickle was undertaken with friction and shearing cutting action. The projected length of blade in the direction of line of action

is called as shear cutting length while that of perpendicular to the line of action is called as friction cutting length. In case sickle having more concavity, the friction cutting length is less while the shear cutting length is more, provided that the blade lengths are same for both sickles. As per geometry, the blade concavity of the improved sickle comes to be 30 mm, which was 36 mm in case of existing Vaibhav sickle.

Handle :

The handle length and diameter were optimized on the basis of anthropometric dimensions of women workers. The anthropometric and strength data of agricultural workers of Konkan region under ICAR Ad-hoc research project was used for optimizing the parameters. Handle length was optimized based on hand breadth at thumb and hand length. The 95th percentile of hand breadth at thumb was 95 mm and 5th percentile hand length 153 mm. The length of handle was kept as 136 mm.

The handle diameter was optimized on the basis of middle finger to palm grip diameter grip diameter (inside). The 95th percentile middle finger to palm grip diameter was 31 mm and the 5th percentile grip diameter (inside) was 39 mm The handle diameter was kept as 32 mm.

Weight :

According to Nag *et al*. (1988), the weight of sickle should be around 200 g. Based on the parameters as mentioned above, the improved Vaibhav sickle was developed.

Comparative performance of sickles :

Six female workers who were well familiar with paddy harvesting by sickle involved in the study (here after will called as subjects). The information about experiment was given to subjects so as to ensure their co-operation. Each subject was asked to rest for 30 minutes sitting in shade before the actual starting of trial. Heart rate values (in beats per min) were recorded using HR monitor (Model RS 400). During the resting period, after 20 minutes of rest, the HR values of the last 10 minutes were recorded, averaged and noted as resting HR for each individual subject. After resting each subject was asked to harvest the paddy with sickle for about 30 minutes, during that period heart rate values were recorded. The recorded heart rate values were downloaded to the computer. The average heart rate was used as working heart rate for the further calculation and analysis. After 30 min operation with transplanter, each subject was asked to indicate the Overall Discomfort Rating (ODR) on the 10- point rating scale. The values were tabulated and averaged. Simultaneously Body Part Discomfort Score (BPDS) of each subject was measured and averaged to get mean score (Corlett and Bishop, 1976). The same procedure was adapted to all the selected subjects.

Comparative ergonomic evaluation of Vaibhav sickle and improved Vaibahv sickle were carried out to get rate of work (field capacity), heart rate, ODR and BPDS of female workers.

Position of centre of mass and its relevance :

The positions of centre of mass for two sickle blades were determined by hanging method. Each sickle blade was drilled with three holes near to the edge. White card board sheet was pasted to the blade. The blade was made to hang at a rigid support at one of the hole. Thorough the same hole, a plumb bob was made to hang. A line was traced along the thread attached to the plumb bob. The point of interaction of three lines drawn along the threads was the centre of mass.

OBSERVATIONS AND ANALYSIS

The detailed dimensions of the improved sickle are given in the following Table 1 and shown in Plate 1.

Centre of mass :

For the better stability of the sickle, so that the wrist will not be twisted, it was necessary to have the centre of mass along the line of action. For Vaibhav sickle, the centre of mass was at distances of 7.3 cm on the left hand side of line of action while, in case of improved Vaibhav sickle, the centre of mass was very close (2mm) to the line of action

The crop parameters (cv: KARJAT 3) observed while are given in the following Table 2 to 4.

The average number of tillers per plant were 8. The average plant height was 72.2 cm. The grain crop ratio was 0.63. The comparative field performance of existing Vaibhav sickle and improved Vaibhav sickle was carried out.

The field capacity of Vaibhav sickle and improved Vaibhav sickle were 99 and 112 m^2/h. The time required for harvesting with Vaibhav sickle and improved Vaibhav

sickle were 101 and 89 h/ha.

Comparative ergonomic evaluation of serrated sickles was carried out with six female workers with average age and weight 45 years and 44 kg, respectively. The working heart rate for operation with Vaibhav sickle and improved Vaibhav sickle were 128.5 and 120.3 beats/min, respectively. The work pulse for the mentioned two sickles were 46.0 and 36.15 beats/min, respectively. Physiologically, the workload was found to be in 'heavy' category in case of Vaibhav sickles while, the work load was found to be in 'moderately heavy' category in case of improved Vaibhav sickle.

Table 1 : The dimensions of improved Vaibhav sickle

Sr. No.	Parameters	Modified sickle
1.	Weight, g	199.2
2.	Length of cutting edge (mm)	225
3.	Maximum width of cutting edge (mm)	24
4.	Chord length (mm)	210
5.	Blade concavity (mm)	30
6.	Pitch (mm)	2
7.	Angle of teeth	60^0
8.	Length of handle (mm)	136
9.	CS- CL ratio	1.07
10.	Average diameter of handle (mm)	32
11.	Angle of blade with handle, deg	157

Plate 1 : Improved Vaibhav sickle

Existing Vaibhav sickle Improved Vaibhav sickle

Plate 2 : Position of centre of mass

Table 2 : Crop parameters observed during the test

Sr. No.	Parameters	Average
1.	Number of grains per ear head	190
2.	Number of plants per square meter	242
3.	Number of tillers per plant	8
4.	Plant height (cm)	72.2
5.	Length of ear head (cm)	17.5
6.	Mass of crop per square meter area (kg)	0.9
7.	Mass of grains per square meter area (kg)	0.6
8.	Grain crop ratio	0.63

Table 3 : Comparative field performance of sickles

Parameter	Vaibhav sickle	Improved Vaibhav sickle
Field capacity, m^2/h	99	112
Time required, h/ha	101	89

Table 4 : Ergonomic parameters for the sickle operation

Implement	Vaibhav sickle	Improved Vaibhav sickle
No. of subjects	6	6
Age of subject, years	36.3	36.3
Weight, kg	45.16	45.16
Resting HR, bpm	82.5	84.15
Working HR, bpm	128.5	120.3
Δ HR, bpm	46.0	36.15
LCP,40 bpm	>LCP	<LCP

Considering, limit of continuous performance, the operation with Vaibhav sickle was in the category of 'more than limit of continuous performance' while that of in case of improved Vaibhav sickle was in the category of 'less than limit of continuous performance'.

The improved Vaibhav sickle was also tested for 20 hours for harvesting of paddy. Total area harvested was 2206 m^2 and accordingly, the field capacity was 110.3 m^2/h.

– The field capacity of improved Vaibhav sickle was found to be 112 m^2/h which was 13.1 per cent higher than existing Vaibhav sickle (99 m^2/h).

– The time required for harvesting of one hectare paddy by improved and existing Vaibhav sickles were 83 and 101 h, respectively, which is 17.82 per cent less over Vaibhav sickle.

– The working heart rates of female workers while using improved and existing Vaibhav sickles were 120.3 and 128.5 beats/min, respectively while the work pulse for those sickles were 36.15 and 46 beats/min.

– Physiologically, the workload was found to be 'moderately heavy' category for improved Vaibhav sickle while, that of in 'heavy' category in case of existing Vaibhav sickle.

– Considering, limit of continuous performance, the physiological work load with improved Vaibhav sickle was in the category of 'less than limit of continuous performance' and that for existing Vaibhav sickle was in the category of 'more than limit of continuous performance'.

– The center of mass was located at distance of 7.3 cm away from the line of action in case of Vaibhav sickle and in case of improved sickle it was located very close to the line of action. This improved the balance of sickle and there is no lateral twisting to the wrist.

Conclusion:

The performance of improved Vaibhav sickle is better in terms of its field capacity, ergonomic design and balancing.

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