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Testing and Evaluation of Scythe for Wheat & Paddy Harvesting in Nepal

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Abstract
In a developing country like Nepal, the development of farm mechanization is poor and farmers get problems during the planting as well as harvesting period of crops like wheat and paddy which are the major crops of Nepal. During harvesting, the unavailability of modern farm machines and labor shortage occur in hilly and mountain regions. 36.3% of the total farm power is human power and most of the farmer sickles sickle for harvesting of crops which is time consuming and more tedious. With the view of this problem, a manual handle high-performance harvesting tool scythe had been fabricated. This work was an attempt to evaluate the development and field-testing performance of harvesting for wheat and paddy harvest and determination of ergonomic properties. From the result obtained during the testing period, the average effective field capacity was 0.0308 ha/hr. (2.43 Katha/hr.) for wheat and 0.0297 ha/hr. (2.35 Katha/hr.) for paddy harvest with scythe whereas the effective field capacity of the sickle was 0.0121 ha/hr. (0.96 Katha/hr.) for wheat and 0.0105 ha/hr. (0.83 Katha/hr.) for paddy harvest. The comparative ergonomic evaluation of sickle and scythe was carried out by smart agriculture gadget for recording oxygen consumption and heart rate in beat per minute. The mean oxygen consumption and mean energy expenditure at working condition with scythe were 0.638 L/min and 9.64 kJ/min whereas those with sickle were 0.548 L/min and 8.45 kJ/min respectively. The average number of labors required with scythe was 3.25 and its operating cost was Rs.1790.25 per hectare which was quite smaller than sickle as 11.91 numbers of labors and its operating cost Rs. 6551.875. Hence, from the series of field performance harvesting capacity and ergonomically analysis result, it can be accepted as eco-friendly hand /human operated tool.

Keywords
Scythe, Sickle, Effective field capacity, Wheat, Paddy, Ergonomic, Harvesting hand tool, Nepal

1. Introduction

In Nepal, the economy is dominated by agriculture. Agriculture is a major source of income for the majority of people and 66 % of total population is directly or indirectly involved in agriculture [1]. The contribution of agriculture sector is about 24% in overall GDP [2], Agriculture has been taken as highest priority since the country's economy is directly related to agricultural production and its economy[3]. It is livelihood for more than 90% of population though there is only 21% agriculture land cultivable[4].Agriculture is the main source of food, income, and employment for the majority. It provides about 33% of the gross domestic product (GDP) [5].

Crops like wheat and paddy are major food crops of Nepal[6].In Nepal, Crops such as wheat and paddy are harvested using sickle which is very much time and labor consuming tool. This traditional equipment can be replaced by an another tool known as scythe which can significantly increase the harvesting efficiency[7].

Historically, a scythe was invented in order to cut hay and grass but later was also used to harvest crops such as barley, wheat and paddy[8].The harvested technique to harvest wheat or paddy be like swung steadily from right to the left in the long arc ending in front of the mower and depositing the cut neatly to the left. The mower takes the small steps forward and repeats the motion, proceeding with the steady rhythm, stopping at the frequent interval to hone the blade. The correct techniques has a slicing action in the wheat or paddy, cutting a narrow strip with each stroke, leaving the uniform stubble on the ground and forming a regular windrow in the left[9].

1.1 Origin of Scythe and Its type

Scythe was first invented in about 500 BC and appeared in Europe during the 12th & 13th century[7]. The scythe appears to have developed during roman times though it probably was not developed by the Romans[10].

There are two types of scythe:

1. American scythe
2. European (or Austrian) scythe

Both types of blade are made in Austria. The American scythe has a thicker, narrower and straight blade made of hard steel and has curved snath. The European scythe on the other hand has a blade that is much thinner, curved and made of slightly softer steel than the American scythe and the snath used is straight [11].

The European scythe is more suited for extensive use as it weighs 1.75 kg whereas the American scythe weighs 2.70kg [12].

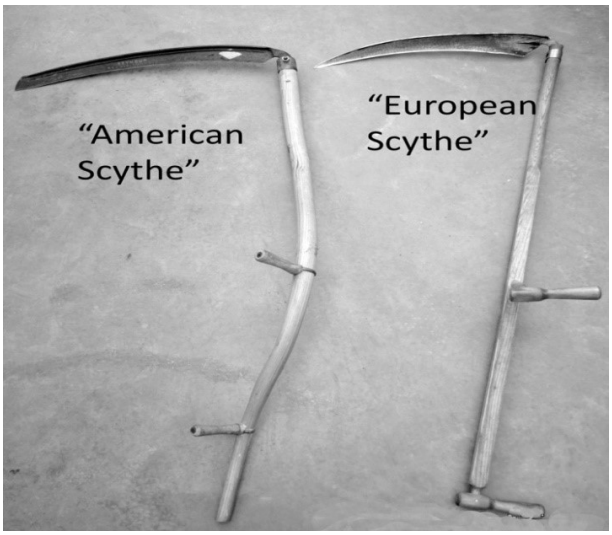

Figure 1: American and European Scythes

1.2 Development of Scythe

Initially, scythe was probably designed for grass but as pasture became harder to find and livestock increasingly fed on different kind of straw, the importance of cutting oats, barley and others grains close to the ground became more important and the scythe became to replace sickle as a way of harvesting crops. It replace sickle as the reaping crops by the 16th century[10]. The scythe is therefore found in most areas of the world where grass and grains such as wheat, barley, oats are the predominant agricultural crop. The scythe belt emanates from Europe and the Middle East, but extends from the mid-west of Canada and the USA, through the whole of Europe, much of Russia, the Middle East, Egypt and some other north African countries, Turkey, Iraq, Iran, Kirghizstan and other colonies of former USSR, a few parts of China and of the Indian subcontinent to Australia [10].

1.3 Scythe in Nepal

According to Namgyal in Dhorpatan Valley 1960, It was the Swiss Red Cross program that introduced Scythe to the farming practices needed for their new settled lifestyle. To sustain themselves in isolated Dhorpatan Valley and the harsh Himalayan environment, self-reliance was a necessity. They learned how to cultivate their fields and take care of their animals in new ways. The two young Swiss agriculturists wisely shared with new Tibetan settlers the Gift of the Scythe. It was a truly 'appropriate technology [13].

In March 2012, volunteer Alexander Vido from Scythe Works,Canada visited the project. He brought with him further blades and a snath (handle) that farmers have been able to replicate. This was followed by a program of introduction and practice of using and maintaining the scythe to cut the spring wheat crop in Surkhet in March and early April. A total of 11 farmers participated and 2 farmers have been selected to teach maintenance and use of the scythes in other areas during the wheat harvest.[14] After successfully completion of Scythe Project in Nepal (SPIN-2012) in Surkhet, Nepal Agricultural Research Council (NARC) was also interested to collaborate with this project so they prepared the proposal of SPIN-2013 and submitted to NARC but didn't get proper commitment from NARC and thus the SPIN-2013 was postponed. To learn the proper use of the scythe is essential because a well-maintained tool is efficient, easier to use, and lasts longer. Solid skills lead to self-sufficiency, resilience, and empowerment. It is capable of cutting grass, grain crops, etc. much faster than the traditional Sickle used in Nepal and for this reason is worthy of research to examine its acceptance in Nepal.[15].

1.4 Objectives

1.4.1 General Objective

- To test prototype of scythe to harvest paddy and wheat crops.

1.4.2 Specific Objective

- To evaluate and modify the scythe components
- To compare the field capacity of scythe with sickle
- To study the ergonomic properties of scythe

2. Methodology

This topic deals with the general development and instrumentation involved in the fabrication and testing of the scythe. The entire study of the project was carried out according to the following sequence:

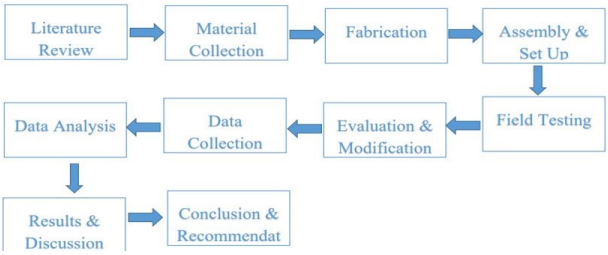

Figure 2: Working Flowchart

2.1 Working Procedure

The working procedure of scythe is well dependent on the mowing technique when used in the field by a mower (a person who uses scythe). At first all the components of scythe are tightly fitted to the snath. The blade is attached to the lower most part of snath which is the main component used for reaping paddy and wheat, the cradle assembly is added to the snath that aligns the seed heads and makes picking up and windrowing easier and the handle grip positioned at least 5 to 10 cm higher than hip joint of mower for easy holding of the snath in position.

Beginning of stroke

- Feet move in rhythm with the blade.
- Right moves forward at the end of cut.
- Left moves forward at the end of return.
- Almost full weight is kept on the right leg and the right knee is bent.
- Weight is equally distributed on both legs

Ending of stroke

- At the end of stroke, the weight is almost on the right leg.
- The right foot starts moving forward.
- At the end of the stroke, special care is taken in tipping over and laying the crops in neat rows as shown above.
- If the stalk gets entangled with the crop while mowing, a piece of cloth or sag is tightly wrapped over the cradle.

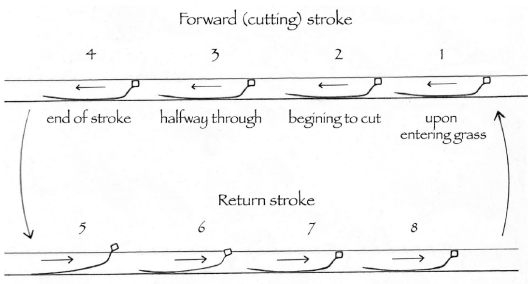

Figure 3: Forward & Backward stroke of Scythe movements

Figure 4: Position during mid-stroke

3. Results and Discussion

Measurement of Energy Expenditure Energy expenditure in harvesting was also calculated by average heart rate (AHR) by using the equation given by [16].

Energy expenditure (kJ/min) = 0.159 × MHR (bpm) - 8.72

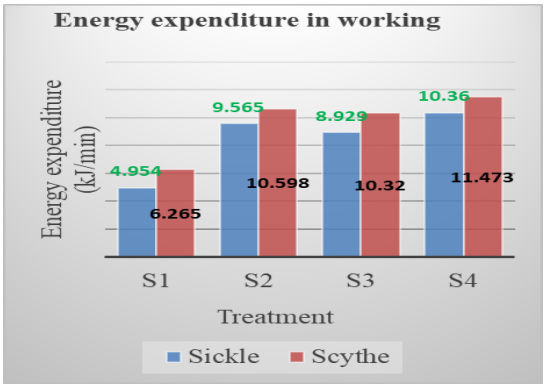

Figure 5: Energy expenditure in working

Measurement of Oxygen Consumption Heart rate of subjects was recorded by smart gadget and digital sphygmomanometer. The oxygen consumption of the subject was estimated on their measured heart rate, based on general equation as given by [17].

$$Y = 0.0114X - 0.68$$

for general equation
Where Y = Oxygen consumption (L/min)
X = Heart rate (bpm)

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.

Man-hr. Labor Requirement Man-hr. requirement and labor per hectare were also calculated by the formula [18].
$Man\text{–}hr.requirement\,perha = 1/(effectivefieldcapacity)$
$Laborrequired\,perha = (Man - hrrequired\,perha)/8$

3.1 Data Analysis

A detailed investigation was carried out to access the performance of the scythe. The data was collected in the field by mowing with scythe and sickle to a block of land of equal area and the harvesting time of each block was noted.

With the observed data the following observations were performed.

Ergonomic test should be evaluated with average energy expenditure working with different treatments. The energy expenditure in harvesting with sickle and scythe have a little difference as examined from bar diagram shown above. The harvesting is important phase in agriculture process and labor requiremet is key element. During data analysis bar diagram shows that per hectar of field need 3 to 4 times more labor by sickle than scythe.

Also comparative study suggests that the use of scythe prevents the delay of planting to the next season crops due to shortage of labor during harvesting time.

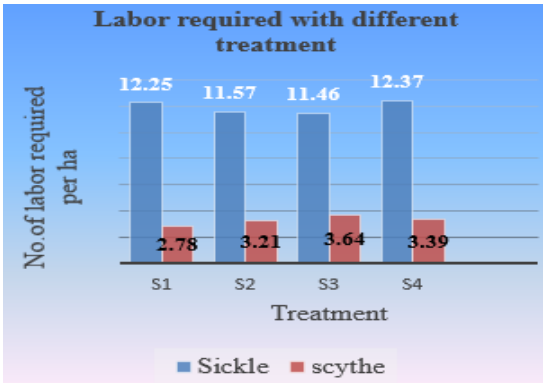

Figure 6: Bar diagram of Labor required with different treatment

This bar diagram helps to differentiates the operating cost in between sickle and scythe with repetition performance by number of subjects.

Also, overall diagram shows that harvesting cost using sickle is nearly 4 times more than harvesting cost using scythe which is impressive result to adopt scythe.

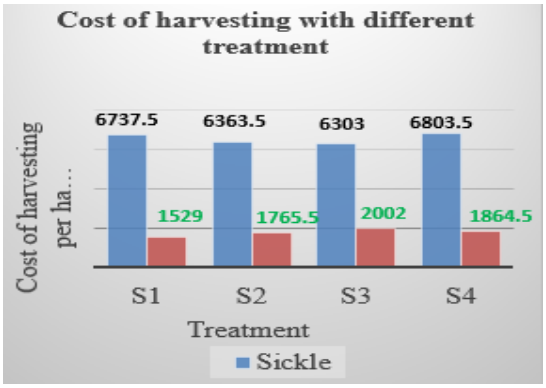

Figure 7: Bar diagram of Cost of harvesting with different treatment

4. Limitations

- Ergonomics study in case of wheat harvest was not performed.
- Weed factor was not considered.
- Scattering and shattering losses were not calculated.

5. Conclusion

This project presents the development and field testing of scythe for wheat and paddy harvest. Tests were conducted on 4th and 6th April, 2019 for wheat and on 20th November, 2019 for paddy. The obtained results are as follows:

5.1 Mean Heart Rate

The heart rate was measured with the help of digital sphygmomanometer both in rest and working condition for sickle and scythe. In the case of harvesting with scythe, the mean heart rates were found to be 94.25, 121.5, 119.75, 127 bpm and that with sickle were 86, 115, 111, 120 bpm for S1, S2, S3 and S4 respectively. Thus, it was found that at working condition with scythe mean heart rate of subjects were more than that of sickle.

5.2 Mean Oxygen Consumption

Similarly, as changes in heart rate, changes in oxygen consumptions were observed. At working condition, it was found to be 0.394, 0.705, 0.685, 0.768 L/min for scythe and 0.289, 0.631, 0.585, 0.688 L/min for sickle for S1, S2, S3 and S4 respectively.

5.3 Mean Energy Expenditure

Like rise in heart rate and oxygen consumption, change in energy expenditure were also observed which were 6.265, 10.598, 10.320, 11.473 kJ/min with scythe and 4.954, 9.565, 8.929, 10.360 kJ/min with sickle for S1, S2, S3 and S4 respectively. This result showed that energy expenditure for scythe was more than sickle.

5.4 Effective Field Capacity

The average effective field capacity of scythe and sickle for wheat was 0.0603 ha/hr and 0.0121 ha/hr. and that for paddy was 0.03875 ha/hr. and 0.0105 ha/hr. respectively. This result showed that we can harvest more field crops with scythe than sickle.

5.5 No. of labor required per Hector

Average no. of labor required per hector with scythe was 3 from data which is 4 times less than that required for sickle. Hence, the extra no. of labors which were required with sickle for harvesting can be used for other productive works.

5.6 Cost of harvesting per Hector

Cost of harvesting is more important aspect in making farming occupation more profitable. So, it was calculated and observed that in case of sickle, average cost of harvesting was Rs. 6551.875 per hector and that with scythe was Rs.1790.25 per hector. This result showed that the performance of scythe was highly significant. Therefore, when harvesting will be performed in big plots, huge amount of money will be saved. This will be very important effort for making farming a profitable operation.

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