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Design, Fabrication and Testing of Finger-Millet Harvesting Machine

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Abstract: Millet harvesting in Nepal is done by conventional method using sickle which is too tedious, time consuming, and inefficient. In this research, a portable millet harvesting machine is designed, fabricated, tested, and its economic analysis is done. This harvesting machine is an approach to solve a real time problem of a millet harvesting. Hence, it can cut earheads and straw separately at a time aimed mainly for the hilly region where a combine harvesting machine is of no use. The machine was tested on small densely planted areas. Machine was able to cut at speed of 1800rpm and power of 0.9kW whereas with decrease in power to 0.7kW and rpm of 1440, cutting was not easy or clear. Manual power was used for motion of wheel, drum and conveyer while cutters were operated by engine power. Due to connection of wheel shaft with drum shaft by chain and sprocket, relatively high manual power was required to push the machine.

Keywords: Finger-Millet Harvest, Agriculture Machine, Cutter Design

1. Introduction

Finger Millet (*Eleusine coracana*) is called kodo in Nepali. It is an important miller crop of Nepal. It is a staple food in many hilly regions of the country and perform poorly above 2000m above mean sea level [5]. It is one of the important millet grown extensively in various regions of India and Africa. With regard to protein (6-8%) and fat (1-2%) it is comparable to rice and with respect to mineral and micronutrient contents it is superior to rice and wheat. Nutritionally; it has high content of calcium (344 mg/100g), dietary fiber (15-20%) and phenolic compounds (0.3–3%) [3]. Most of the varieties are matured within 100- 130 days [3]. Harvesting done by cutting the earheads with sickle first and then the straw cut close to the ground is conventional harvesting machine. The earheads are heaped in sun on the threshing floor for 1-4 days for drying [4]. Threshing is done by beating with sticks or trampling by the bullock fit. The grains are then cleaned. In modern harvesting system, a combine millet harvesting machine is used. But due to its size and cost, combine harvesting machine is not common in Nepal, especially in hilly region. This machine is specially design for the millet harvesting in hilly region where terrace farming is done. It can separately cut earhead and straw at a time which make harvesting efficient and increase the productivity.

Significance of the study: People are wasting lot of their time and labor force due to lack of technology. Due to this limitation, people are also discouraged to cultivate millet. And to fulfill market demand millet are imported from other countries. This could stop if technological improvement is done on harvesting field. It would reduce our dependency on foreign import and contribute to the national economy. Nepal though recognized as agricultural country, due to deficit of technology in agricultural equipment, huge amount of food materials are being imported. With the development of this machine it will introduce new technology in millet production. It enhances production of millet. Thus produced millets can be used as food crops for the farmer and also for making beverage. This beverage can be the source of income for the farmer. This machine reduces labor and time of farmer. That time and labor can be used in other productive work. It increases life standard of people. This machine cuts earheads and straw separately. Due to this, farmer can feed straw to the domestic animal easily without any heavy efforts.

2. Literature Review

Students of M.S Ramaiah School of Advance Studies had developed prototype for harvesting and threshing finger millet. The harvesting (cutting) mechanism consists of two cutting blades the fixed blade and moving blade. The fixed blade is the stationary blade which remains stationary while cutting takes place and the moving blade slides on the fixed blade by the slider crank mechanism and cuts the straws a bevel gear box is used to transmit the power to 90º.

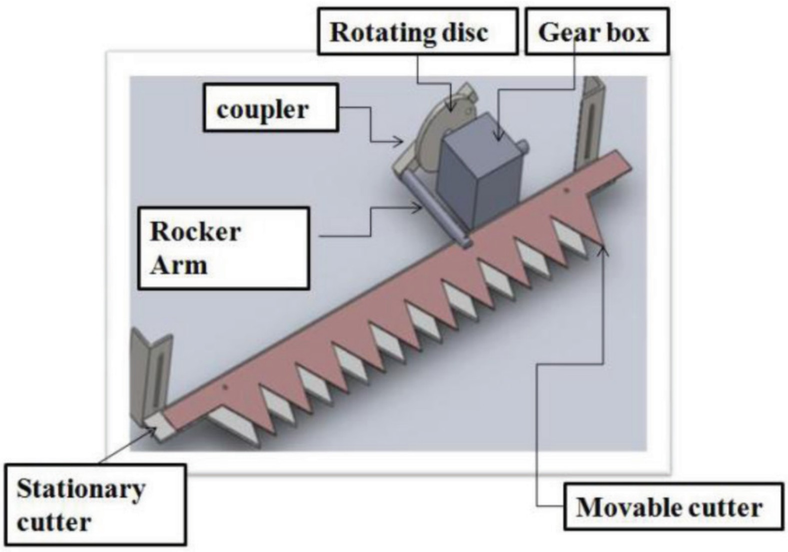

Fig. 1: Mechanism of harvesting

For the motion of cutting mechanism for blades a simple “Slider-Crank Mechanism" is employed which has fixed blade, movable blade, rotating disk, rocker arm and coupler in which the fixed blade and moving blade has prismatic joint, coupler and rocker arm has revolute joint, the coupler and rotating disk has revolute joint and the rocker and moving blade has fixed joint. This mechanism is used to convert rotary motion into the reciprocating motion. This can be achieved by mounting the coupler off set from the center of rotating disk as shown in Fig. 1 [2]. Solar Grass Cutter with Linear Blades was also developed in India where they have used scotch yoke mechanism for converting reciprocating motion to linear motion [1].

3. Design and Modeling

The project was undertaken by performing a series of experiments with the design of the machine.

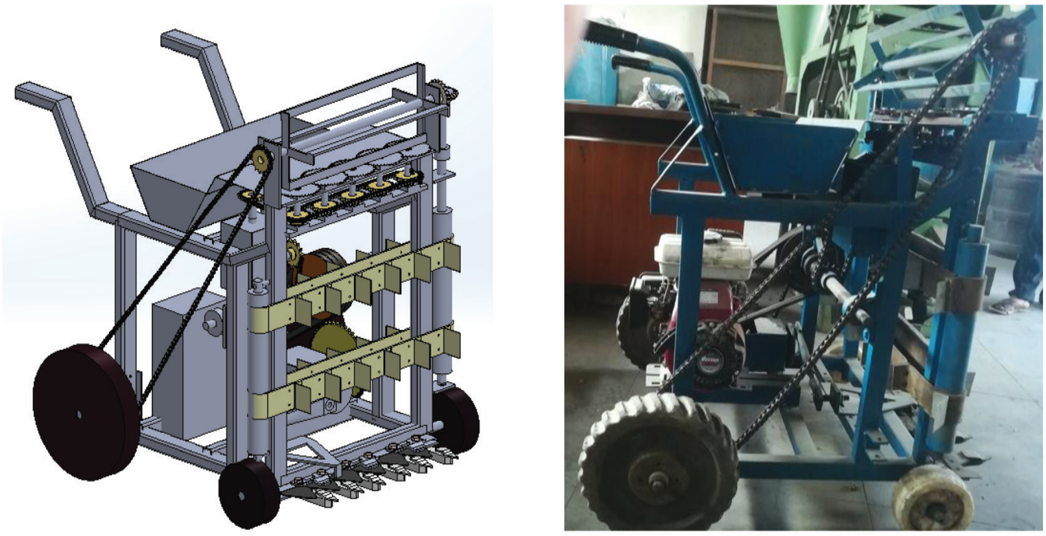

Fig. 2: Model and prototype of Harvesting Machine

Different designs was derived, analyzed and modified as necessary with the use of Solid Works 2014 for 2D sketch, dimensioning and 3D modeling.

Table 1: Calculated data

Radius of crank	0.04m
Torque on crank	47.12Nm
Maximum Displacement	0.04m at 90 degree
Maximum velocity	0.764 m/s at 90 degree
Maximum acceleration	17.02m/s^2
Speed of conveyor	0.587rpm
Small pulley diameter	0.07m
Large Pulley Diameter	0.150m
Belt Selection	A825
Chain Selection	Single Stand of Number 40 Chain
Main Shaft Diameter	0.01422m
Bearing Selection	17-20 mm deep groove ball bearing.

4. Financial Analysis

Table 2: Total Cost of Fabrication

Components	Rate	Quantity required	Total (NPR)
Frame	1150 (per 6m =1 pcs)	1.5	1150
Shaft	650 (25Ø, per ft) 850 (20Ø, per ft)	2 6	1300 5100
Gear	3500 (per set)	3	10500
Gear box		2	500
Bearing	350 (6004) 300 (6204) 200 (6002) 250 (6200)	2 10 2 10	700 3000 400 1500
Chain	850 (1 set)	2	1700
Drum		1	700
Conveyer	350 (belt per ft)	2	700
Wheel	500	4	2000
Sheet metal	700 (per sqft)	4	2800
Engine	10000	1	10000
Pulley	1800 (150Ø) 1300 (70Ø)	1 1	1800 1300
Belt	290 (A36)	3	870
Circular cutter	200	5	1000
Handle	1200 (per set)	1	1200
Shear cutter	5000	1	5000
Fittings			2000
Labor cost			8000
Miscellaneous			8000
Total investment			71220
Project research cost			5000
Total cost			76220

Economic Analysis: In this financial analysis the different assumptions that we have made are:

1. The number of working days in a year for machine is assumed to be 30.
2. The analysis period has been assumed to be 5 years.
3. The interest rate for the time value of money has been taken 8% which is the inflation rate in Nepal.
4. Number working hours in a day is assumed to be 8 hours for both machine and man.

Table 3: Data for economic analysis

Fuel used	Petrol
Cost of petrol per liter(Rs)	98
Average fuel consumed by engine(lit/hr)	0.7
Labor cost per day(Rs)	500
Time taken by machine to harvest 1 hectare(hours)	55
Time taken by human to harvest 1 hectare(hours)	400
Days taken by human to harvest 1 hectare	50
Total working hours for machine(hours)	240
Total hectare harvested by machine annually	4.36

Initial investment = Rs. 71,220
Labor cost per year = Rs. 500×50×4.36 = Rs. 1,09,000
Operation cost = (Rs. 500×6.875+Rs. 98×0.7×55)×4.36 = Rs. 31,437.78
Maintenance cost = Rs. 5,000
Total cost for machine harvesting = Rs. 36,437.78
Total annual saving = (Rs. 109000-Rs. 6437.78) = Rs. 72562.22

Now,

NPV of machine = -71220+72562.22(P/A,8%,5) = Rs. 218500
Since the NPV of the project is positive, we can say that investment in the project will be beneficial to the investment.

5. Testing

For testing of our machine, we used different strategies. They are:

1. Testing of machine at low power and speed

We used motor of power 0.7kW and speed 1440rpm. Then we operated the machine. We did this testing just to check whether power less than we selected is sufficient to cut or not. At that time machine did not move.

2. Testing of machine at specified power and rpm

We used engine having power 0.9kW and rpm of 1800. At this time, machine was able to move so, we were able to test drum, conveyer and upper cutter as well.

For testing the machine, we tested machine for three different plots.

Table 4: Data collected

Plot	Crops Spacing (in)	Length(m)	Breadth(m)	Area (m^2)	Time consumed (min)	Time required to harvest 1 hectare (hrs.)
1.	1	4	1	4	2.7	104.17
2.	4	4	1	4	1.3	54.17
3.	3	3	1	3	1	55.56

6. Results

- **i.** For plot 1, since the plot was dense, it was difficult to cut. Supplied power was not sufficient to cut those dense areas. Also the efficiency of machine was poor.
- **ii.** For plot 2, since plot was not dense but was inclined, it was comparatively easy to cut. Due to inclined nature of crops, machine pushed the crops so all crops were not cut properly which leads to decrease in efficiency of machine. But performance was comparatively better than that for plot 1.
- **iii.** For plot 3, crops were straight. It was easy to cut lower part. In this plot we were also able to test upper cutter. With the motion of wheel, drum rotated and grabbed upper part of crops and cutter cut the lower portion.

While testing in all three plot, we also found that comparatively more power was required to push the machine which was due to the direct connection of wheel shaft with drum shaft by chain sprocket.

7. Conclusion

The development of the machine prototype involved several designs, corrections and iterations in the workshop. During the testing, it is found that the power should be greater than 0.7KW and 1440rpm. Also, it should not be too high as it leads to more vibration of machine. It was difficult to cut dense and inclined planted crops. It is also concluded that it was difficult to push machine forward due to direct connection of wheel shaft with drum by chain and sprocket. An economic analysis shows that a machine is beneficial for harvesting purpose as its NPV is positive.

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