

# Design and Fabrication of Soybean Reaping and Collecting Mechanism

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**Abstract** – The focus of this project is to design a combined reaping and collecting mechanism for the farmers, to harvest soybean more efficiently. Our aim is to reduce the losses during harvesting to zero. The main purpose of our project is to help small scale farmers who having land area less than 4 acres by designing small scale harvester machine to harvest grains very efficiently. Our project work will focus on ease of harvesting operation to the small scale farmers for harvesting varieties of grain in less time and at low cost by considering different factors such as cost of equipment, ease of operation, time of operation and climatic conditions. This mechanism is compact and can cut up to three rows of soybean plant. It has cutting blades which cut the crop in a scissoring type of motion. A collecting mechanism is provided for the collection of crops directly into the trolley to one side after cutting. The power to move the cutting blades and conveyor is taken from the PTO shaft of the tractor. The mechanism is mounted in front of the tractor. It is easy to handle also the maintenance is low. This mechanism is manufactured using locally available spare parts and thus, its cost is less than other machines. This mechanism will be the solution to the problems faced by farmers regarding cost, availability of labour and losses during the harvesting of soybean crop. [2]

**Keywords**– Reaper, harvesting, scissoring action, conveyor, etc.

## I. INTRODUCTION

Soybean is one of the most valuable crops in the world not only as an oil seed crop and feed for livestock, but also as a good source of protein for the human diet and as a bio fuel feedstock it cannot be utilized as a pulse. It is now the second largest oilseed in India after groundnut. The most versatile of the world's major crops, soybeans can be grown in a wider variety of soil and agro-climatic conditions than any other major world crop. Soybean is grown on an estimated 6 percent of the world's arable land. In the recent past, soybean cultivation has increased many folds as compared to any other oil seed crop in the country and stands next to groundnut. For soybeans, harvesting at the right time and in the correct way maximizes grain yield and minimizes grain losses and quality deterioration. [1] Manual labour takes time and is not effective as they can work for 3- 4 hours at a stretch. Even if the land holding is small, it takes two or three days to completely harvest the soybean crop. Also the planting is not done with proper care. Hence the crops are strewn with a lot of non required plants, which grow with the soybean. So to harvest these unwanted crops along with the soybean is a tedious work. Recently Maharashtra has seen a shortage of skilled labour available for agriculture. Because of this shortage the farmers have transitioned to using harvesters. These harvesters are

available for purchase but they are not affordable, because of their high costs. However, agriculture groups make these available for rent on an hourly basis. But the small holding farm owners generally do not require the full- featured combine harvesters. Also, these combine harvesters are not available in all parts of rural Maharashtra due to financial or transportation reasons. Thus, there is requirement of a compact and efficient combine harvester which would be more accessible and also considerably cheaper. The mission is to create a portable, user- friendly and low cost mini harvester. The idea was to create a machine which is cheap and will reduce the labour required to harvest crops. [2]

## II. LITERATURE REVIEW

Amar B. Mule, Pravin T. Savarkar, kapil R. Gaurkar 2018 [1] This machine targets the small scale farmers who have land area of less than 2 acres. The machine is compact and can cut up to two rows of soybean plant. It has cutting blades which cut the crop in a scissoring type of motion. It runs on two stroke petrol engine of 3HP, this power from engine, is provided through pulley and gear box arrangement to the cutter. A collecting mechanism is provided for the collection of crops to one side after cutting. This mechanism is also powered by pulley arrangement. This compact harvester is manufactured

using locally available spare parts and thus, it is easily maintainable.

Dinesh B. Shinde, Ritesh D. Lidbe, Manisha B. Lute, Shubham R. Gavali, sharad S. Chaudhari, ShivaniN.Dhandale 2017 [2] The main purpose of the Project was to help small scale farmers who having land area less than 5 acres by designing small scale harvester. The paper focus on ease of harvesting operation to the small scale farmers for harvesting varieties of grain in less time and at low cost by considering different factors such as cost of equipment, ease of operation, time of operation and climatic conditions. This machine has cutting blades which cut crops in scissoring type of operation can cut up to two rows of crops.

A.V. Gajakos, R.S. Gaikwad AND V.V. Saraf 2015 [3] Collection of harvested crop by the reaper was carried out manually but it's too difficult and time consuming operation. To overcome this problem development of collection and unloading unit was carried out. The overall performance of reaper was observed to be satisfactory. Ebrahim Zareishahamat, Samsollah Abdollah Pour\*, Mohammadali Maysami - Design, construction and performance evaluation of a reaper for small farms, 2019 The results of machine performance evaluation showed that forward speed has a significant effect on field efficiency and crop losses. Increasing the machine forward speed caused decreasing the field efficiency and increasing crop losses. Jannatul Ferdows Nipa Agricultural Engineering Hajee Mohammad Danesh Science & Technology University - Study on Performance Evaluation of Self-propelled Reaper, 2016 In this study two different models were used for evaluating performance. For aush season Korean machine and for aman season Vietnam machine was used. Several measuring criteria's were considered during field experiment including operating speed, time of harvesting, fuel consumption, shattering loss, soil moisture, plant height & density, field efficiency, grain loss before & after harvesting, fixed costs, variable costs etc. were asked to get a generalized idea about the various types of manufacturing equipment.

### III. METHODOLOGY

#### 1. Design Process

1. What are the equipments manufactured for the farmers today?
2. How many of these manufactured equipments are available for small scale farmers?
3. Why are there no small scale harvester collector manufactured for

It is the systematic, Theoretical analysis of the methods applied to a study or to the theoretical analysis of the method and principles associated with branch of study.

#### 1. Studying the present mechanisms.

- Field Survey
- To identifying the potential problem.
- Problem definition.
- Literature review.
- Design of crop cutter.
- Calculation.
- Drawing of project.
- Fabrication.

With the demand for the grains on rise, the aim was to fabricate affordable reaper collector for increasing the economy of small scale farmers. For the fulfillment of this aim, it is decided to follow following steps:

- Interview the local farmers who have small scale land holding and enquire about the harvesting practices and the crops produced and emerging trends in crop harvesting.
- Interview agricultural equipment manufacturers to get information about various equipments that are available and are in demand.
- Refer various international papers in small scale harvesters produced earlier.
- Design of reaper collector harvester.

#### 2. Conducting Interviews with Farmers:

The design of this machine was to be based on the demand for a compact and affordable harvester. This demand could have been seen only with personal interaction with small scale farmers. The purpose of this visit was to see and enquire about the harvesting machines that are being used by the farmers. The following questions were asked to the farmers:

- What are the machines available for harvesting?
- What do these machines cost?
- Are these machines feasible for small scale farms?
- What are the traditional techniques used for harvesting?
- Can a small reaper collector be able to satisfy the increasing prices of labour?
- What is the labour cost for harvesting, as it is the most labour intensive work?

These questions gave the basic idea about the situation of small scale farmers. We came to know the needs and the requirements of the farmers.

#### 3. Consulting Agricultural Machines Manufacturer:

We visited The India's biggest Agricultural Festival that is 'KISAN'. Many agricultural equipment manufacturers came there from all over India. We interrogated them about to get the basic idea about the manufacturing equipments that are available. The following questions farmers?

- Why does the company consult local farmers while designing a new product?

- What difficulties are faced while designing a machine based on the needs of the farmers?

All these questions were recorded and notes were collected for further study

#### • Archival Reports:

The past data bases like Google scholar, Google Patents and relevant papers for small scale soybean harvesters were examined. The purpose was to gain an insight into what were the previous researches done on the topic and what were the implications of those designs.

The data that obtained from the interviews and research is used to finalize the specifications of our mechanism; this included general size and functionality. On the basis of information collected from farmers, manufacturer and researchers the following objectives being set;

- Designing a compact machine.
- Decrease the cost of machine.
- Decrease the labour requirement for harvesting.
- Decrease the efforts required for harvesting.
- Using proper collecting mechanism to increase the efficiency of harvesting.

So considering these points related to harvesting an attempt is made to design and fabricate such equipment which will able to perform the operations more efficiently and also will results in low cost.

### IV. FACILITIES REQUIRED

#### 1.Necessary Software's

- Solid work
- CATIA V5
- ANSYS APDL

#### 2.Hardware

- Lathe machine
- Grinding machine
- Band saw machine
- Gear box
- Bike sprocket
- Welding machine
- Drilling machine
- Gears
- Slider crank mechanism
- Chain drive

#### 3.Soybean Plant Dimensions

- Length = 500mm
- Stem width = 10mm
- Weight = 20g
- Distance between two rows = 400mm
- Pod position from ground = 50-100mm
- Specifications of Tractor Selected :

Table –I: Tractor Specifications

Model	Kubota B242U
PTO Power	17.4 HP
PTO Speed	540 RPM
Wheel Base	1300mm
Overall Length	2400mm
Overall Width	1015mm
Ground Clearance	325mm

### V. PROPOSED MECHANISM

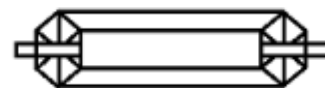
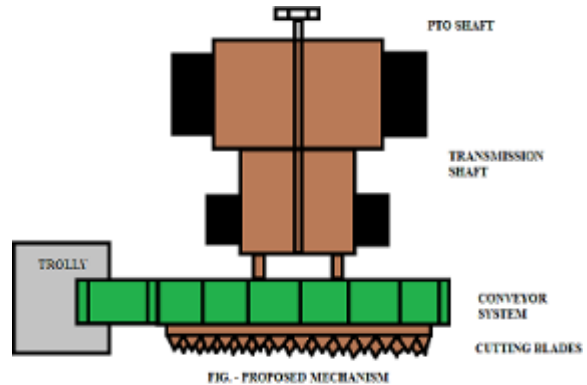


FIG - MECHANISM TO MOVE CROPS TOWARDS CONVEYOR

Fig. 1. Block Diagram.

This mechanism is mainly composed of cutting section and conveying section each having different characteristics with different kinds of mechanisms. In cutting section, i.e. cutting mechanism, reciprocating cutter is used. The machine performs two operations namely 'Harvesting and collecting'. There are two cutter blades; one is moving and another is stationary. The scotch yoke mechanism is used to convert rotary motion to linear sliding motion. Scissoring action is obtained due to reciprocating movement of cutter blade over stationary blade is used to cut the crops. The crop is cut by the cutting mechanism and then it is conveyed with the help of conveyor and collected in the trolley beside it.

### VI. WORKING OF THE SYSTEM

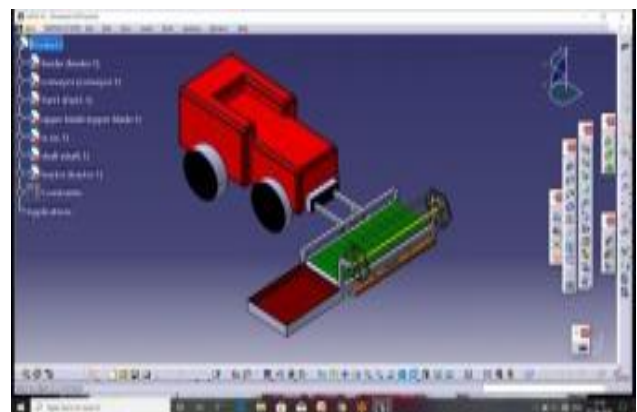


Fig. 2. CAD Model.

### Cutting section-

This section of cutting blades and slider crank mechanism. The mechanism will get the power from PTO of tractor at rear end. The power from the PTO is transmitted to the front of the tractor through transmission shaft. The speed of shaft is reduce by chain sprocket arrangement and then the power will distribute to the cutting section, feeder mechanism and conveyor system by means of spur gears. The rotary motion of shaft is converted into reciprocating motion with the help of slider crank mechanism. The cutting blades are of two types i.e., fixed blades and moving blades. The reciprocating motion of moving blades brings out the scissoring action.

### Feeder mechanism-

The feeder mechanism is placed above cutting blades which rotates and feed the crop towards the blades and force them to fall on the conveyor belt. It avoids the shattering of seeds at the time of cutting.

### Conveyor system-

The system is placed just behind the cutting blades it takes power from transmission shaft with reduced speed hence the conveyor belt moves with low velocity. After cutting the soybean plant will fall on conveyor belt and then it will conveyed to the trolley through the conveyor and collected in it.

## VII. COMPONENTS USED

### Transmission Shaft

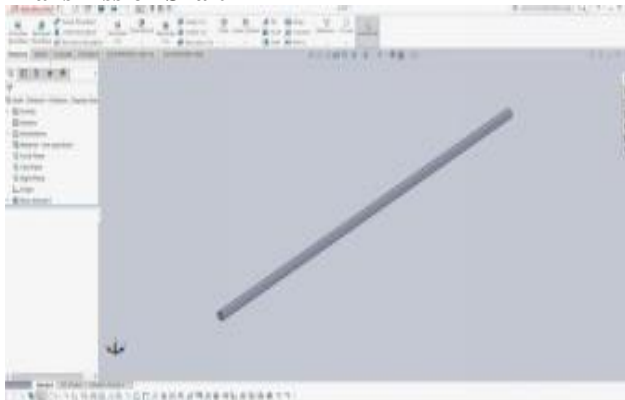


Fig. 3. Transmission Shaft.

The shaft is used to transmit the power from rear end of tractor to front end. The power given to the shaft from PTO of tractor through chain and sprocket assembly. As torque carriers, drive shafts are subject to torsion and shear stress, equivalent to the difference between the input torque and the load. They must therefore be strong enough to bear the stress, while avoiding too much additional weight as that would in turn increase their inertia. By considering all these parameters, we find the inner and outer diameter of shaft as 30mm and 40 mm respectively.

### Chain and Sprocket

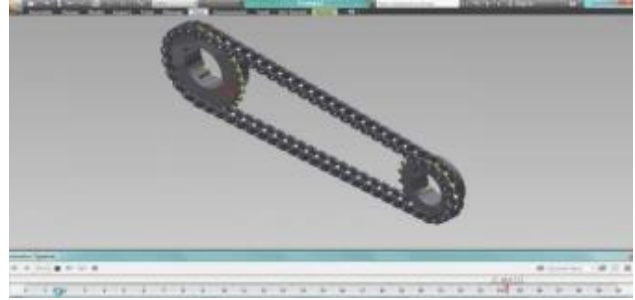


Fig.4. Chain and Sprocket.

Chain and sprocket arrangement is used to reduce the speed of PTO shaft. The chain and sprocket arrangement is used with gear ratio of 4:1, to reduce the rpm from 540rpm to 135rpm. The smaller sprocket is mounted on PTO whereas the larger sprocket will mount on the transmission shaft.

### Bearing



Fig.5. Bearing.

A ball bearing is a type of rolling-element bearing that uses balls to maintain the separation between the bearing races. The purpose of a ball bearing is to reduce rotational friction and support radial and axial loads. It achieves this by using at least three races to contain the balls and transmit the loads through the balls. In most applications, one race is stationary and the other is attached to the rotating assembly (e.g., a hub or shaft). As one of the bearing races rotates it causes the balls to rotate as well. Because the balls are rolling they have a much lower coefficient of friction than if two flat surfaces were sliding against each other. Ball bearings tend to have lower load capacity for their size than other kinds of rolling-element bearings due to the smaller contact area between the balls and races. However, they can tolerate some misalignment of the inner and outer races. The bearing is selected as per the requirement.

### Conveyor System

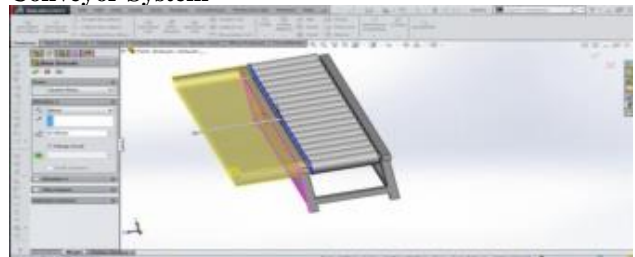


Fig.6. Conveyor System.

A conveyor system is a common piece of mechanical handling equipment that moves materials from one location to another. Conveyors are especially useful in applications involving the transportation of heavy or bulky materials. Many kinds of conveying systems are available and are used according to the various needs of different industries. In our project the conveyor is used to transfer the soybean plant to the trolley after cutting. The speed of conveyor belt is kept 0.467m/s and roller diameter is found 66.5mm.

### Scotch yoke Mechanism

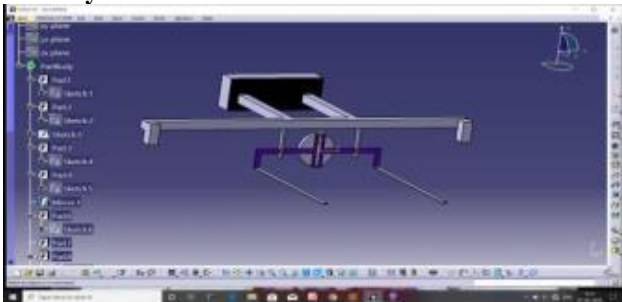


Fig.7. Scotch yoke Mechanism.

The scotch yoke mechanism is used to convert rotary motion of shaft into reciprocating motion of cutting blades. The slider part is directly coupled to reciprocating yoke with a slot that engages a pin on the rotating part. The crank length is considered as 50mm, the displacement of the blade is taken as 40mm, the velocity of blade taken as 1.5 m/s and the connecting rod length is found as 270mm.

### Cutting Blades

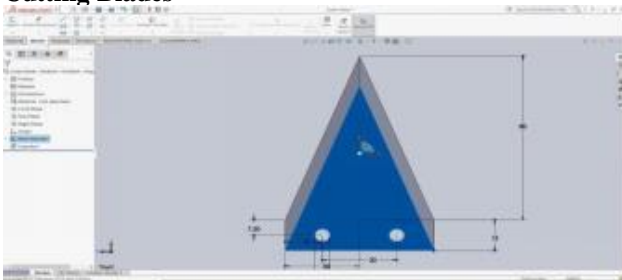


Fig.8. Cutting Blade.

Cutting blades are used to cut the crop. In cutting mechanism there are two blades that are upper and lower blades. The lower blades are fixed whereas the upper blades are moving. The upper blades move in reciprocating motion which gives scissoring action to cut the crop. The blades are in triangular shape with 3mm thickness and moving with the speed of 1.5m/s.

### Feeder

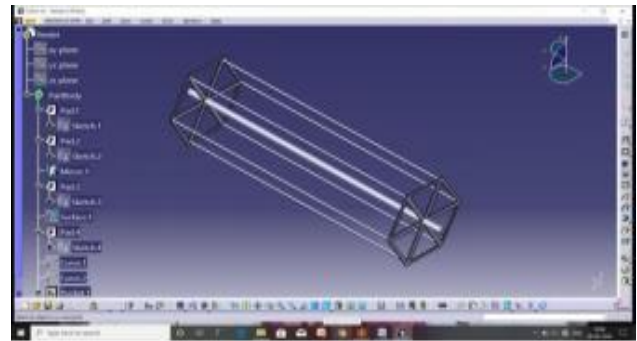


Fig.9. Feeder.

The feeder mechanism is placed above cutting blades which rotates and feed the crop towards the blades and force them to fall on the conveyor belt. It avoids the shattering of seeds at the time of cutting. It is 1400mm long and 500mm wide. The central shaft is of 30mm diameter.

## VIII.CALCULATIONS

Overall width of mechanism= 140cm = 0.140m Power at PTO= 17HP@540rpm

$$17HP = 17 \times 746 = 12682W = 12.68KW$$

$$P = (2 \times \pi \times N \times T) / 60$$

$$T = (12682 \times 60) / (2 \times 3.141 \times 540)$$

Torque at PTO= 224.26N-m Reduction through chain and sprocket :  $G = N1/N2 = T2/T1$

Assume  $G = 4:1$

Design of Shaft : Gear ratio = 4 : 1  $N1/N2 = T2/T1$   
 $540/N2 = 52/13$   $N2 = 135rpm$

$$T = 12682 \times 60 / (2 \times 3.141 \times 135) = 896.92N-m$$

Torque at shaft = 896.92N-m @135 rpm Solving eq. (2), we get

$$D = 40mm, d = 30mm, k = 0.6 = (D/d)$$

Outer & inner Dia. Of shaft = 40mm & 30mm respectively.

- **Design of Cutting Blades :**

Triangular shaped blade (80\*60\*3mm). Number of Blades = 20 upper + 20 lower = 40

Angle between cutting edge and axis of knife section = 31° Rake Angle = 22°

Material = High carbon steel

- **Design of Scotch Yoke Mechanism:**

Crank length= 50mm Connecting rod length= 270mm Displacement = 50mm Velocity = 1.5m/sec

- **Conveyor Design :**

The average weight of each soybean stem at this stage was 20 g.

Cut area per time (m<sup>2</sup> s<sup>-1</sup>) = cutting width (m) × forward speed (m s<sup>-1</sup>) = 0.01\*1.5 = 0.015m<sup>2</sup>/s

Number of cut stems per time (stems s<sup>-1</sup>) = 3

Mass of cut crop per time (kg s<sup>-1</sup>) = number of cut stems per time (stems s<sup>-1</sup>) × mass of one stem (kg) = 3\*0.02 = 0.06 kg

1) Velocity of conveyor = Distance/Time = 1.4/3 = 0.467m/s

2)  $V = (\pi * D * N) / 60$

0.467 =  $(\pi * D * 135) / 60$

D = 66 mm = roller dia.

3) Width of belt : 18 in or 45mm

Feeder Design:

Overall length = 1400mm Overall width = 500mm

Central shaft diameter = 30mm

Hexagonal plate thickness = 3mm Speed = 50rpm

Table -II: Dimensional specifications of reaper

Sr.No.	Item	Specifications
1	Length (mm)	2100
2	Width (mm)	1500
3	Height (mm)	1100
4	Weight (kg)	80
5	Cutting width (mm)	1200
6	No. of cutter blades	40
7	No. of rows cut in single pass	3

### IX. ANALYSIS OF THE FORCES ON BLADE

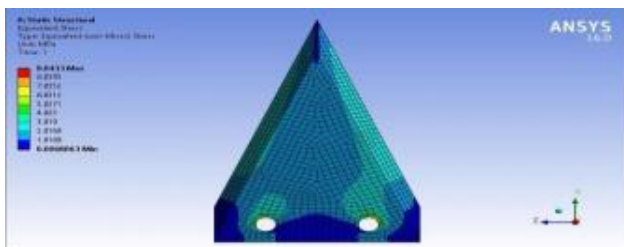


Fig.10. Equivalent Stress.

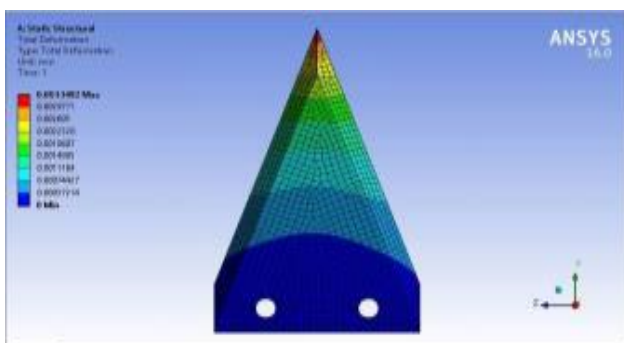


Fig.11.Total Deformation.

The force analysis on the cutter blade is done. A uniformly distributed load of 200N is applied on the cutting edge. This force generated a von-Mises stress of 6.03N/mm<sup>2</sup> and the total deformation of 0.0033mm. This rendered the cutter blade is safe from cutting forces.

### X. COST ESTIMATION

Table -III: Cost Estimation Table

Sr.No.	Parts	Cost
1.	Frame	1500
2.	Shaft	1000
3.	Chain and Sprocket	800
4.	Bearing	1000
5.	Bevel Gear	1500
6.	Cutter Blades	400
7.	Conveyor Belt	1500
8.	Spur Gear	200
9.	Nut and Bolts	200
10.	U-Joint	400

Component Cost= 8500 Rs.

Total cost = Component cost + Manufacturing cost = 8500+ 3500

### XI. SAFETY PRECAUTIONS

The following points should be considered for the safe operation of

1. All the parts of the machine should be checked to be in perfect alignment.
2. All the nuts and bolts should be perfectly tightened.
3. The operating switch should be located at convenient distance from the operator so as to control the machine easily.
4. The inspection and maintenance of the machine should be done time to time.

### XII.ADVANTAGES

1. The machine have compact design and operator can easily control over the machine handling
2. Due to less cost reduces the initial cost of machine allow poor farmers to buy this machine.
3. The machine is suitable for small as well as large farms due to its less weight and higher work efficiency.
4. The machine has low maintenance cost and the efforts required for harvesting are less.
5. Because of proper collecting mechanism there are minimum losses during harvesting.
6. Less number of labours required.

### XIII. APPLICATIONS

It is used in agriculture field for multipurpose cropping. It is used to crop the soybean and chana.

### XIV. RESULTS

A. Comparison of Harvesting Cost by Traditional Method and Our Harvester:

Harvesting done by manual process:

Amount paid to the labour for one day = Rs. 250 per labour

Total number of labour required in general to harvest the 1 acre farm of soybean in a day = 6

Total amount paid to the labour =  $6 \times 250$   
= Rs. 1500 per acre in one day

Therefore, total expenditure in one day is = Rs. 1500

Harvesting done by machine:

Quantity of diesel require for 0.25 to 0.3 acre = 1 litre

Quantity of diesel require for 1 to 1.2 acre = 4 litre  
Cost of diesel per litre = Rs. 68

Total cost of diesel for 1 acre farm for a day =  $4 \times 68$  =  
Rs. 272  
Amount paid to the labour = Rs. 250 per day

Total expenditure = Total cost of diesel + Amount paid to the labour

+ Maintenance

=  $272 + 250 + 60$

= Rs. 582 ~ Rs. 600

Amount saved by using the harvester =  $1500 - 600$  = Rs. 900 per day per acre.

[6]. Jannatul Ferdows Nipa Agricultural Engineering  
Hajee Mohammad Danesh Science &  
Technology University - Study on Performance  
Evaluation of Self-propelled Reaper, 2016

[7]. [6]<http://india.gov.in/topics/agriculture>

## XV.CONCLUSION

It is possible to harvest soybean just like any other farm operations using locally available technologies. Late harvesting and thereby loss of crop in the field can be avoided if the options proposed can be adopted as a national mechanization strategy by farmers and the government. The options reduce harvesting time significantly to 2 hr/day and therefore limit potential field quantitative and qualitative losses from shattering and weather related causes. This mechanization model reduces the harvesting time requirements and drudgery associated with soybean harvesting thereby improving the quality of life for farmers.

## REFERENCES

- [1]. Amar B. Mule<sup>1</sup>, Pravin T. Sawarkar<sup>2</sup>, Akshay A. Chichghare<sup>3</sup>
- [2]. Akash N. Bhiwapurkar<sup>4</sup>, Dhananjay D. Sirsikar<sup>5</sup>, Kapil R. Gaurkar<sup>6</sup> - Design and fabrication of harvesting machine, Jan-2018.
- [3]. Dinesh B. Shinde<sup>1</sup>, Ritesh D. Lidbe<sup>2</sup>, Manisha B. Lute<sup>3</sup>, Shubham R. Gavali<sup>4</sup>, sharad S. Chaudhari<sup>5</sup>, Shivani N. Dhandale<sup>6</sup> - Design and Fabrication of Mini Harvester, 2017.
- [4]. A.V. GAJAKOS, R.S. GAIKWAD AND V.V. SARAF - Development of collection and unloading unit attachment for self-propelled vertical conveyor reaper, 2015.
- [5]. Ebrahim Zareishahamat, Samsollah Abdollah Pour\*, Mohammadali Maysami - Design, construction and performance evaluation of a reaper for small farms, 2019