DEVELOPMENT OF PINEAPPLE HARVESTING ATTACHMENT FOR BRUSH CUTTER

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PROJECT REPORT

Submitted in partial fulfillment of the requirement for the degree of

Bachelor of Technology

in

Agricultural Engineering

Faculty of Agricultural Engineering and Technology

Kerala Agricultural University

DEPARTMENT OF FARM POWER MACHINERY AND ENERGY

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY

TAVANUR-679573, MALAPPURAM

KERALA, INDIA

2016

DECLARATION

We hereby declare that this project report entitled "**Development of a pineapple harvesting attachment for brush cutter**" is a bonafide record of project work done by us during the course of project and that the report has not previously formed the basis for the award of any degree, diploma, fellowship or other similar title, of another University or Society.

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CERTIFICATE

Certified that this project work entitled "**Study and development of suitable pineapple harvesting attachment on brush cutter**" is a record of project work done jointly by Ms. Athira Prasad, Ms. Shahama K. and Mr. Mukesh Kumar under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to them.

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ACKNOWLEDGMENT

With whole heartedness we thank '**God the Almighty**' for the help, rendered through various hands, which helped us to the completion of this endeavor.

None other than our guide **Er. Shivaji K P.** *Assistant Professor,* Dept. of Farm Power Machinery & Energy, Kelappaji College of Agricultural Engineering and Technology, Tavanur deserves at the second place, our heartfelt thanks for his persistent initiation, efficacious advice and zealous intellectual support.

We greatly indebted to **Er. Sindhu Bashkar**. *Assistant professor*, Dept. of farm power machinery & Energy, Kelappji college of Agricultural Engineering and Technology, Tavanur for the great support and encouragement.

We sincerely thank to **Dr. Jayan P R.** *Associate Professor and head,* Dept. of Farm Power Machinery & Energy, Kelappaji College of Agricultural Engineering and Technology, Tavanur for the help rendered us during the project.

We sincerely express our gratitude to **Dr. Joby Bastian**, *Associate Professor.* Regional Agricultural Research Station, Kumarakom for his constrictive suggestions offered in this study.

We are greatly indebted to **Dr. M S. Hajilal** *Dean (Ag.Engg),* KCAET, Tavanur, for his interest and kind advice given to us at all stages of our studies.

We offer our profound gratitude to the head and other staffs of Aralam Farm, Kannur for providing all facilities for the field work.

We offer our sincere and well devoted thanks to **Mr. Mathew John and Mr. James George** for all facilities and support for the field work.

We sincerely express our gratitude to all other technicians of the Workshop, KCAET, Tavanur, especially **Mr. Manu,** and **Mr. Shajith** for their help during the conduct of this project.

We express our thanks to all the **staff members of library**, KCAET, Tavanur for their ever willing help.

Words do not suffice to express our gratitude to all our juniors especially and all our other classmates and friends who have helped us immensely during the period of our study and the project work.

We are greatly indebted to our **parents** for their blessings and prayers and support without which we could not have completed this work.

We are thankful to **all those**, who directly or indirectly helped us.

ATHIRA PRASAD

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MUKESH KUMAR

Dedicated

to

The Almighty God

and

Our loving Parents

INTRODUCTION

CHAPTER I

INTRODUCTION

Pineapple (*Ananas comosus*) is one of the most important fruit crop in the horticultural sector. Pineapples contribute to over 20% of the world production of tropical fruits. India ranked sixth with a share of 8% of the world production of pineapple. The main varieties of pineapple grown in India are 'Kew' and 'Mauritius'. The states Assam, Karnataka, Kerala, Meghalaya, and West Bengal are the major producers of pineapple in India. The total area under pineapple cultivation in India is about 88700 ha in the year 2012 - 13 (Joy, 2013). It is recorded that the overall production of pineapple in India is about 1571000 tonnes in the year 2012 - 13 (FAO, 2015).

In Kerala the area under cultivation of pineapple during 2012 - 13 is 10200 ha. In Kerala, the area under cultivation of pineapple is maximum in Ernakulum district and the contribution is 62% during 2013 - 14. In the year 2013 - 14 Kerala has a share of 4.2% of national production with a production of 72.86 tonnes (Joy, 2013).

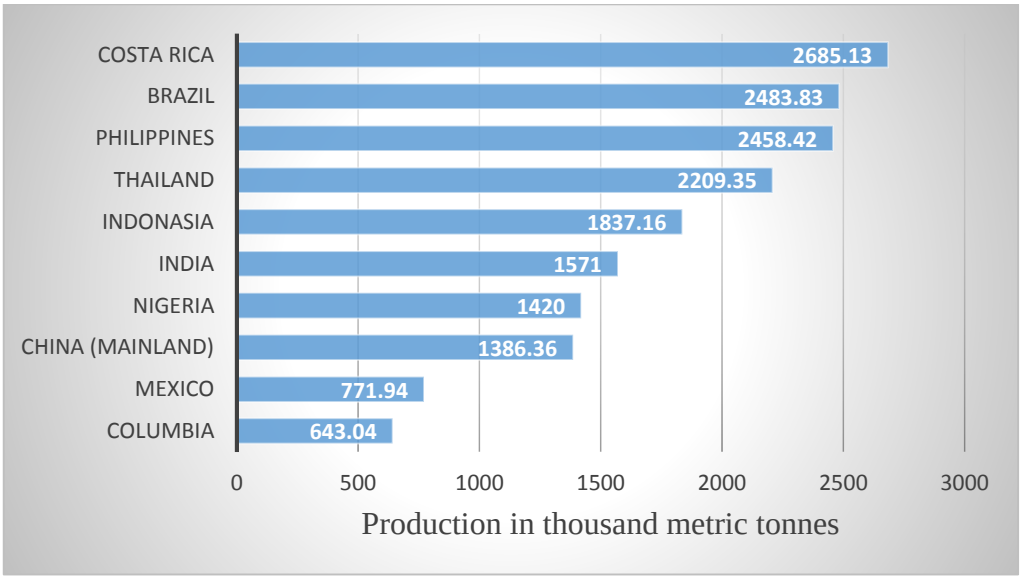

Fig.1.1 Leading countires in pineapple production world wide in 2013

(FAO, 2013)

For commercial cultivation for table purposes and distant marketing, Mauritius variety of pineapple is recommended. These are usually cultivated as an intercrop in coconut, newly planted rubber and cashew plantations, garden land, reclaimed low lands and wet lands.

Planting, intercultural operations and harvesting of pineapples are doing manually. Among which, harvesting of pineapple is very tedious process. Separation of mature fruits from the plant involves breaking them or by cutting the fruit stalk, which is in the centre of mature plant with a clean cut of a knife. The foliar coverage of a single plant ranges between 1 to 1.5 m, it covers the inter space between the rows. This makes the walking between the rows difficult while harvesting. While harvesting the pineapple the workers should wear gloves in order to protect them from the sharp spines on the edges of pineapple leaves, but these clothing is too hard to wear. Lack of labours and high labour costs are the crisis in this sector. Therefore mechanisation of pineapple harvesting is becoming inevitable.

Brush cutter which is also called as string trimmer is a very commonly used garden tool in the state Kerala. The string trimmer was invented in the early 1970s by George Ballas of Houston, Texas and it works on the principle that a line is turned fast enough to cut the grass. The global market of brush cutter is growing with the increasing urbanisation and industrialisation. The global brush cutter market is growing at a compound annual growth rate (CAGR) of 3.83% over the period 2014 - 2019 (ReportsnReports, 2015).

Advantage of gas brush cutter includes its mobility and maximum power. Brush cutter consists of a long shaft with a handle and sometimes a shoulder strap at the end of which the cutting head is mounted. Cutting element may be nylon wires or metal blades. The power is taken from an internal combustion engine which is at the other end of the long shaft. The trigger on the handle is used to control the operations. A safety cover unit is also provided.

Brush cutter allows the head, the hub or the lower part of the shaft to be replaced with accessories. The common accessories are: replacing monofilament line with metal or plastic blades; replacing the lower shaft with a small chain saw to create a power pole saw; replacing the lower shaft with a hedge trimmer; and replacing the lower shaft with a cultivator. The cutting head can be modified so that it can perform many operations rather than the forage harvesting. It had been already modified to simple paddy harvesting machine, sugar cane harvesting machine etc. The long handle permits the operator to operate the trimmer from a distance. By tilting the machine the cut can be done in vertical direction also and can even adjust the cutting head in different angles. Being simple in operation and light in weight it can easily carried to field and can easily operate it. Availability of a small and light machine makes it suitable for women also. Considering the popularity and availability of brush cutter in the state of Kerala, this study was undertaken with the following objectives:

- To study of suitability of pineapple harvesting attachment for brush cutter
- To develop a pineapple harvesting attachment for brush cutter
- To test the pineapple harvesting attachment for its functionality and to suggest optimum machine parameters for design

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

This chapter deals with the reviews about the crop (pineapple), its cultivation practices, characteristics and also about the various research work carried out on fruit harvesting.

2.1 PINEAPPLE – HISTORY AND CULTIVATION

The plant pineapple is indigenous to South America and is said to originate from the area between southern Brazil and Paraguay; however, little is known about the origin of the domesticated pineapple (Pickersgill, 1976). Bertoni (1919)[;] considered the Paraná–Paraguay River drainages to be the place of origin of *A. comosus*. The natives of southern Brazil and Paraguay spread the pineapple throughout South America, and it eventually reached the Caribbean, Central America and Mexico, where it was cultivated by the Mayas and the Aztecs. Columbus encountered the pineapple in 1493 on the leeward island of Guadeloupe. He called it *piña de Indes*, meaning "pine of the Indians," and brought it back with him to Europe, thus making the pineapple the first bromeliad to leave the New World. The Spanish introduced it into the Philippines, Hawaii (introduced in the early 19th century, first commercial plantation 1886), Zimbabwe and Guam. The fruit is said to have been first introduced in Hawaii when a Spanish ship brought it there in the 1500s. The Portuguese took the fruit from Brazil and introduced it into India by 1550.

Collins (1949) conducted a study on the history, taxonomy and culture of pineapple. Although the wild species of pineapple, native to tropical America, are seeded, seedless varieties were selected and cultivated by the Indians or their predecessors long before the advent of Columbus. In this semi-popular article an account is given of the distribution and taxonomy of the wild and cultivated species, the history of the main cultivated varieties, and the methods of cultivation practised in Hawaii.

Teisson **(**1973) conducted a study on Development and growth of the inflorescence of Ananas comosus (cv. Smooth Cayenne). The fruit was ready for picking after 5 months. The fruit peduncle grew very rapidly until it reached its maximum size 7 weeks after induction treatment. At this stage the crown began to grow rapidly until harvest. Changes, in weight with time, and as a percentage of the total weight of stem, fruit and crown were also studied.

Floether (1976) has written an article about the contour cultivation of pineapple. The article describes a development project for the settlement of landless farmers on the eastern slopes of the Western Ghats in South India. The forested slopes of 5-10% were cleared for the cultivation of field crops, but because of the monsoon rains the area has a high potential for erosion. Contour cultivation has therefore been proposed using large ditches for the temporary storage of surface runoff. To compensate for the high investment required for the initial construction of the erosion control ditches using earth-moving machinery, it is planned to cultivate high value crops such as pineapples in the beds of these channels. The long-term conservation effects are considered to justify the high initial costs as the returns are high from pineapples and the land is simultaneously prepared for normal contour cultivation thereafter with built-in erosion control for a considerable period.

Rajasekharan (1989) conducted studies on Pineapple intercropping in the first three years of rubber planting in small holdings: an economic analysis. Rubber occupies about 15% of net cultivated area in Kerala. As it has a long gestation period of 7 years, growers often intercrop other agricultural products with it to provide them with income. This study is an economic analysis of pineapple intercropping in the first three years of rubber cultivation on smallholdings in Kerala. Total cost and gross income are estimated for the season ending June 1989, taking into account land rent. Other factors related to pineapple cultivation such as capital productivity and marketing are also discussed. Traders were found to meet harvesting costs, of which hired labour formed a larger share than family labour. The processing and marketing of pineapple, however, is

regarded as inadequate. Special attention is drawn to the potential profitability of pineapple leaves as fibre for raw material.

Joseph (2007) conducted a study on the economics and cultivation of pineapple in Kerala. This paper describes pineapple cultivation in the State of Kerala, India. The climate and soil in the State are conducive to pineapple cultivation. This description includes the varieties cultivated in the State, their quality analysis, propagation and methods of cultivation, intercropping, fertilizer and hormone application, fruiting, harvesting, uses and economics of pineapple cultivation in Kerala.

Tochi *et al*. (2008) describes that, Pineapple mainly contains water, carbohydrates, sugars, vitamins A, C and carotene, beta. It contains low amounts of protein, fat, ash and fibre. Pineapples contain antioxidants namely flavonoids, vitamin A and C. These antioxidants reduce the oxidative damage such as that caused by free radicals and chelating metals. It also has the enzyme complex protease (bromelain). Bromelain contains peroxidase, acid phosphate, several protease inhibitors and organically bound calcium.

Joy (2010) studied on pineapple, which describes that Pineapple (*Ananas comosus*, Bromeliaceae) is a herbaceous perennial, 90 to 100 cm in height with spreading leaves which gives the plant a rosette appearance. The plant bears a single fruit terminally on a peduncle protruding out from the centre of the rosette. The Pineapple variety ‘Mauritius’ is also known as 'European Pine', 'Malacca Queen', 'Red Ceylon' and 'Red Malacca' in international trade. It is important in India, Malaya and Ceylon. Mauritius is exclusively grown for table purpose. The leaves are dark green with broad red central stripe and red spines on the margins. Crown is also spiny. The fruit is medium, 1.36 - 2.25 kg, yellow externally; has a thin core and very sweet golden yellow flesh and juice. It is sold fresh and utilized for juice. Vazhakulam pineapple is considered the best in quality, sweetness aroma and flavour. Hence, it is recommended for commercial cultivation in Kerala for table purpose and distant marketing, due to its shorter duration, better

fruit quality, keeping quality and transportability. It is grown in the districts of Ernakulam, Kottayam, Pathanamthitta and the low elevation areas of Idukki district in Kerala. In Kerala, pineapple is cultivated in an area of 12500 ha with a production of 102400 t and a low productivity of 8.2 t/ha, consistently stable over the last few years.

2.2 HARVESTING

Williams (1947) has conducted studies on Harvesting, handling and packing of pineapples. A description is given of the proper procedure for selecting, handling and packing pineapples in Queensland. There are 11 photographic illustrations of packing methods and a table showing the packing counts for pineapples packed in the tropical case (611.505 × 30.48 × 30.48 cm).

Huang *et al.* (1960) conducted studies on the picking maturity of the pineapple. For use as fresh fruit and for canning pineapples should be picked when the flesh is light yellow and tender, and the flavour not too acid. A microscopic study of the cross section of a sepal from an unripe fruit showed a pink colouration in the cells under the epidermis and green chloroplasts in the spongy tissue. On ripening the pink colour disappeared and the chloroplasts turned yellow.

2.3 FRUIT HARVESTINGEQUIPMENTS

Obrein *et al.* (1970) in his article Is mechanically harvesting pineapple practical, describes a pineapple harvester and its advantages and disadvantages are assessed in relation to hand picking. Crop losses would be 2.5 times greater with machine harvesting, and they would not be offset by reduced costs. Mechanical harvesting could become economic only with modified cultural practices (a 2-year cycle in particular), and if labour was in very short supply.

Gaillard (1978) researched on Mechanised harvesting of orchards and pineapples. Pineapple harvesting mechanization is limited to the provision of

conveyor belts and transport to processing plant and is only suitable for large plantations (over 10000 t/year). Citrus fruits are chemically treated to assist abscission then powerful alternating blowers are drawn along the rows and finally the fruit are swept into rows by a machine sweeper and picked up by a machine similar to a potato digger and loaded into transport bins. Funicular transport systems for bananas are under consideration in the Amazon region where road making costs are prohibitive.

Rosa *et al.* (1990) describes development and evaluation of machine SAP-36 for pineapple semimechanized harvesting. The SAP-36 semimechanized pineapple harvester used in Cuba which can harvest pineapples with or without the crown is described. The construction and operation of the harvester are detailed. The theoretical productivity of the machine was estimated at 24 t/h and mean productivity obtained during trials was 13.92 t/h. Operating costs could be reduced by Rs. 12.099 per tonne with the machine.

Soon (1992) developed a hydraulic powered cutter for harvesting fruits such as pineapple, banana or oil palm. Both laboratory tests and field investigations were conducted to identify a suitable blade and operating mechanism. The hydraulic cutter/harvester could be operated either by hand pump or by a gear pump driven by a 900 W portable engine. The cutting blades operated by the ram were connected to one end of a long extendible aluminium pole, and the pump was attached at the other end. The total weight of the cutter was 6 kg with hand-pump, and 12 kg with engine driven pump attached.

Bakhtiari *et al*. (2013) studied on picking mechanism for fruit harvesting and results of field experiments are reported. A prototype model was designed for both efficiency and cost effectiveness. Experimental results showed the proposed mechanism yielded a good accuracy; where a total of 210 fruits are used for evaluating the device, 200 of them were grasped and 9% damaged. The experimental picking system demonstrated potential for using robots in harvesting of fruits with satisfactory quality.

Hotegni *et al.* (2015) investigated reducing the heterogeneity in pineapple in the field by pruning slips on selected plants, in order to promote the fruit growth on these plants. Slips are side shoots that develop just below the pineapple fruit during fruit development. The fraction of plants pruned and pruning time had no consistent effects on fruit quality nor on variation in fruit quality. The lack of any consistent effect on average quality was surprising because slip development overlaps with fruit development and it was obvious that competition for available assimilates or nutrients within a plant might take place between the developing slips and the fruit as is the case in many crops producing fruits and side shoots, e.g. in tomato (Heuvelink 1997) and tangelo (Morales *et al*. 2000). Also the size of the side shoots to be removed at pruning time and their number were substantial.

2.4 BRUSH CUTTER

Bora *et al*. (2007) studied on low cost mechanical aid for rice harvesting. This describes that a small engine-powered harvesting aid for small area rice farmers were developed. The machine was a modified brush cutter. The original cutter blade was replaced by a 25 cm diameter circular saw blade. A metal plate and rubber guard assembly was fitted behind the blade on the handle to guide the cut stalk to the left side. The machine performed well in the field conditions with a field capacity of 0.51 ha/day consuming 0.25 l of fuel in an hour. It was 7.5 times faster than manual harvesting though the field loss was around 2.3% as against 1% in manual harvesting. The break-even area was 1 ha and the payback period for the investment was one year. The machine should be affordable to low income farmers in developing countries and women would also able to taste the fruits of mechanisation.

Langton (2007) studied on design of a brush cutter blade and its integration into a semi mechanized sugarcane harvesting system. Sugarcane is an important crop for South Africa. In South Africa manual harvesting is currently the dominant harvesting method, which is labour intensive and may be sensitive

to issues. The majority of South Africa's sugarcane is planted on steep topographies where mechanical harvesters are unable to operate. It has, therefore, become important to re-evaluate sugarcane cutting systems in an attempt to make sugarcane cutting easier, cheaper and more efficient. The aims for the project were, first, to design a blade that can be attached to a brush cutter to cut sugarcane effectively and efficiently and, second, to integrate the brush cutter into an economically and ergonomically sound sugarcane harvesting system. A harvester was developed called the Illovo Sugarcane Harvester and trials were conducted to assess performance, efficiency, economics and blade durability. A major constraint with the design was the durability of the blade and this limitation contributes significantly to the cost of the system. Using the system it was found to harvest sugarcane effectively and economically but further aspects are outlined for further research. An ergonomic study was performed and results suggest that significantly less energy is required to harvest sugarcane per ton compared to manual harvesting. More energy is, however, required in a work shift and might be detrimental to the labourer. An additional study was performed on the lower back, which is often the leading cause of musculoskeletal disorder experienced in the workplace. Results were favourable and clearly showed that there is less stress and strain on the back when using this system compared to manual harvesting. The system was implemented in a commercial environment and several recommendations were determined.

Reddy *et al.* (2010) studied on design and analysis of a revised gas trimming device. This paper presents design methodology for fabrication and testing of a petrol operated gas trimming device under Indian scenario. Components like drive shaft spindle, its bushed sleeve and trimming head system were developed from available workshop scrap material. During operation, optimum hand handle position over a different engine speeds and cutting length thread was predicted so as to minimise operator’s fatigue. ANOVA showed that hand vibrations during operation were significantly influenced by length of nylon-thread than speed of the engine in three hand-handle positions considered. Optimum values of operating parameters for minimum hand vibrations in all

positions were: nylon thread length, 20 cm; and engine speed, 3300 rpm. Rate of fuel consumption with nylon thread over an equivalent trimming operations using metallic cutter was comparatively low (22%). Exhaust additional muffler unit reduced engine noise level by 6 dB.

Handaka *et al.* (2011) were conducted a study on modification of grass cutter into a small rice harvester. Because of high price of rice harvester machine that meet the standard of law shrinkage and affordable by consumers, a commercial lawn mower has been modified into a rice harvester machine. Modifications that had been made were (1) replacing the cutter blade with a rotary blade; (2) changing the dynamic balance of harvester machine into a mower type; (3) adding a guider and a propeller; and (4) adding an operator belt. Performance test on 100 square meter with a standard engine for crop harvest showed that the modified machine had a working capacity of 18-20 hours/ha. Fuel consumption is 15 l/ha. Working efficiency of 95% and weighing about 10 kg. All the standard components were available in the market. While the frame of the propeller and the operator belt could be made domestically.

Qiu Lei Du *et a*l. (2014) researched on the study and design of lawn brush cutter. Based on the survey of existing brush cutter and the analysis of the known conditions, this paper mainly studied design mechanism and principle of brush cutter, and carried on calculation and calibration of spiral bevel gear cutting machine parts, so as to ensure that the design of brush cutter is safe, efficient, simple, comfortable and environmentally friendly. Product after research is of reliable performance, convenient operation, low noise and zero smoke and higher safety factor, making it get more extensive application in the industry.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

This chapter deals with the methodology adopted for the preliminary studies including crop geometry, physical properties of pineapple fruits and materials and methods used for the development of a suitable attachment on brush cutter for pineapple harvesting. For the preliminary studies the details were collected from pineapple growers in the state Kerala and also from Aralam Farm, Kannur.

3.1 CROP GEOMETRY

Pineapple is a tropical fruit usually cultivated as an intercrop in crops like rubber, cashew plantations, etc. Crop geometry including the variety, cultivation practices and intercultural operations were studied.

3.1.1 Cultivation practices

The cultivation practices of crop including the bed width, bed spacing, row to row spacing, were measured using a tape and also number of rows in a bed, arrangement of plants in rows, and plant density were included in the study.

3.1.2 Intercultural operations

The details about the intercultural operations performing during the crop growing season, application rate of hormone and stage of plant at which the hormone is applying was noted.

3.2 PHYSICAL PROPERTIES

Physical properties of crop and fruit which will have direct influence on mechanical harvesting were studied.

3.2.1 Crop

Number of leaves in a mature plant was noted. Foliar coverage of first year, second year and third year plant, diameter of stem, position of fruit from ground are measured with tape, steel rule and Vernier caliper.

3.2.2 Fruit

Weight of fruit is measured using a digital weighing machine. Height of fruit including crown and diameter of fruit were measured using steel rule and Vernier caliper respectively.

3.3 BRUSH CUTTER

An Oleo-Mac 740 T brush cutter was used for the modification purpose which consisted of a gasoline engine, central shaft, cutter blade, Shoulder strap and protective shield. The specifications of the brush cutter are tabulated in table 3.1. Plate 3.1 shows the brush cutter used for the study.

Plate 3.1 Oleo-Mac 740 T brush cutter

Table 3.1 Specifications of Oleo-Mac brush cutter

Type	**Trimmer**
Engine type	Gasoline, two-stroke
Power	1.80 hp (1.34 KW)
Engine location	Top
Working volume	38 cc
Fuel tank	0.9 l
Rod	Straight
Options	Shoulder strap, reel and line, drive / knife
Features	T-handle
Weight	6.6 kg
Diameter of round blade	250 mm

The envisaged design of the attachment consists of two elements, the cutting element and holder attachment. Details of these elements are discussed below:

3.4 CUTTING ATTACHMENT

Round blade was identified and selected as the cutting element for the harvester attachment. Commercially available 250 mm diameter circular blade was used for developing the attachment. The blade has 60 numbers of teeth. Plate 3.2 shows the blade used as cutting element in the unit.

Plate 3.2 Circular blade

3.5 HOLDER ATTACHMENT

The harvesting attachment is mounted vertically above the round blade at an inclination of 15 degree with the horizontal. The attachment consists of a square plate, a rectangular flat connecting plate, a round base plate, a welded mesh cover and two crop guides. Plate 3.3 shows the holder attachment. The top view of the holder attachment is shown in fig.3.1.

Plate 3.3 Pineapple harvesting attachment

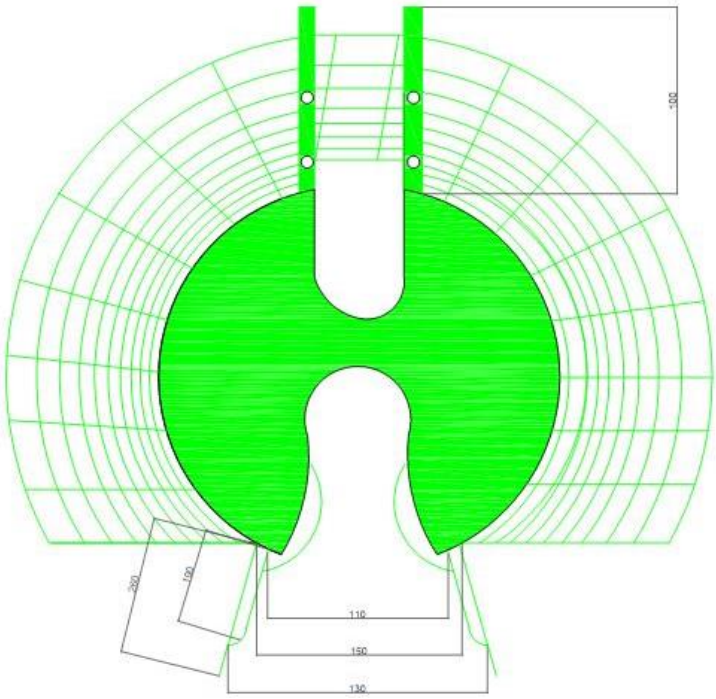

Fig. 3.1 Top view of pineapple holder attachment

3.5.1 Square plate

A MS square sheet of size 120 x 120 x 4 mm was selected for mounting the attachment on the brush cutter. It consists of 4 holes of 8 mm diameter by means of which it is attached to the brush cutter and it also has 6 pairs of 8 mm diameter holes for mounting the attachment by means of connecting plate. Nuts and bolts of 10 mm diameter and 25 mm length are used to connect the square plate to the brush cutter and attachment to the square plate. Plate 3.4 shows the square plate.

Plate 3.4 Square plate

3.5.2 Connecting plate

A MS flat plate of size 100 x 22 x 3 mm acts as a connecting member between the square plate and the base plate of attachment. It is welded to the bottom of the base plate and at the junction the base plate is bent to 15 degree angle. It has two holes of 8 mm diameter with a centre to centre distance of 30 mm. By changing the holes we can adjust the position of attachment.

3.5.3 Base plate

A GI circular sheet of 180 mm diameter and 3 mm thickness is used as the base plate. The base plate will act as a platform for holding the pineapple. The base plate is having a bent portion and a hole at the centre for the entry of pineapple stem into the attachment and for holding the pineapple inside.

3.5.4 Welded mesh cover

A welded mesh of 25 mm x 25 mm square is used to cover $3/4^{th}$ of the circumference of the base plate up to a height of 300 mm. Two MS rods of 8 mm diameter are welded to the base plate on which the square mesh is welded. The purpose of the welded mesh cover is to hold the fruit inside.

3.5.5 Crop guides

There are two crop guides made up of GI wires of 4 mm diameter. Each crop divider consists of three GI wires of length 260 mm, 195 mm and 100mm respectively. The two long wires are extending from the base of the two MS rods. The MS rods are used for providing a spring action for guiding and gathering the fruit along with some leaves, to the holder. Plate 3.5 shows the brush cutter with the holder attachment.

Plate 3.5 Brush cutter with holder attachment

3.6 PERFORMANCE EVALUATION

The designed attachment was tested for its functional performance at Aralam Farm, Kannur district. The details of the field are given in table 3.2.

Table 3.2 Details of the field

Sl. No	Particulars	Details
1	Location	Aralam Farm, Kannur, Kerala
2	Longitude and latitude	75.77^0 E 11.95^0 N
3	Test date	28^{th} December 2015
4	Crop variety	Mauritius
5	Area under cultivation	162 ha
6	Plant spacing	450 mm
7	Row spacing	450 mm
8	Year of planting	First

3.6.1 Performance parameters

Machine parameters namely time of operation, fuel consumption, angle of inclination of the attachment and the position of the attachment on the square plate influence the harvesting operation. These parameters were to be optimized to achieve the harvesting. Hence time of operation, fuel consumption and angle of inclination of the attachment were selected as the parameters to be recorded during performance evaluation.

3.6.1.1 Time of operation

The time required for harvesting 15 number of fruits was noted. Time taken for the operator to move from one fruit to another, operator's rest time was also accounted. From this the time required for harvesting 1 ha was estimated.

3.6.1.2 Fuel consumption

The fuel consumption changes with respect to time operation. The fuel tank was filled before starting the operation. After operating for a particular time

the tank is again filled and the quantity of fuel required to fill was recorded. The fuel consumption per harvesting unit area was estimated from these recorded data.

3.6.1.3 Angle of inclination of the attachment

An optimum angle of inclination is required for the proper harvesting of the pineapple fruit. Otherwise no proper conveyance of the fruit into the attachment takes place. The inclination was not fixed initially, but provision for altering this was provided at the time of initial fabrication.

3.6.1..4 Position of the attachment

For proper harvesting of the fruit, the position of the harvesting attachment on the square plate has to be adjusted. Otherwise no harvesting may occur.

3.7 OPERATIONAL PROCEDURE

The attachment is mounted on the brush cutter. The crop guides will gather the fruit stem along with some leaves into the centre portion of the base plate. As the operator moves towards the crop, the crop dividers due to its spring action will expand and allow the fruits and leaves to enter into the attachment. When the dividers starts gathering the blade is operated and the blade cut the fruit stem along with some leaves. Due to the inclination provided fruit will fall to the welded mesh and is supported by the base plate. After harvesting one plant the fruit is safely dropped to the side by lowering the whole unit. Then the process is repeated for further harvesting.

RESULTS AND DISCUSSIONS

CHAPTER IV

RESULTS AND DISCUSSIONS

The crop and fruit properties measured at field, which will influence the design of a mechanical harvesting system, are discussed in the chapter. The result of the performance evaluation of developed model is also presented.

4.1 CULTIVATION PRACTICES AND BIOMETRIC PROPERTIES OF PINEAPPLE PLANT AND FRUIT

The common cultivation practices followed in Kerala and the biometric property of the variety commonly planted in the state are discussed in the following subsections.

4.1.1 Cultivation practices

The common variety of pineapple cultivated in Kerala is a mid-season variety of the Queen group, Mauritius. Plate 4.1 shows Mauritius variety of pineapple. It is having a medium size and the fruits are deep yellow. Fruits are oblong, fibrous and with a medium sweetness. This is suitable for table cultivation. Contour planting is adopted in sloppy areas. The usual cultivation practice adopted in Kerala is paired rows. The details of this cultivation practice are given in table 4.1. Plate 4.2 shows the cultivation practice of pineapple in Kerala.

Plate 4.1 Mauritius variety of pineapple

Table 4.1 Cultivation practices

Sl. No	Particulars	Details
1	Row to row spacing, cm	45
2	Spacing between beds, cm	150
3	Plant population per ha	19800 - 22230
4	Yield taken from one plant before replanting	3
5	Replanting period, years	3

Plate 4.2 Cultivation of pineapple

4.1.2 Intercultural operations

Pineapple plants are prone to lodging due to its shallow root system and weak stem. Hence earthing up is necessary. It is done by pushing soil to the base of the plant from the periphery or into the trench from the ridge. The weeding operations are usually done manually. Dried leaves such as that of coconut, uprooted weeds and grasses are kept over the fruit for the protection from scorching of sun during summer season.

For the uniform flowering of plants 25 ppm ethephon hormone is applied on mature plants having 39 - 42 leaves (7 - 8 months after planting) at a rate of 1.25 ml ethephon solution,1 kg of urea and 20 g calcium carbonate in 50 l of water for 1000 plants. After 30 days of growth regulator application, flowering

starts and completes within 40 days. Within 130-135 days after the application of growth regulator, fruits will be ready for harvesting.

4.1.2 Biometric properties

4.1.2.1 Crop

The various biometric properties related to pineapple plant are presented in the table 4.2

Table 4.2 Biometric properties of crop

	Year of harvesting	**Minimum**	**Maximum**	**Average**
Foliar coverage (m)	1st	1.1	1.25	1.175
	2nd	1.2	1.3	1.25
	3rd	1.42	1.5	1.46
No. of leaves	1st	38	42	40
	2nd	43	45	44
	3rd	44	46	45
Plant height (m)	1st	0.7	0.8	0.75
	2nd	1.05	1.2	1.125
	3rd	1.2	1.3	1.25
Distance of fruit from ground (m)	1st	0.21	0.3	0.225
	2nd	0.23	0.29	0.26
	3rd	0.28	0.35	0.315
Diameter of stem (m)	1st	0.025	0.033	0.029
	2nd	0.020	0.024	0.022
	3rd	0.023	0.030	0.0265

It is observed from the table 4.2 that the foliar coverage of the crop is increasing from 1st year to 3rd year. The number of leaves in a mature plant ranges from 40 to 46. The plant height is increasing with the year. The distance of fruit from ground ranges from 0.2 to 0.35 m. The average stem diameter is about 0.025 m.

4.1.2.2 *Fruit*

The various biometric properties related to pineapple fruit are presented in the table 4.3

Table 4.3 Biometric properties of fruit

Physical property	Year of harvesting	Minimum	Maximum	Average
Weight (kg)	1st	1.1	1.5	1.3
	2nd	0.9	1.0	0.95
	3rd	0.82	0.89	0.855
Height (mm)	1st	400	450	425
	2nd	350	355	352.5
	3rd	290	300	295
Diameter (mm)	1st	100	120	110
	2nd	104	110	107
	3rd	102	110	106

It is observed from the table 4.3 that the average weight of fruit is 1 kg. The height of the fruit ranges between 300 to 400 mm. The diameter ranges between 100 to 110 mm

4.2 PERFORMANCE PARAMETERS

4.2.1 Angle of inclination of the attachment

It is observed that when the angle of inclination was 30 degrees, fruit was not conveyed properly to the attachment. When it was reduced to 15 degrees proper harvesting occurred.

4.2.2 Position of the attachment

The proper harvesting was achieved when the attachment is fitted in the second set of holes. The distance between the extreme end of the cutting blade and centre of the holder was measured as 60 mm for proper harvesting of the fruit.

4.2.3 Time of operation

Table 4.4 Time of operation

Average time taken for harvesting 15 plants	225 sec
Average time taken for harvesting 1 plant	15 sec
Average time taken for harvesting one ha.	82.5 h

Based on the observations made, the estimated man hours for harvesting one ha land was 82.5 h or 11 man days. Considering the fact that the harvesting has to be finished in minimum time, it can be concluded that 11 labours are required for completing the harvesting of one ha land in one day, by using the developed unit.

4.2.4 Fuel consumption

Table 4.5 Fuel consumption

Average fuel consumption for 1 h	850 ml
Average fuel consumption for harvesting 15 plants	53.125 ml
Average fuel consumption for 1 ha.	70 l

The fuel consumption per ha is 70 l.

4.3 ECONOMICS

The detailed cost economics of machine harvesting is worked out and is compared with manual harvesting. Calculation of cost of operation per ha is given in Appendix I. Manual operation cost is given in Appendix II. Fig. 4.1 and fig. 4.2 shows the comparison of cost and time in manual and mechanical harvesting. Table 4.6 gives the economic analysis. Table 4.7 gives the savings in time and cost

Table 4.6 Economic analysis

	Manual harvesting	Mechanical harvesting
Average time taken for 15 plants (sec)	900	225
Average time taken for 1 plant (sec)	60	15
Average time taken for 1 ha. (days)	41	10

Table 4.7 Savings in time and cost

Particulars	Manual harvesting	Mechanical harvesting	Savings by using machine (%)
Time per ha. (h)	330	82.5	75
Cost per ha. (Rs.)	16500	14685	11

From the table it is clear that by adopting mechanical harvesting the time for harvesting can be saved to 75 percent cost can be saved to 11 percent.

Plate 4.3 Manual harvesting of pineapple

Plate 4.4 Mechanical harvesting of pineapple

Plate 4.5 Mechanically harvested pineapples

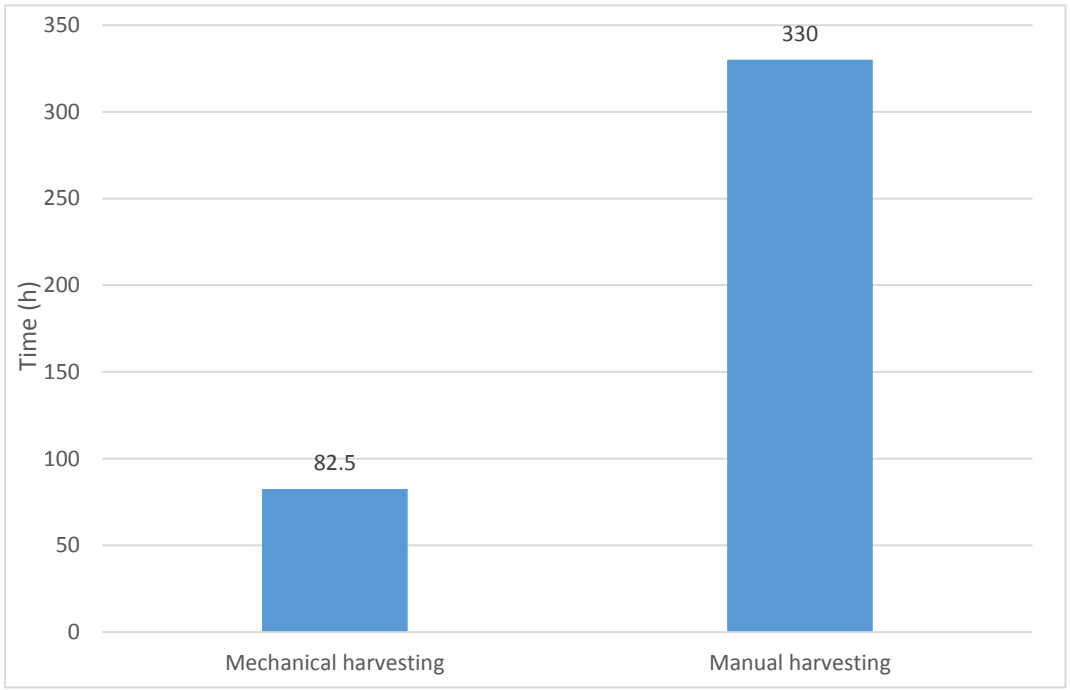

Fig.4.1 Comparison of time in mechanical and manual harvesting

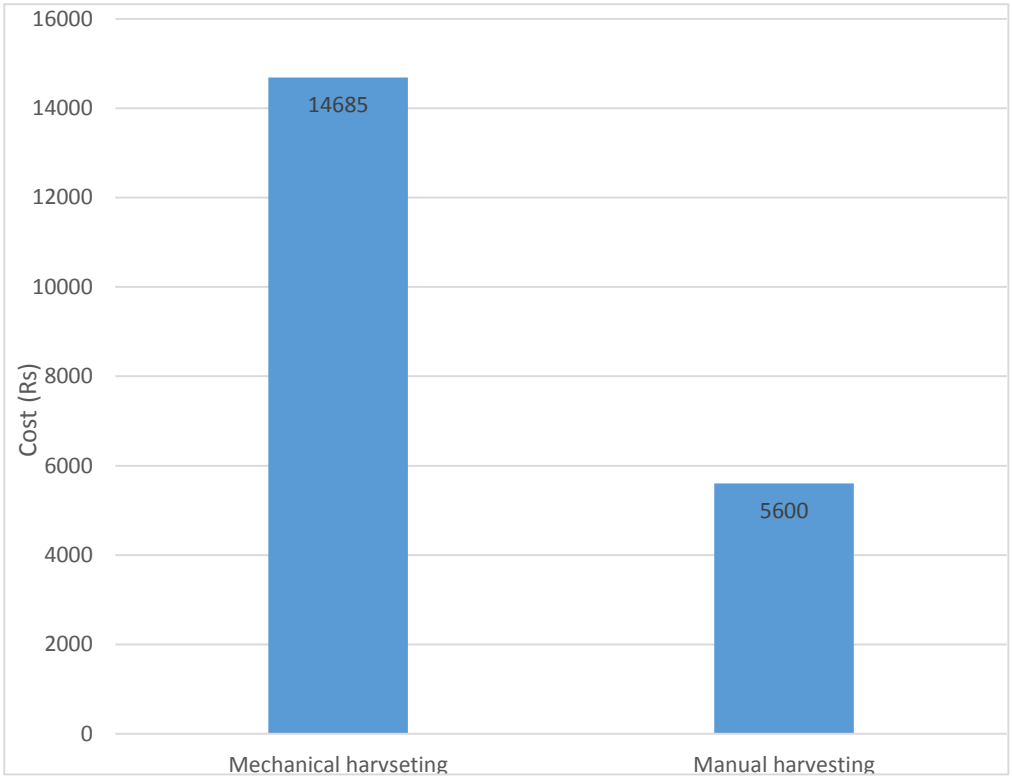

Fig.4.2 Comparison of cost in mechanical and manual harvesting

SUMMARY AND CONCLUSIONS

CHAPTER V

SUMMARY AND CONCLUSIONS

Pineapple is a tropical fruit whose world demand is increasing day by day. Pineapples are usually consumed in fresh, cooked, juiced, and preserved forms. Planting, intercultural operations and harvesting of pineapples are done manually. The harvesting of pineapple involves breaking the fruits from the plant or is done by cutting the fruit stalk by means of large knives, which is very tedious process due to the presence of sharp thorns in the leaves and is more time consuming. Hence mechanisation of pineapple harvesting is becoming inevitable. Brush cutter is a very common garden tool used now a days and it is light in weight and easy to operate. This study was undertaken to develop a pineapple harvesting attachment to brush cutter, with the following objectives.

- To study of suitability of pineapple harvesting attachment for brush cutter
- To develop a pineapple harvesting attachment for brush cutter
- To test the pineapple harvesting attachment for its functionality and to suggest optimum machine parameters for design

For achieving these objectives, a brush cutter fitted with a harvesting attachment was developed. The harvesting attachment was developed in the Machine Shop of the Kelappaji College of Agricultural Engineering and Technology, Tavanur. The attachment consists of a square plate, a rectangular flat connecting plate, a round base plate, a welded mesh cover and two crop dividers and the whole attachment is mounted vertically above the circular blade at an inclination of 15 degree with the horizontal. A MS square sheet of size 120 x 120 x 4 mm is selected as the square plate. The square plate is used for mounting the attachment on the brush cutter. A MS flat plate of size 100 x 22 x 3 mm is used as the connecting plate and it acts as a connecting member between the square plate and the base plate of attachment. A GI circular sheet of 180 mm diameter and 3 mm thickness is used as the base plate. The base plate will act as a platform for

holding the pineapple. A welded mesh of 1 inch square is used to cover 3/4th of the circumference of the base plate up to a height of 300 mm. The purpose of the welded mesh cover is to keep the fruit inside. The two crop guides are made up of GI wires of 4 mm diameter. Each crop guide consists of three GI wires of length 260 mm, 195 mm and 100mm respectively. The MS rods provide a spring action for gathering the fruit along with some leaves. For performing the harvesting operation the attachment is mounted on the brush cutter at proper position. The crop guides due to its spring action will expand and allow the fruits and leaves to enter into the attachment as the operator moves towards the crop and the blade cut the fruit stem along with some leaves. Due to the inclination provided fruit will fall to the welded mesh and is supported by the base plate. After harvesting one plant the fruit is safely dropped to the side by lowering the whole unit. Then the process is repeated for further harvesting.

The functionality test was conducted at Aralam Farm, Kannur. The results show that for the proper harvesting the angle of inclination of the holder attachment was 15 degree and the distance between the extreme end of the cutting blade and centre of the holder was measured as 60 mm. The fuel consumption per ha is 70 l. The cost of harvesting is Rs. 178 per h. The estimated man hours for harvesting one ha land was 82.5 h or 11 man days ie, 11 labours are required for completing the harvesting of one ha land in one day. Therefore by adopting mechanical harvesting the time for harvesting can be saved to 75% and cost can be saved to 11%. The long handle of brush cutter permits the distant operation. By the tilting of the machine the pruning can also be done.

APPENDICES

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Appendix I

Cost analysis of the brush cutter with the pineapple harvesting attachment.

Brush cutter (Oleo – Mac 740 T)

A. Basic information

(i) Cost of the brush cutter including the holder attachment, Rs : 21000

(ii) Useful life, year : 5

(iii) Hours of use per year : 1000

(iv) No. of skilled labour required : 1

(v) Rate of interest : 10%

(vi) Salvage value

(10% of investment cost) : 2100

(vii) Fuel requirement, l h^{-1} : 0.85

B. Various costs

I. Fixed cost

(i) Depreciation cost per year, Rs : $\frac{\text{Initial cost} - \text{Salvage value}}{\text{Useful life}}$

: $\frac{21000 - 2100}{5}$

: 3780

(ii) Interest on investment per year, Rs :

$\frac{(\text{Cost of brush cutter} + \text{Salvage vqalue})}{2}$ x Interest rate

: $\frac{(21000 + 2100)}{2}$ X 0.10

: 1155

(iii) Taxes, insurance and shelter per year, Rs : Cost of brush cutter x 0.02

: 21000 x 0.02

: 420

(iv) Total fixed cost per year, Rs : 3780+115+420

: 5355

(v) Total fixed cost per hour, Rs : $\frac{\text{Totalfixedcostperyear, Rs}}{\text{Hoursofuseperyear}}$

: $\frac{5355}{1000}$

: 5.355

II. Variable cost

(i) Repair and maintenance per hour, Rs : $\frac{\text{Costofbrushcutterx 0.05}}{1000}$

: 1.05

(ii) Fuel cost per hour, Rs : Fuel requirement x Rate of fuel

: 0.85 x 70

: 59.5

(iii) Cost of lubricant per hour, Rs : Fuel cost x 0.02

: 59.5 x 0.2

: 11.9

(iv) Labour cost per hour, Rs : 100

(v) Total variable cost per hour, Rs : 1.05 + 59.5 + 11.9 + 100

: 172.45

III. Total cost per hour, Rs : Fixed cost + Variable cost

: 5.355 + 172.45

: 177.805

Rounded to the value, Rs : 178

Appendix II

Time required for harvesting 1 ha. (h)	: 330
No. of labours required for harvesting one ha in one day	: 41
Labour cost, Rs.	: 400 (each)
Total labour cost, Rs.	: 41 x 400
	: 16500

DEVELOPMENT OF PINEAPPLE HARVESTING ATTACHMENT FOR BRUSH CUTTER

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ABSTRACT

Submitted in partial fulfillment of the requirement for the degree of

Bachelor of Technology

in

Agricultural Engineering

Faculty of Agricultural Engineering and Technology

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2016

ABSTRACT

A prototype of pineapple harvester as an attachment for brush cutter was developed. The cutting element of the brush cutter used was circular blade. The attachment consists of a square plate, a rectangular flat connecting plate, a round base plate, a welded mesh cover and two crop guides and the whole attachment is mounted vertically above the round blade at an inclination of 15 degree with the horizontal. The square plate is used for mounting the attachment on the brush cutter. A flat plate is used as the connecting plate and it acts as a connecting member between the square plate and the base plate of attachment. A circular sheet is used as the base plate. The base plate will act as a platform for holding the pineapple. A welded mesh is used to cover 3/4th of the circumference of the base plate up. The purpose of the welded mesh cover is to keep the fruit inside. Each of the two crop guides consist of three GI wires. The crop guides provide a spring action for gathering the fruit along with some leaves. The fuel consumption per ha is 70 l. The cost of harvesting is Rs. 178 per h. It is estimated that by the adoption of mechanical harvesting 11 labours are required for completing the harvesting of one ha land in one day. Hence time for harvesting can be saved to 75 % and cost to 11% compared to manual harvesting. The difficulties in manual harvesting can also be reduced since the harvesting operation is done from a distance.