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Design and Development of Groundnut Harvesting (Threshing) Attachment

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Abstract

Groundnut harvesting is a crucial aspect of farming, traditionally carried out manually by farmers. However, advancements in technology present an opportunity to develop machinery that can streamline and enhance the process. To meet this demand, a new groundnut harvesting product has been designed, taking into consideration various parameters such as customer needs, product size, mechanism type, ergonomics, spare parts availability in rural areas, and field performance. To identify the specific requirements for groundnut production, a comprehensive study was conducted, involving interviews with approximately 300 farmers. Statistical analysis and experimental data were used to make assumptions, and a Chi-square value was calculated using cattle livestock as a factor. The resulting probability values were compared to expected frequencies. After analyzing the data, it was found that the degrees of freedom and level of significance from the chi-square value table indicated α >0.05. This indicates that there is a significant correlation between the category of farmers and the availability of cattle livestock. In summary. Likert scale is used to evaluate the facilities, like labor availability, machinery and wages paid during cultivation season is analyzed. And also prepared the Product Design Specification for develop the product. Based on these findings, three concepts were generated and created in 3D virtual models. The final concept was selected using the PUGH matrix method, and the resulting product consists of a wheelbase, engine, belt and chain drives, and handles are the important parts to develop the new concept.

Keywords: Groundnut harvesting, Threshing, Groundnut secondary harvesting, Pod removal, Mechanisation

1. Introduction

Groundnut, also known as peanuts, belongs to the legume or "bean" family. It is believed to have been first domesticated and cultivated in the valleys of Paraguay. India holds the distinction of being the second largest producer of groundnuts globally. In fact, groundnut is a primary oil seed crop in India, playing a crucial role in addressing the country's vegetable oil deficit. Groundnut harvested in two-crop cycle in March and October, groundnuts are available throughout the year in India. These protein-rich crops are predominantly grown under rain-fed conditions, making them essential for the Indian agricultural landscape. Notably, the majority of farmers in India still employ traditional harvesting

methods and machinery, as they value retaining the plant for cattle over an extended period of time.In India, the use of farm power has increased significantly compared to previous years. Soil and seed bed preparation has become 40% mechanized, while harvesting and threshing have seen a 65% increase in mechanization for certain crops. However, when it comes to groundnut harvesting, the level of mechanization is still quite low. The contribution of agriculture to India's GDP is around 14%, whereas in the United States, it is only 1%. This highlights the heavy reliance on marginal and small farmers in India, who make up more than 83.3% of the farming population. Due to migration to urban areas, there is a shortage of labor in the agricultural sector, making machinery essential to compensate for this shortfall [1]. However, the increasing cost of labor in India poses a challenge for marginal and small landholders who cannot afford machinery for every farming operation. Mechanization facilities are predominantly available to large landholders.

2. Literature Review

In India, the majority of farmers (over 85 percent) are small and marginal, which poses challenges for them in terms of purchasing farming equipment and affording custom hiring services. These costs become even more burdensome during peak times [2]. To address this issue, a tractor-mounted combine harvesting and threshing machine has been developed. This machine is capable of penetrating the soil to a specified depth and efficiently digging the groundnut crop and pods. It features a specially designed collecting chamber for gathering the pods. Once the groundnut crops are harvested, the machine moves through a belt drive. In the feeding zone, a threshing cylinder is attached to separate the pods from the vines of the groundnut crop, while a blower effectively blows away dust particles and segregates the pods [3]

Mechanized methods have revolutionized farming operations by significantly reducing labor hours for ploughing, harvesting, and threshing. This has proven to be more efficient compared to traditional intercultural operations such as weeding, fertilizer application, and chemical spraying. However, it is worth noting that mechanized farms require additional labor compared to traditional farms. This consideration is particularly important in Bangladesh, where more than eighty percent of the population resides in rural areas. In recent years, many people have transitioned from using draft power to power tillers in their agricultural practices [4]. An interesting trend in groundnut production is the increasing involvement of women workers. They actively participate in various stages of the production process, including weeding, harvesting, processing, storage, and marketing. This demonstrates the significant contributions made by women in this sector. In Nigeria, a majority of farmers operate on small-scale farms, with around 85 percent having a farm size of less than two hectares. To enhance productivity, it is crucial to focus on employing improved varieties, utilizing bio pesticides, adopting efficient harvesting methods, and implementing effective processing techniques [5].

The tractor-mounted digger cum shaker attachment is specifically designed for groundnut crops. With a total frame size of 2000 mm and 460mm, and a cutting width of 1200mm, it offers optimal coverage and efficiency. Operating at an average speed of 3.8km/h, it can dig to an average depth of 12 cm.By utilizing this machine, the labor requirement, harvesting time, and costs can be significantly reduced. Compared to other machines, the count of damaged and buried pods is considerably lower as the

groundnut pod region is typically found at an average depth of 10cm. This results in an average loss rate of only 10 percent, while improving digging efficiency to 90 percent. Sources: [6][7]

Groundnut farming can be quite labor-intensive and expensive when it comes to harvesting. However, there is a solution that can significantly reduce both the time and cost involved, while also increasing profits. By utilizing solar-powered harvesting machines, farmers can enjoy a more efficient and cost-effective process. Not only does this method save on expenses, but it also yields higher profits compared to traditional petrol or diesel engines. This groundbreaking innovation has been studied and confirmed by experts [8]

3. Material and Methods

Study Area : The data was collected from Chitradurga and Tumkur districts of India, which is located in the central dryzone of Karnataka. This is located between 760 34’49.86”E to 760 51’ 32.13”E and 140 14’13.63”N to 140 30’28.30” The temperature in these areas varies from 170C to 430C depending on the seasons. The rain fall ranges between 453.5 and 717.7 mm and found to be maximum during Kharif season. The soil is sandy loam and red in major areas and remaining areas are deep black. The main crops grown in these areas are Groundnut, Ragi, Jowar and vegetables.

Ethnography study:

Based on government guidelines, the collected research data has been categorized into five groups: marginal, small, semi-medium, medium, and large farmers. A sample size of approximately 300 farmers was collected, and the results revealed that the majority of farmers were classified as marginal or small farmers.It was observed that in the central dry zone of Karnataka, over 90% of farmers still rely on traditional methods of harvesting for groundnuts production.

Traditional method : To remove the groundnut from plant from the field to store at one place for 10 to 15days, during that moisture is dried and then harvest the groundnut manually. For this need more labour for harvesting the groundnut. Approximately 5 to 7 labour required for one acre of groundnut. This process is more tedious and time consuming. About 70-80 % of the farmers harvesting the groundnut traditional method. In traditional method harvest completely this plant food for cattle. Mainly Small and medium land holders prepared this method as shown below figure 1.1

Figure 1.1 Groundnut harvesting traditional method (pod removal)

Mechanized method: About 20 to 30% of the farmers preparing mechanized method of harvesting. Due to labour problem in rural area, large land holders are preparing mechanized method of harvesting. In mechanised method of harvesting 10 to 20 % of the groundnut retain in the plant and plant also broken in to small pieces. The broken pieces of plant can't retain for long duration. Because of this many farmers use the traditional method of harvesting as shown in figure 1.2

Figure 1.2 Field visit data of Mechanized method of harvesting

Even if farmers choose the mechanized method for Threshing 10 to 20% of the ground retain in the plant, so we need labour for segregating the groundnut. Because of this more number of farmers uses traditional way of harvesting. Another disadvantage is plant will broke into small pieces and more dust is will be generating during harvesting time. And clean the dust through natural air as shown in figure 1.2

4. Results and Discussion

Using likert scale evaluated facility scale of 1 to 5 range

Availability of machinery during cultivation season: The availability of machinery during the cultivation season is significantly lower than normal days, as rated by farmers on a scale of 1 to 5. 37% of farmers rated the availability as "Very Poor," 56% rated it as "Poor," and only 6% rated it as "Average." Demonstrate that machinery availability is severely lacking during this season.

Amount of wages paid during cultivation season for labor: The amount paid during the season is significantly higher than during normal days, as evidenced by farmers who rated it on a scale of 1 to 5. An impressive 35% of the farmers rated it highly, and 50% rated it very highly, with an average score of 12%.

Amount paid during cultivation season for Machinery: The cost of machinery during the cultivation season is incredibly high due to the limited availability of machinery in rural areas. Farmers need to complete their work in a short span of two to three days, and therefore, end up paying exorbitant prices for tractors, which can range anywhere from 700 to 1000 rupees per hour. According to Figure 1.6, 60% of farmers consider these prices to be 'very high', 27% rate them as 'high', 10% think they are 'average', 2% find them 'poor', and 1% rate them as 'very poor.

Statistical Analysis of Data

The research data collected is analysed and evaluated using Chi-square method. In 1900,Karl Pearson developed chi square test and applied it to the goodness fit for frequency curve (Stigler1999).

Hypothesis test results were predicted using chi-square method: Data's were collected through field survey. The relative values were either accepted or rejected based on the standard values of hypothesis. The relative value commonly used in research was $\alpha > 0.05$ i.e., probability of deviation derived from observed and expected values. If $\alpha > 0.05$ then the deviation in probability value would be found to have more than 5% error.

The chi square value can be calculated using the equation

$$(x)^2 = \sum \frac{(O_i - E_i)^2}{E_i}$$

x^2 = Chi squared value
O_i = Observed Value
E_i= Expected value

The values obtained are analysed

Table 1.1 Chi-square and probability value of live stock

Sl No	**Farmers category**	**Sample farmers (N=300)**	**Significance value-0.05 (α = 0.05)**	**Statistical inference at (alpha = 0.05) 5% level of significance**			
				Chi square value	**Critical Value**	**Degree of freedom**	**p-value (Probability value)**
1	**Marginal farmers**	108	0.05	41.0637	31.42	20	0.003655698
2	**Small farmers**	104					
3	**Semi medium farmers**	45					
4	**Medium farmers**	37					
5	**Large farmers**	6					

Hypothesis method:

From the above table we compared the chi square value (41.0637) with the critical value (31.42) from the above table and found that the chi square value is greater than the critical value (41.0637 > 31.42). Therefore, we reject the null hypothesis and accept the alternate hypothesis.

The P-value (0.003655698) is less than the significance alpha value (0.05), which provides strong evidence to reject the null hypothesis and accept the alternative hypothesis. This result indicates that the observed data is statistically significant and supports the alternate hypothesis.

Null hypothesis H_0: It can be concluded that there is no correlation between the category of farmers and their livestock in the dry zone of Karnataka. This is evidenced by the lack of any statistical data or evidence linking the two variables. Further research is needed to better understand the dynamics of this relationship in the region.

Alternative hypothesis H_1: It is clear from this evidence that there is a strong correlation between the category of farmer and livestock ownership in the dry zone of Karnataka. This relationship is particularly important for the livelihoods of farmers in the dry zone, as livestock provides a much-needed source of income and food security in these areas.

The Product Design Specification (PDS) is a comprehensive list of design parameters, specifications, and customer requirements for product design. Developed early in the design process, the PDS drives the customer needs and provides designers with detailed guidelines for their engineering activities. The aim of the PDS is to design a product that meets the needs of the end user, while also laying the foundation for future construction. By focusing on the product as the main subject of work, the PDS aims to ensure that the design work is well-defined and meets the customer's requirements [9],[10].

Product Design Specification (PDS) for Harvesting (Threshing) of groundnut (Remove the Pod from plant)

The PDS is ready to extract the pods from the plant, utilizing hoppers to place the dried plants, and blades for cutting the pods or plants that are squeezed between rubber belts. Subsequently, the pods and dust are separated using the air blower or vibration method for efficient removal. This ensures that the pods are completely removed from the plant, thus preventing any potential contamination.

Table 1.2 Product Design Specification for harvesting (Threshing) of groundnut (Remove the Pod from plant)

Sl No.	Parameter	Factors	Specifications
1		Product Name	Automated groundnut production system
2		Area of use	Indian Village
3		Target customer	Small and medium land farmers
4	**Geometry**	Maximum Size	900 x 1300 x 900 mm (LBH)
		Weight	80 Kg with attachment
		Distance between the wheel	558.8 mm
		Wheel size	Wheel Diameter: 315mm
5	**Serviceability**	Life span	10 Years
		Maintenance	Every 200 Hrs. of usage and Oil changing , cleaning and assembly fittings
		Quality	Durable, low cost maintenance
6	**Usability**	Ergonomics	Design with reachable controls and Accessibility
		Features	Main Body and Post Harvesting with attachment (remove the pod from plant)
7	**Safety**	The product must be safe for the operator	Design with no sharp edges and considering Low accident risk for the operator

8	**Technical Specification**	Motor Specifications	1.26 HP , 4-Stroke Air-Cooled, single cylinder
		Power	3600 RPM
		Displacement:	198cc
		Fuel type	Petrol
		Fuel Tank capacity	3.5 Litres
		Type of mechanism	Belt drive and chain drive
		Type of mechanism	Belt
		Feeding method	Manual, hopper
		Remove the pod	Cutting Blade
		Method of remove the pod (Threshing)	Rotating method, Hitting by rubber belt
		Method of segregating the plant and pod	Vibration , Air blower
9	**Manufacturing Method**	Manufacturing of product	Metal Components , Fabrication, standard parts (Machining process, sheet metal stampings)
			Plastic Components, (Injection Mould)
10	**Materials**	Rigid Materials used	Structural frame , MS Angle. Attachment part sheet metal Handle : Steel
11	**Efficiency**	Capacity	Two to three hectare of plant per day
12	**Cost**	The device is economical	INR 40,000 to 60,000/-
13	**Standard parts**	Available in Local Area	Fixing components like nut and bolts, washer , diesel motor and Inserts replace very quickly,

Power requirement for product

Horsepower is a critical factor for any agricultural machinery and equipment. When horsepower is too low, slippage, overloading and an inability to complete the work within the set timeframe can occur, leading to increased operational costs. Horsepower depends on the type of land and the operations being performed, and can vary drastically according to soil conditions, moisture levels, and the gradient of the land. Most tractors, tillers and other equipment are rated according to their maximum observed Power Take Off (PTO) power. However, due to slippage, overload and other factors, the PTO power can drop to 10-15%, while the DrawBar Horse Power (DBHP) can drop to as low as 62.5% on firm soil, 55% on tilled soil, and 47.5% on loose soil (as reported by Robert G. White) [11],[12]

Requirement of power calculations

A single groundnut plant contains 15 to 30 pod
Length of groundnut root = 30 mm
Length of groundnut = 20 mm

Width of groundnut = 10 mm
Specification of Drum
Length of the drum = 600 mm
Drum diameter = 300 mm

Torque, T = Force x Perpendicular distance

Force, F = 300 N (Approx) from ref (Rajasekar.M)
The Perpendicular distance is the distance among the shaft axis and the drum surface is 150 mm
Torque, T = 300 x 150 = 45000 Nm.
Torque, T = 45 Nm

Power calculation

Power, P = 2 π N T / 60
Speed required N = 200 rpm (approx., this will varies)
P = (2 x π x 200 x 45) / 60
P = 942 W
P = 1.26 HP
The horse power required operate the harvesting machine is **1.26 HP**

Concept of Base Product: After conducting a detailed survey, generated innovative concepts to effectively remove groundnuts from the ground. Developing the walking tiller that combination of belt and chain drives with an engine, wheels, and handle. This product is illustrated in Figure 1.3, Designed main base product and various attachments to helpsto remove groundnut plants from the ground.

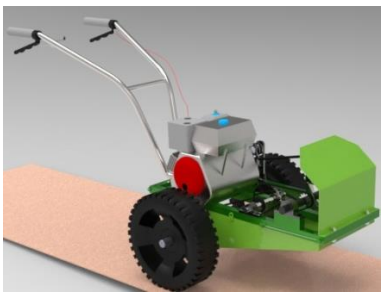

Figure 1.3 Main base walking tiller

Concept- Groundnut Harvesting (Threshing)

Groundnut harvesting, also known as threshing, is a crucial step in agriculture that plays a vital role in achieving a bountiful and top-notch crop yield. It entails the careful removal of mature nuts from the plant. By executing the harvesting process promptly and employing proper threshing techniques, farmers can optimize their yields and guarantee the utmost quality of their crops. With the integration of innovative concepts, groundnut harvesting and threshing can become a highly productive and profitable venture, paving the way for a better future in this field.

Concept-1 Groundnut harvesting (threshing)

The first concept involves attaching a threshing attachment to a walking tiller. This attachment is equipped with rubber belts and cylindrical rubber strips that are evenly spaced apart. When a groundnut

plant bunch is fed into the threshing zone and the rotating belts are activated, they efficiently remove the pods from the plant. These innovative concepts make groundnut threshing easier and more efficient, saving time and money in the cultivation process. The Figure illustrates the connectivity of the driving system from the engine to the harvesting machine. The pods fall into a tray mounted on a tapper and then move to the next tray due to gravity. The cam mechanism is connected to the bottom tray, causing it to vibrate in a to-and-fro motion, facilitating the downward movement of the pods. Elongated holes are provided in the tray to allow any gravel, dust, stones, or high-density material to fall below. The groundnut pods are collected at the outside of the machine, and this system can cover around 1-1.5 acres of groundnut land. This system reduces time consumption and productivity costs when compared to manual harvesting, providing an efficient and economical solution as shown in figure 1.4.

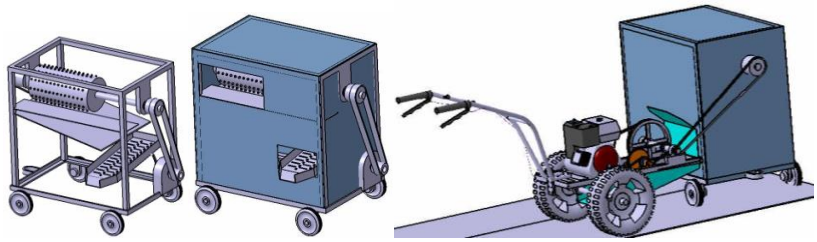

Figure 1.4 Concept-1 harvesting (threshing) attachments for groundnut

Concept-2 Groundnut harvesting

The Concept 2 design differs slightly from the Concept 1, as depicted in the figure below. In this new design, an external power source is connected to the walking tiller base through a belt drive. The revolving shaft assembly supports the cylindrical hub, which plays a crucial role in harvesting and bundling groundnut plants. These plants are gathered into bunches, with the root at one end and the leaves at the other. By placing the freshly harvested groundnut plant bunches against the reciprocating cylindrical hub mechanism, the root end is swiftly removed, causing the groundnut pods to effortlessly drop into the tray. This innovative design enables fast and efficient groundnut harvesting. Enhancing the groundnut harvesting experience, our Tray Fan System offers a superior alternative to manual methods. By connecting one end of the tray fan system, the fan generates air pressure, which effectively blows away lightweight and low-density materials. This leaves behind only the high-density groundnut pods, which conveniently fall onto the screening tray and seamlessly roll down to the outlet. Additionally, this advanced system incorporates small holes to ensure optimal functionality as shown in figure 1.5.

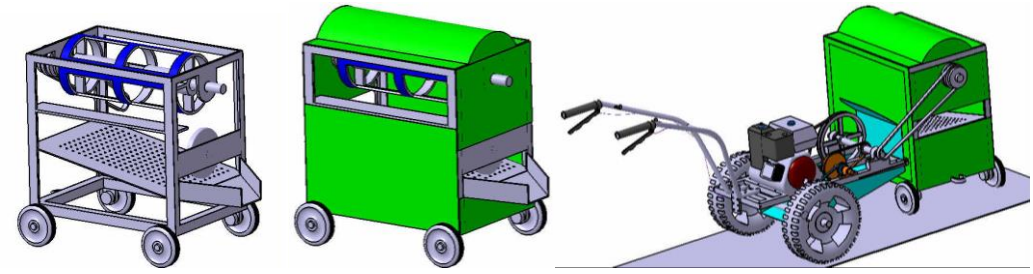

Figure 1.5 Concept-2 harvesting (threshing) attachments for groundnut

Concept-3 Groundnut harvesting (threshing)

The Concept 3 stands out from Concept 1 and Concept 2 with its unique design and functionality, as illustrated in the figure below. It incorporates an external power source and utilizes a walking tiller base with a belt drive for efficient assembly.Key design elements of Concept 3 include two cylindrical hubs mounted on revolving shafts, with "C" shaped strips inserted in series around the cylinders. As groundnuts are introduced into the hopper, they are guided between the rotating cylinders, where the strips effectively remove the pods. The pods and plant material then pass beneath the screening tray, which offers ample space to keep the pods intact. With the help of gravity, the pods and plant material descend into the tray, which is equipped with four blades and an additional shaft. In the second stage, any remaining pods from the previous stage are eliminated. A tapered screening mechanism is integrated to facilitate the downward movement of the pods and plants. To enhance the efficiency of the separation process, a fan system is strategically positioned in the middle of the tray. This system generates air pressure, effectively blowing away lightweight and low-density particles. With its innovative features, the Concept 3 offers improved performance and precision in separating groundnuts from their pods, making it an ideal choice for efficient agricultural operations as shown in figure 1.6.

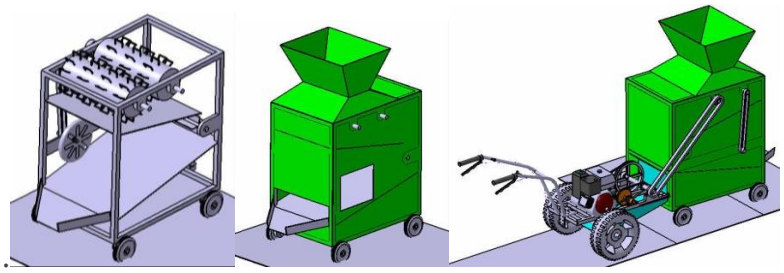

Figure 1.6 Concept-3 harvesting (threshing) attachments for groundnut

Concept Selection of groundnut harvesting (pod removal) equipment

Table 1.3 Concept selection groundnut harvesting (pod removal) equipment

Criteria	Datum	Concept-1	Concept-2	Concept-3
				
Compact	0	+1	+1	+1
Less maintenance	0	+1	+1	+1
Easy assembly and disassembly	0	0	+1	0
Cost of Product	0	+1	+1	0
Damage of husk	0	+1	+1	+1
Easy of use	0	+1	+1	+1
Availability of spare parts	0	+1	+1	+1
Ergonomics	0	+1	+1	0
Screening of pod	0	+1	+1	+1

Damage of Plant	0	+1	+1	-1
Total Score		9	10	5
Rank		II	**I**	III

Based on above parameter concept 2 is selected and very efficient and user-friendly for users
Final concept of groundnut harvesting

Figure 1.7Rendered model of final concept of harvesting (threshing) attachments

5. Conclusion

Harvesting is a crucial aspect of farming, traditionally performed manually by farmers. However, with the growing demand for food and sustainable practices, it is imperative to adopt new techniques that enhance crop production. The selection of the most suitable harvesting method is essential. To address this need, three concepts were developed and evaluated using the PUGH matrix. The best concept was then customized to cater to the needs of small and medium-scale farmers. This innovative harvesting attachment not only reduces costs but also saves valuable time compared to the manual method. Extensive research has shown that it is highly cost-effective, efficient, and beneficial for small and medium-scale farmers. If manufacture the final concepts fulfill the user needs and very efficient.

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