DESIGN, DEVELOPMENT AND TESTING OF WALK BEHIND GROUNDNUT PODS PICKING MACHINE

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by

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CERTIFICATION

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Supervisor: ___________________________

Dr. Zia-Ul-Haq

Dedicated

to

Almighty Allah Subhanautalla

And Syedina RasoolAllah

(sallallahu alaihi wa'alaihe wasallam)

And

to our beloved parents

(Whose Contributions are Unforgettable

For Us)

CONTENTS

ABBREVIATIONS

%	Percentage
Km/h	Kilometer per hour
S_1	Speed 1
S_2	Speed 2
S_3	Speed 3
CPP	Collected Pods Percentage
DP	Damage Pods
LOP	Left out pods
FE	Field Efficiency
m^2	Meter square
MT	Million Tones

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EHTISHAM ALI

ABSTRACT

Groundnut (Arachis hypogaea) holds significant importance as an oil seed and cash crop. Its cultivation primarily takes place in the sandy loam soil of the Pothwar region. The major problem faced by groundnut growers is their post-harvest losses. After harvesting, farmers simply pick the groundnut by hand and separate it from its shell. The output of this method is very low and does not fulfill the market demand. Completely picking up all the groundnut pods from the soil is not possible as it is costly and also a time-consuming job. Groundnut growers demand manual pods picking machines suitable for existing local farming systems. The development of this manual groundnut pod-picking machine offers a promising solution to address the challenges faced by groundnut growers in terms of efficiency and post-harvest losses. The groundnut pods picking machine stands out as an optimal solution for groundnut farming, showcasing its excellence through a recommended speed of 2.5 km/h, which ensures optimal performance with an impressive field efficiency of 85% and a collected pods percentage of 73%. The machine's simplicity, affordability, and ergonomic design make it suitable for adoption by small-scale farmers in various agricultural sectors.

Keywords: Groundnut picking; Pods Collection; Left-Over Pods; Damaged Pods

CHAPTER 1
INTRODUCTION

Agriculture is the backbone of Pakistan's economy. Over two-thirds of Pakistan's population is rural and their work generally relies upon farming. Groundnut is the most important cash crop in the country's Pothwar region. Groundnut crop area is 81.5 thousand hectares, with a yearly production of 91.4 thousand tons and an average dry pod yield of 1121 kg per hectare (Raza et al, 2017).

Many countries use groundnut oil as edible, and its residue (oilseed cake) is used as animal feed. The world's largest groundnut-growing region is Asia which contributes 67% of worldwide production. India has the largest acreage 6.7 million ha China is second with a 4.7 million ha area for groundnut production. Over the past two decades, Asia's harvested area has significantly increased, primarily in China, Hong Kong, Japan, Korea, and Taiwan (Nayak et al., 2021).

Groundnut kernel contains fats, proteins, and carbohydrates, and generally, their percentage depends on the groundnut variety. Usually, groundnut kernel contains 36- 54% fat, 16-36% protein, and 10- 20% carbohydrates. It is cultivated on around 24 million hectares producing 38 million tons (MT) of groundnut annually around the world (Konate et al., 2020).

Worldwide groundnut is one of the widely grown oilseed crops in more than 100 countries. Agro-climate, a variety of soil types, and water all affect groundnut products. Groundnut needs an average of 400 to 500 mm of water to reach the level of full maturity. To achieve good yield rainfall ranges between 400 and 600 mm and evenly distributed throughout the entire *Kharif* growth season is required (Patel et al., 2019).

Groundnut is grown in different soil types and climatic situations. In groundnut production sunlight and temperature are directly involved in several phonological phenomena (Omar et al., 2018).

In Pakistan, groundnut is the major cash crop in the *Pothwar* region of Punjab Province. In this region, the main source of revenue for these farmers comes from groundnut production. Groundnut is grown over 0.106 million hectares with almost 77.6 thousand tons of production. In Pakistan, the average yield of groundnut is almost 0.88 tons/ha (Asghar et al., 2014).

There are a lot of other suitable areas that can be utilized to enhance the country's groundnut production. One suitable location is the *Thal* region, which has a subtropical climate and dry climatic conditions. Although this area receives 250mm of rainfall annually, supplemental irrigation may be supplied to fulfill the moisture deficiency. Identifying new areas for the cultivation of groundnuts is urgently needed for enhancing its production. There is a considerable gap between domestic production and consumption of edible oil is there in Pakistan. Unfortunately, the production of oilseed crops (apart from cottonseed) is restricted by small farmers due to their low yield (Ijaz et al., 2021).

Traditionally, pods have to be picked manually by farm workers**.** In Pakistan, groundnut is mostly grown in the *Pothwar* region of the Punjab Province. On average production of groundnut is lower than its potential level of production. Its low production per unit area is caused due to many factors. These factors directly affect the productivity of crops. However, the majority of farmers in the *Pothwar* region pay attention to growing the local varieties of groundnut. Farmers are unaware of the improved and hybrid varieties of groundnut. This lack of awareness and shortage of improved varieties of groundnut are the key barriers to low production of groundnut in *Pothwar* (Hussain et al., 2020).

A significant number of leftover pods remain in the field as post-harvest losses. Harvesting with a groundnut digger contains picking the groundnut plant/vine from the soil. The harvesting process is completed in bright sunshine so that pods attached to vines may be dried thoroughly in the field. Traditionally, methods of groundnut harvesting are manually uprooting groundnut pods from the soil and tractor-drawn groundnut digger. To reduce the leftover pod losses digging and picking are the two steps involved in groundnut harvesting. After the crop gets the proper maturity, the harvesting process is carried out accompanied by threshing operations after a period of field drying. Machine harvesting has shown better results in enhanced production of groundnut. However, in Pakistan about 84% of Pakistan's groundnut area lies in Punjab, 13% is in Khyber Pakhtunkhwa (KPK) and 3% is in Sindh (Shah et al., 2012).

Groundnut harvesting at the appropriate time is important for better production of crops. It is also essential for the availability of fields for the next crop (wheat) sowing at the appropriate time. However, too early harvesting causes shrinkage in immature which decreases the yield. Separating and cleaning groundnut pods from the soil is considered to be the most important post-harvest process. The cultivation of groundnut typically relies on well-drained sandy loamy soil due to two primary factors. Firstly, the soft texture of sandy loamy soil facilitates easy penetration of needles into the ground following germination, while also minimizing losses of pods during the harvesting process. Secondly, both soil moisture content and the forward speed of tractors have a notable influence on the operation of groundnut pod-picking machines. Soil moisture content plays a pivotal role in determining the efficiency of the picking process. Commonly, the bunch-type groundnut varieties are sown 30 cm apart and the depth of the ripen pod ranges from 8-10 cm around the plant in a circular shape. Normal groundnut crop height is 20-25 cm above the surface of the ground. In all varieties, the maturity of the groundnut crop is typically expected to take place 100- 120 days after sowing (Yadav, 2020).

The post-harvest losses of leftover groundnut pods in the field may be up to 10-30%, depending upon the soil, crop types, and climatic conditions. Farmers are facing difficulties in collecting leftover groundnut pods after harvesting from the field which is generally picked up manually by farm workers. Complete picking up all the groundnut pods from the soil is not possible as manual labor is scarce, other means are not available and sometimes there is a shortage of farm workers in the market during peak harvesting season. This manual method is costly, hazardous time-consuming. This method is a hectic job and hazardous to human health being dirty while working with the soil. In this method, all the leftover pods could not be collected and these pods germinate in the field during favorable climatic conditions disturbing the sowing geometry of the next (groundnut) crop. Late manual picking does not allow the farmers to sow the wheat in winter as well. Keeping in view the above-mentioned problem, an experiment was designed to test the feasibility of the tractor-mounted groundnut pod-picking machine in the *Pothwar* region (Noronha et al., 2018).

CHAPTER 2

LITERATURE REVIEW

In this chapter, a review of related research work interconnected with the current study conducted by several scientists is presented. It is accessible and summarized under the following headings.

Groundnut, also known as peanuts, is a highly nutritious crop that offers various health benefits. It is a rich source of protein, and essential vitamins like vitamin E, and provides energy through its oils, fats, and dietary fiber. Moreover, groundnuts contain a variety of important nutrients and minerals such as Potassium (K), Sodium (Na), Calcium (Ca), Manganese (Mn), Iron (Fe), and Zinc (Zn) (Ojiewo et al., 2020).

For successful groundnut cultivation, it is typically grown during the summer season, and it takes approximately 120-140 days from sowing to reach maturity before harvesting. However, to ensure optimal crop growth and an improved harvest system for groundnuts, certain measures need to be taken. These include enhancing the production area, reducing costs, and adopting improved agricultural technologies. By implementing these steps, farmers can achieve better yields and enhance the overall quality of groundnut crops (Zerbato et al., 2014).

Groundnut shells are used in the production of plastic wallboards, abrasives, and fuel. They are additionally used to make cellulose (utilized in rayon and paper) and adhesive (stick). Groundnut shells are utilized to make animal feed. The protein cake (oil cake supper) buildup from oil preparation is utilized as an animal feed. Groundnut can be utilized as vegetables/grains to make lactose-free milk like refreshment, and nut milk. Groundnut shells are used to produce 25-30% of the total amount of legume (Kumar, 2017).

A mechanized harvesting method for groundnut is needed to maximize yield with minimum losses. Accurate weather forecasting plays a vital role in large-scale groundnut production as certain weather conditions can disrupt the harvesting process. The approach employed for harvesting groundnuts in large-scale production entails the threshing or uprooting of groundnut vines. India is the largest exporter of

Groundnut followed by Commonwealth of Independent States (CIS), North East (NE) Asia, and West Asia. However, groundnut is grown in Indonesia, the Philippines, Vietnam, Malaysia, Thailand, Ukraine, Russia, and Pakistan respectively (Palanisingh et al., 2020).

Yol (2018) stated that around 66% of the world's groundnut production is used for edible oil extraction, making it a major oilseed crop. Groundnut can be used to make non-food goods such as cleansers, medicines, beautifiers, medications, emulsions for insect control, and diesel fuel. Groundnut shells may be used as animal feed, as a crude wellspring of natural synthetics, and as hardboard in the structure exchange. Groundnuts have historically been a key food legume crop for small-scale farmers in underdeveloped countries. They currently play a considerable role in the food supply of developed areas of the world. About 25% protein and 50% oil are present in the groundnut. Groundnut one of the world's oilseed and edible oil crops is now considered a rich source for oil extraction and direct use as roasted food in the global market. Asia and Africa produce about 90% of the world's groundnut, while the semiarid tropics (SAT) areas account for 60% of production. It is one of the major sources of oilseed, along with soybean, sunflower, and palm oil, because about two-thirds of its production is utilized for oil.

The ideal soils for growing groundnuts are sandy loam and loam with good drainage. Tractor-operated implements are used for soil tillage, cutting, inversion, pulverization, and movement of the soil. About 70% of the groundnut production area is in semi-arid tropical regions with irregular and low rainfall. Rainfall is the major climatic factor impacting groundnut production. According to reports, the major factors of low average yields across the majority of Asia and Africa areas were reported to be low rainfall and longer dry spells during the crop growth period. The key challenges to the production of groundnuts are drought. As soil type and conditions have an impact on groundnut digging pods attached to the plant roots below the soil's surface, it depends on the structure and moisture content of the soil. The resistance of the pods to break is a significant aspect to identify the losses in the groundnut digging. The completion of the operation which must be carried out with the highest possible quality, trying to reduce losses, depends on the soil's textural variations related to its moisture content at the time of digging (Kumar and Stiger, 2010).

Mutungi et al. (2022) stated that groundnut pods are used in various forms, including oil, roasted, and salted groundnut, boiled or raw groundnut or as paste popularly known as groundnut (or groundnut) butter. In some regions of West Africa, the fragile leaves are utilized as a vegetable in soups. The crop's most valuable byproduct, groundnut oil, is consumed both domestically and industrially. The world's groundnut production (75%) is utilized to extract edible oil. It is mostly used in food preparation, candy items, or as butter. It is also used to make cereals, cookies, breads, candies, and salad dressings. The most popular groundnut product is groundnut butter. Groundnut is also utilized for industrial items like oils, flours, inks, lotions, lipsticks, etc. because of its high-fat content. Groundnut has been successfully used to make biodiesel in the context of biofuels.

2.1 PRODUCTION CONSTRAINTS IN GROUNDNUT

The adoption of modern agricultural technology in groundnut production is hindered by several challenges faced by the farming community. These challenges include limited availability of seeds, high prices of inputs, lack of knowledge, insufficient financial options, and pressure from pests and diseases. In underdeveloped countries, farmers often resist growing new crop varieties. The primary obstacles that restrict groundnut production include the absence of improved varieties, a lack of agricultural loans, scarcity of production tools, expensive seeds and fertilizers, drought conditions, and disease outbreaks. Furthermore, the Central-Eastern and Central-Northern regions experience shorter growing seasons which are exacerbated by unpredictable and irregular rainfall patterns, leading to drought. This situation, combined with a lack of interest in adopting new groundnut varieties, harms groundnut production. To tackle these issues, some short-duration (90-day) varieties have been introduced and promoted as potential solutions to overcome these limitations (Sinare et al., 2021).

The productivity of groundnuts is severely impacted by late sowing dates, inadequate use of inputs, and challenging environmental conditions. Groundnut cultivation requires a long, hot climate, approximately 500 mm of optimal rainfall, and temperatures ranging between 25 and 30 °C to achieve desirable yields. In the Pothwar region, groundnut production serves as a source of income for farmers. However, irregular weather patterns, including unpredictable rainfall and droughts, contribute to low production levels in the area. Farmers in the region often neglect proper input applications for the crop. Furthermore, the absence of new improved varieties of groundnuts and warm weather conditions further contribute to decreased yields. In the Chakwal district, the persistent preference of local farmers for traditional varieties, particularly the desi variety (337), significantly hampers groundnut productivity. During peak harvesting periods, there is a shortage of labor, which negatively impacts the potential yield. To address these challenges, mechanization of root crop harvesting is necessary to save time, reduce labor-intensive tasks, and lower harvest costs (Mehmood et al., 2021).

The harvesting methods employed for groundnuts also carry significance in evaluating the milling quality of the crop. In numerous developing nations, it is a common practice to allow harvested plants to undergo field drying, to reduce losses resulting from rotting, termites, and fungal growth. Manual harvesting has resulted in losses ranging from 10% to 20%, whereas automated harvesting of pods leads to losses of 3% during digging and 5% during picking. Traditionally, groundnuts have been harvested manually, which demands a considerable amount of labor in the field. The scarcity of labor results in higher cultivation costs and a time-consuming process. To overcome these challenges, it is crucial to design, develop, and implement affordable and reliable harvesting techniques. The collection of leftover pods after harvesting is one of the most essential and labor-intensive processes in groundnut cultivation. However, manual collection entails a substantial amount of labor for gathering the pods (Rathod et al., 2019).

Groundnut harvesting time is the key factor for getting better production. A dry day is the most suitable time for groundnut harvesting. Soil is in better condition for harvesting on dry and sunny days. Selecting the best time for harvesting is a difficult task for growers. Additionally, growers are facing challenges in determining the maturity peak level of crops (Prusty, 2020).

Mechanical loss, also known as "digging loss," occurs when pods remain in the soil after being separated from their stem attachment at the plant during digging. Digging losses are typically estimated to account for 8% of the overall yield, but they can rise to 40% at a time beyond optimal maturation. The economic feasibility of groundnut production depends on accurately determining groundnut maturity before digging (Rowland et al., 2006).

2.2 MECHANIZED GROUNDNUT HARVESTING

To adequately tackle the challenges and leverage the potential offered by international markets, it is essential to adopt sustainable mechanized agricultural technologies. Empirical evidence has indicated that mechanized operations substantially minimize losses in comparison to manual methods. In the context of groundnut harvesting, the utilization of a specifically designed machine is necessary to carry out essential tasks including ground digging, soil removal, and separation of pods from the main plant (Reddy, 2020).

The effective separation of soil particles from groundnut pods is accomplished by employing controlled vibrations with the aid of a specially designed belt. This belt serves the purpose of transporting the pods to a collection chamber while allowing the soil to separate and fall off through the sieves. Within the mechanized machine, a dedicated mechanism is utilized to ensure the gentle separation of pods from the soil, minimizing any potential damage. The adoption of mechanized techniques is essential for the efficient harvesting of groundnuts (Noronha et al., 2018).

The fuel consumption and operating costs of the groundnut harvester vary depending on the operating conditions, including soil type, soil moisture content, blade cutting depth, and operating speed. It has been observed that the minimum speed required for the machine to harvest one hectare in four hours is determined to be 2.11 km/h. On the other hand, the maximum speed that ensures minimal pod damage and high machine efficiency has been identified as 4 km/h. These findings highlight that the fuel consumption and operational expenses of the groundnut harvester are influenced by factors such as soil conditions and the chosen operating speed (Dhliwayo and Mushiri, 2018).

Waliyar et al. (2015) performed a power-operated groundnut decorticator and stated that it gives 94% decortications efficiency along with pretty much lower broken grain percentage (3%) and unshelled grain percentage (3%). As the maximum moisture content for the sample testing was fixed at 30% MC concerning storability aspects, the decorticating efficiency is also optimized at 30% MC withdrawing the lowest power consumption of the machine. Machines used after harvest, including threshers, dryers, and shellers, help in improving yield and speed up drying and processing. They are hence frequently linked to lower aflatoxin contamination in groundnuts.

The groundnut digger-inverter is responsible for uprooting the groundnut vine from the field, resulting in the removal of a significant portion of soil along with the inverted plants carrying pods on top. The subsequent stage involves threshing the dried plants, which entails separating the shells or pods from the stems. To facilitate the drying process, harvested groundnut plants are typically left in the field for a minimum of 5 days, taking into account prevailing weather conditions. Once the desired moisture content is reached in the pods after drying, threshing is conducted. It is generally considered suitable to thresh groundnuts with an average moisture content ranging from 14% to 20%, although some farmers opt to thresh at moisture levels as low as 6%. The picking loss rate in groundnut harvesting is influenced by factors such as the speed of the axial cylinder, the picking clearance, and the speed of the tangential cylinder in the groundnut pod collector. A combination of a tangential cylinder speed of 360 r/min, an axial cylinder speed of 425 r/min, and a picking clearance of 35 mm resulted in a non-picking loss rate of 0.52% and a damage rate of 0.75% for groundnut pods (Yang et al., 2022).

Lv et al. (2019) developed a test device for evaluating the alignment capabilities of semi-feeding groundnut combine harvester. The experimental setup comprised several components, including a conveying platform, ridge ditch, hydraulic execution system, signal detection mechanism, and signal processing and control system. The aim was to assess the effectiveness of the automatic alignment system and analyze the impact of key variables. The results of the tests revealed that certain factors significantly influenced the response time of the system, including spring preload, forward speed of the groundnut harvester, deviation distance of the digging shovel, and hydraulic system flow rate. As the spring preload and deviation distance increased, the reaction time also increased. On the other hand, as the forward speed increased, the response time gradually decreased and eventually reached a relatively constant level. The groundnut combine harvester demonstrated the capability to perform various operations such as pick-up, picking, cleaning, and collecting in a single pass, effectively reducing labor intensity and enhancing productivity.

2.3 POST-HARVEST LOSSES OF GROUNDNUT

Shortage of manual labor and rapidly increasing labor charges during groundnut harvesting season increased the importance of groundnut mechanization. Mechanical techniques involve digger, digger inverter, and thresher and pods picker machines operated with tractors. Adoption of these techniques led to reducing time and cost of operation. Additionally, mechanical harvesting of groundnut helped its growers in preparation for the field for sowing the next crop. Collecting groundnut from the soil resulted in digging losses. These losses are impacted by a variety of variables, including harvesting season, environment, crop health, maturity, machinery control, and, in particular, soil properties like moisture content and texture (Voltarelli and Santos, 2017).

Padmanathan et al. (2007) stated that groundnut pod picking is arduous, time-consuming, and labor-intensive. Uprooting by hand with hand tools or a tractor-operated digger is the most common harvesting method. In the harvesting process due to insufficient soil moisture or over-mature crops, a significant portion of groundnut pods is lost. Expanding the width of the belt conveyor from 0.45 to 0.55 m^2 demonstrated a noticeable improvement in the picking efficiency of the groundnut pod picker conveyor, increasing it from 84.15% to 99.92%. Similarly, enhancing the width of the picker blade from 400 to 1000 mm led to a substantial increase in both the picking and conveying efficiency of the picker conveyor.

Azmoodeh et al. (2014) stated that a delay in harvesting after physiological maturity might cause groundnut pod pegs to weaken, leaving many leftover pods in the soil. This loss depends upon age, condition of the plants, soil type, variety, and moisture content. The best quality of groundnut is obtained after harvesting matured pods when they have turned dark in color. When the pegs are weakened by over-maturity or premature defoliation brought in extremely hard and dry soil, heavy digging loss is unavoidable. The lowest groundnut pod loss percentage was observed at 1.8km/h forward speed at 19.9% soil moisture content. The experimental data were compared with data collected from manual harvesting. Mechanically and manually losses were 3.48% and 20.23% of all groundnut pods collected, respectively.

2.4 MECHANIZED METHOD TO REDUCE POST-HARVEST LOSSES

Bako et al. (2015) stated that after harvesting picking groundnut pods left in the field as harvesting losses is a difficult task. Farm workers pick these leftover pods manually from the soil. There are no such mechanical means available that can pick these pods with minimum losses and maximum picking efficiency. Moreover, this manual picking resulted in a time-consuming and expensive process. In developing countries, there is a very need for mechanical ways to pick groundnut pods left in the soil. This mechanical picking can reduce operational costs and time of operation.

Karthik (2018) developed a groundnut pods collector and reported that aside from three openings one on top and the other two at the bottom were closed by a cylindrical contraption. The collected pods were supplied through the top opening where a spiked cylinder was installed. The third outlet was used to dispose of the fine dust and other debris. Groundnut pods were extracted by a robotic arm from the soil and placed on a rotating drum with spikes.

Chen et al. (2018) designed the groundnut screw-type bending tooth pod picker roller. The experimental results showed that the bending teeth were divided into two parts straight part and a bending part. The length of the bending part was 35mm. The teeth height was 60 mm, the diameter of each bending tooth was 10mm, and the bending angle of the bending tooth was lower than 90° to avoid losses of the groundnut pods. During the picking process, pods mixed with soil enter the feeding mouth of the machine. The groundnut pods were in constant relative motion due to the spinning of the roller and the inter-axle difference between the rollers. They were expelled via the outlet in the same direction.

Hu et al. (2018) observed that based on the preliminary groundnut pods picking operation of the tangential cylinder and considering the reasons such as reducing the damage caused by striking and ensuring the smooth backward transportation of groundnut pods to the axial cylinder, the speed of the tangential cylinder should not be too high. The kinetic analysis of groundnut pods in the pods picking machine is that when the pods are in rotating motion along with the roller approaching the outlet with axial speed. The impact force of bending tooth and screw on groundnut pods waterfall. A little bit of fluctuation in acceleration was examined which is required for picking groundnut pods. The higher speed of the roller results in a decreasing trend in the picking rate. Groundnut picking machine should be operated keeping in view the roller speed as it has a significant impact on its picking efficiency.

Shukla et al. (2018) stated that the mainframe, digger blade, dirt-throwing roller, soil extension plate, sieve shaking unit, depth control wheel, transportation wheel, and power transmission assembly are the key parts of the tractor-mounted groundnut pod collector. The soil-cutting blade is made of a 12mm thick, 1200×100mm spring steel blade. It was welded to the dirt transporting plate's front part. To transfer the soil mass, the plate (39 × 120 ×0.2 cm) was welded to the main frame at a 35° angle. The manual and mechanized methods of pod picking were compared. Research findings concluded that the mechanical pods picking technique required less time than the traditional pods picking method. They stated that to decrease the losses during the picking of groundnut, a groundnut pod collector machine was used to pick the left-over pods from the harvested field.

2.5 SUMMARY OF LITERATURE REVIEW

The literature review revealed that a substantial percentage (20-30%) of groundnut pods was lost as post-harvest losses due to the limitations of traditional and modern harvesting methods. Manual picking of these leftover pods is challenging, costly, and time-consuming, affecting field preparation or the next crop.

Efforts to reduce losses through factors like variety selection and timely harvesting have proven insufficient. To address this gap, a locally developed tractor-mounted groundnut pod picking machine was tested in the Pothwar region of Punjab, Pakistan, to assess its feasibility and potential to minimize losses and improve efficiency for farmers.

CHAPTER 3

PROBLEM STATEMENT & OBJECTIVES

3.1 PROBLEM STATEMENT

Farmers engaged in groundnut cultivation are facing the challenging task of manually collecting residual groundnut pods left out in the soil. Due to various constraints such as labor scarcity, high costs, and limited alternatives, it is not feasible to completely retrieve all the groundnut pods from the ground. The manual method is costly too, and it consumes a lot of time hence it is a hectic job and hazardous to human health. In manual picking, there is more chance of leftover pods and these pods often germinate in the field during favorable climatic conditions. Therefore, a manual groundnut pod picking machine is developed for farmers' feasibility.

3.2 OBJECTIVES

The Project has the following objectives;

1. To develop a mini groundnut pod-picking machine
2. To evaluate the performance of a mini groundnut pod picking machine.

CHAPTER 4

MATERIALS AND METHODS

This chapter describes the study area and procedure adopted for the testing of the manual groundnut pods.

4.1 STUDY AREA

The performance of a manual groundnut pod picking machine has been tested in the laboratory of the Faculty of Agricultural Engineering and Technology (FAET) at PMAS Arid University. PMAS Arid University is located in the region of Rawalpindi, Pakistan, and is renowned for agricultural research and development.

The FAET laboratory at PMAS Arid University was selected for evaluating the groundnut pod-picking machine. The laboratory is equipped with advanced facilities and equipment, offering a controlled environment for accurate testing and analysis. By conducting experiments under controlled conditions, this research aims to assess the machine's efficiency, accuracy, reliability, and safety in harvesting groundnut pods.

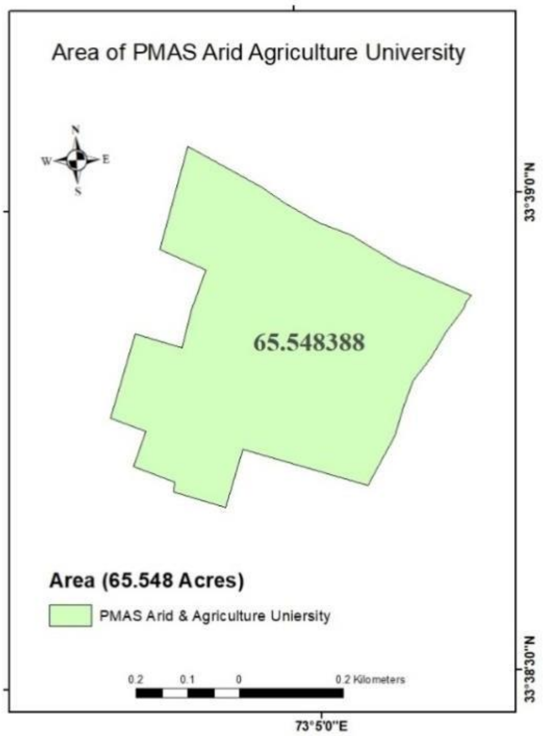

Figure 4.1: Map of PMAS Arid Agriculture University

4.2 MACHINE SPECIFICATION

The machine has the following parts:

1. Digger Blade

The digger blade is an integral component of the machine. It is responsible for excavating and moving soil or other materials during operation. The digger blade is designed to efficiently cut through the ground and facilitate the movement of excavated material.

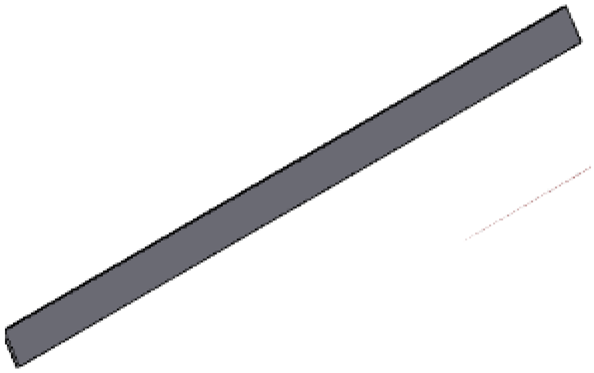

Figure 4.2: Digger Blade

2. Conveying Rotary Valve

The conveying rotary valve plays a crucial role in the machine's operation. It functions as a mechanism for controlled material transfer within the machine. The rotary valve allows for the precise and controlled discharge of material from one section of the machine to another, ensuring smooth and efficient operation.

Figure 4.3: Conveying Rotary Valve

3. Soil Grader Shaking Sieves

The machine is equipped with soil grader shaking sieves. These sieves are designed to sort and grade soil particles based on their size. The sieve included in the machine has holes with a diameter of approximately 4mm. This specific size allows for the separation of soil particles, ensuring that only particles smaller than 4mm pass through the sieve while larger particles are retained.

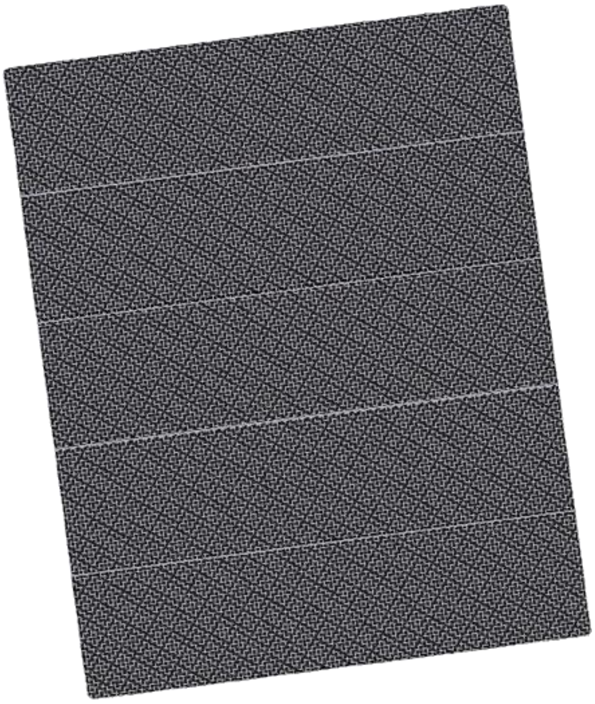

Figure 4.4: Soil Grader Shaking Sieves

Figure 4.5: Walk-Behind Groundnut Pods Picker

4.3 MEASURING VARIABLES

To accurately determine and evaluate various aspects of the machine's performance, precise measuring variables are utilized.

4.3.1 Theoretical Field Capacity (TFC)

TFC represents the maximum amount of work the machine can accomplish when operating at full capacity without considering any time losses during farm operations. It is expressed as acres per hour or hectares per hour (Yadav, 2020).

$$TFC = \frac{W \times S}{10} \quad \text{......4.1}$$

TFC= Theoretical field capacity, ha/h

W= Width of cut, m

S= Forward speed, km/h.

4.3.2 Effective Field Capacity (EFC)

Based on field time, this is the actual rate of field coverage. It is the ratio of the total area covered to the total time taken (Yadav, 2020).

$$\text{Effective Field Capacity} = \frac{\text{Total Area (acre)}}{Time\ (hr)} \quad \ldots\ldots 4.2$$

4.3.3 Field Efficiency

The field efficiency factor is a percentage that represents the ratio between effective field capacity and theoretical field capacity. It serves as a useful tool for estimating the actual work output of a machine. By utilizing field efficiencies, the effective field capacity of a machine can be estimated when the theoretical field capacity is already known (Yadav, 2020).

$$\text{Field Efficiency} = \frac{Effective\ field\ capacity}{Theroretical\ field\ capacity} \times 100 \ldots\ldots 4.3$$

4.3.4 Collected Pods Percentage

The collected pod percentage is the ratio of the weight of pods collected by the machine to the total weight of pods collected from the field. The collected pod percentage was determined by the given formula (Shukla et al., 2018).

$$\text{CPP (\%)} = \frac{Weight\ of\ Collected\ pods\ by\ the\ machine\ (g)}{Total\ weight\ of\ the\ pods\ collected\ from\ field\ (g)} \times 100 \ldots\ldots 4.4$$

4.3.5 Damaged Pods Percentage

The damaged pods percentage is the ratio of the weight of damaged pods during the picking operation to the total weight of pods collected from the unit area. The damaged pod percentage was calculated by the given equation (Shukla et al., 2015).

$$\text{DP (\%)} = \frac{Weight\ of\ damaged\ pods\ collected\ by\ machine\ \ (g)}{Total\ weight\ of\ the\ pods\ collected\ from\ field\ (g)} \times 100 \ldots\ldots 4.5$$

4.3.6 Left-over Pods Percentage

Left-out pod percentage is the ratio of the weight of left-out pods after machine operation to the total weight of pods collected from the unit area. Left-out pod percentage was calculated by the following formula (Shukla et al., 2018).

$$\text{LOP (\%)} = \frac{Weight\ of\ \ Leftover\ pods\ collected\ after\ the\ operation(g)}{Total\ weight\ of\ the\ pods\ collected\ from\ field\ (g)} \times 100 \ldots\ldots 4.6$$

CHAPTER 5

RESULTS AND DISCUSSIONS

Walk behind groundnut pods picking machine will play an important role to minimize the post-harvest losses of groundnut. An experiment was conducted at three different forward speeds S_1 (2 km/h), S_2 (2.5 km/h), and S_3 (4 km/h) to check the best possible speed to operate the machine and to calculate the machine capacities as well as the efficiency.

5.1 THEORETICAL FIELD CAPACITY

It is the maximum possible capacity obtainable at a given speed, assuming the groundnut pods picking machine was used with full width (Yadav, 2020).

$$TFC = \frac{W \times S}{10}$$

i. **At speed S_1 (2 km/h)**

$$TFC = \frac{0.6096 \times 9}{10}$$

= 0.122 acre/h

ii. **At speed S_2 (2.5 km/h)**

$$TFC = \frac{0.6096 \times 4}{10}$$

= 0.244 acre/h

iii. **At speed S_3 (4 km/h)**

$$TFC = \frac{0.6096 \times 6}{10}$$

= 0.366 acre/h

5.2 EFFECTIVE FIELD CAPACITY

It is expressed as the total area that the machine can cover per unit of time and can be calculated by using the formula (Yadav, 2020).

$$\text{Effective Field Capacity} = \frac{\text{Total Area (acre)}}{Time\ (hr)}$$

i. **At speed S_1 (2km/h)**

$$EFC = \frac{0.0027\ acre}{0.020}$$

= 0.10 acre/h

ii. **At speed S_2 (2.5km/h)**

$$EFC = \frac{0{,}0027}{0.015}$$

=0.18 acre/h

iii. **At speed S_3 (4km/h)**

$$EFC = \frac{0{,}0027}{0.016}$$

=0.16 acre/h

5.3 FIELD EFFICIENCY

The field efficiency factor is a percentage that represents the ratio between effective field capacity and theoretical field capacity (Yadav, 2020).

$$\text{Field Efficiency} = \frac{Effective\ field\ capacity}{Theroretical\ field\ capacity} \times 100$$

i. **At speed S_1 (2km/h)**

$$\text{Field Efficiency} = \frac{0.10}{0.122} \times 100$$

= 80%

ii. **At speed S_2 (2.5km/h)**

$$\text{Field Efficiency} = \frac{0.18}{0.15} \times 100$$

= 85%

iii. **At speed S_3 (4km/h)**

$$\text{Field Efficiency} = \frac{0.16}{0.24} \times 100$$

= 67%

Table 1: Effect of forward speeds on Field Efficiency

SPEED	FE_1	FE_2	EF_3	MEAN
S_1	80	81	83	81
S_2	85	86	87	86
S_3	67	65	69	67

5.4 COLLECTED PODS PERCENTAGE

The collected pod percentage is the ratio of the weight of pods collected by the machine to the total weight of pods collected from the field (Shukla et al., 2018).

$$\text{CPD}\ (\%) = \frac{Weight\ of\ Collected\ pods\ by\ the\ machine\ (g)}{Total\ weight\ of\ the\ pods\ collected\ from\ field\ (g)} \times 100$$

i. **CPP at S_1 (%) =** $\frac{320\ (g)}{600\ (g)}$

= 54%

ii. **CPP at S_2 (%) =** $\frac{420\ (g)}{600\ (g)}$

= 70%

iii. **CPP at S_3 (%) =** $\frac{240\ (g)}{600\ (g)}$

= 40%

Table 2: Effect of forward speeds on Collected Pods %

SPEED	CPD_1%	CPD_2%	CPD_3%	MEAN
S_1	54	57	59	57
S_2	70	73	75	73
S_3	40	43	45	42

5.5 LEFT-OVER PODS PERCENTAGE

Left-out pod percentage is the ratio of the weight of left-out pods after machine operation to the total weight of pods collected from the unit area (Shukla et al., 2018).

$$\textbf{Left-Out Pods (\%)} = \frac{Weight\ of\ Leftover\ pods\ collected\ (g)}{Total\ weight\ of\ the\ pods\ collected\ from\ field\ (g)} \times 100$$

i. **Left-Out Pods at speed S_1 (%)** $= \frac{280(g)}{600\ (g)}$

$= 46\%$

ii. **Left-Out Pods at speed S_2 (%)** $= \frac{180(g)}{600\ (g)}$

$= 30\%$

iii. **Left-Out Pods at speed S_3 (%)** $= \frac{360(g)}{600\ (g)}$

$= 60\%$

Table 3: Effect of forward speeds on Left-over %

SPEED	LEFTOUT PODS %	LEFTOUT PODS%	LEFTOUT PODS %	MEAN
S_1	46	44	40	43
S_2	30	35	34	33
S_3	60	63	65	62

5.6 DAMAGED PODS PERCENTAGE

The damaged pods percentage is the ratio of the weight of damaged pods during the picking operation to the total weight of pods collected from the unit area (Shukla et al., 2018).

Damaged pods (%) = $\frac{Weight\ of\ damaged\ pods\ collected\ during\ operation(g)}{Total\ weight\ of\ the\ pods\ collected\ from\ field\ (g)} \times 100$

i. **Damaged pods at speed S_1 (%) =** $\frac{40(g)}{600\ (g)}$

= 7%

ii. **Damaged pods at speed S_2 (%)** = $\frac{30(g)}{600\ (g)}$

= 5%

iii. **Damaged pods at speed S_3 (%) =** $\frac{60(g)}{600\ (g)}$

= 10%

Table 4: Effect of forward speeds on Damage Pods%

SPEED	DAMAGED PODS **%**	DAMAGED PODS **%**	DAMAGED PODS **%**	**MEAN**
S_1	7	8	6	7
S_2	5	5.5	5	5
S_3	10	11	12	11

CONCLUSION

1. The Mini Groundnut Pods Picker machine performed better at a speed of 2.5 km/h and the operator experienced ease of operation.
2. The leftover pods % and damaged pods % were less at 2.5 km/h.
3. 80% of pods were collected at 2.5 km/h speed.

CHAPTER 6

SUMMARY

Groundnut is grown throughout the world in tropical and subtropical regions. It is utilized as a portion of food, oil, and a high-protein intake. The world's largest groundnut-growing region is Asia which contributes 67% of worldwide production. Groundnut harvesting is one of the important aspects as it requires a higher share of cultivation costs. However, during harvesting a significant amount of groundnut pods are left in the field as post-harvest losses. The problem addressed in the research is the high post-harvest losses faced by groundnut growers due to manual picking methods. This inefficient approach fails to meet market demands and poses challenges for farmers. To tackle this issue, a manual groundnut pods picking machine has been developed. The experimental results confirmed the benefits of the machine. Different speeds (S_1, S_2, and S_3) have been tested, and it has been found that operating the machine at a speed of 2.5 km/h (S_2) achieved the best balance between field efficiency, collected pods percentage, and minimizing post-harvest losses. This speed yielded a field efficiency of 86% and a collected pods percentage of 73%, indicating its suitability for meeting market demands. The development of the manual groundnut pod picking machine provides a practical solution for groundnut growers, particularly small-scale farmers in the Pothwar region. By adopting this machine, groundnut farmers can enhance their productivity, reduce losses, and improve their overall agricultural practices.

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