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KEY FACTORS IN GROUNDNUT DIGGER PERFORMANCE: AN ANALYTICAL REVIEW

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ABSTRACT

As a key component of Indian agriculture, groundnuts are highly nutritious and contribute significantly to low-cost, vitamin, high protein level and rich carbs. It provides gainful employment to about two – third of the population of India. Agriculture sector provides food security for the entire population. Oil seeds / edible oils are next to food grains. The oil seed is one of the cash crops. Groundnut is an important oilseed crop in India which occupies first position in terms of area and second position in terms of production after soyabean. Groundnut harvesting must be efficient and timely and efficient. The history of groundnut harvesting is outlined in this paper, starting with traditional methods and continuing to apply various groundnut diggers that are powered by engines, animals, power tillers, tractors, and self-propelled machines, all of which are classified according to their power source. This study focused on key design variables, such as forward speed, digging depth and digging blade type that have an impact on digging performance and reduce the losses during harvesting. This thorough study is needed to increase the body of knowledge on diverse groundnut digger landscapes and enable us to make more informed decisions regarding effective, more accurate and sustainable harvesting methods.

Key words : Blade, Digger, Digging depth, Forward speed, Groundnut and Rake angle.

Introduction

The additional names for groundnuts, termed "the unpredictable legume," include peanut, earthnut, monkey nut, and manilla nut. It ranks fourth in terms of importance for oilseed crops and 13th among food crops worldwide. The greek terms Arachis, which means legume and hypogaea, which means below ground, connect to the geocarpic structure of pod development. These words are combined to give the scientific name *Arachis hypogaea* L. (Lakhani and Vagadia, 2023).

Groundnut is an annual legume that is cultivated in 109 countries due to the high quality of its oil and protein content in its seeds. After soybean plants, groundnuts are the third-most common oil-producing plant in the world (Dobreva *et al*., 2021). India is the fourth-largest oil-producing nation in the world, behind the United States, China and Brazil, harvesting approximately 26.67 million tons of oilseeds annually compared to the global production of 250 million tons.

Groundnut, rapeseed mustard, linseed, sesame, and castor are the primary oilseeds of India (Naidu *et al*., 2014). India accounts for 14% of the oilseed area, 7 - 8% of oilseeds production, 6 - 7% of vegetable oil production, 9 - 12% of vegetable oils imports and 9 - 10% of edible oil consumption (Madhusudhana, 2013).

The crop is an important characteristic of Indian agriculture because of its simple cultivation, high yield per unit area, and potential for numerous seasonal harvests. Its notable output is mostly attributed to the states of Gujarat, Rajasthan, Tamilnadu, Madhya Pradesh, Karnataka, Andhra Pradesh and Maharashtra (Anonymous, 2022) (Fig. 2).

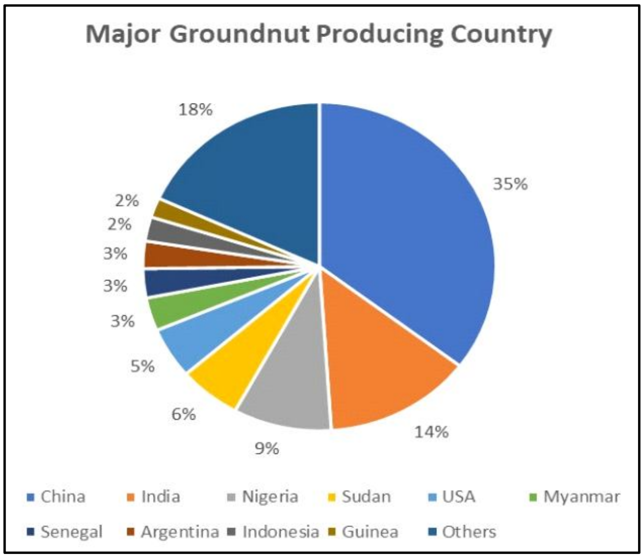

Fig. 1 : Major groundnut-producing countries in the world (Tiwari *et al*., 2018).

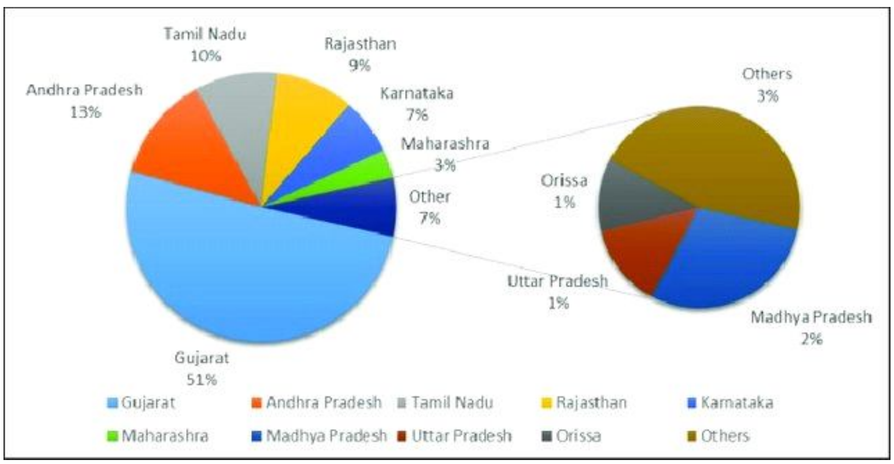

Fig. 2 : Major groundnut -producing states in India (Tiwari *et al*., 2018).

Groundnut digging, a chronological and time-sensitive operation essential for maintaining optimal product quality, is a critical step in the journey of groundnut from field to table. When pods turn dark from light, dark spots appear inside the shell, the kernels turn red or pink when pressed, and oil appears on fingers, at which time the plants are harvested. The process is optimal before the temperature rises above 30°C to minimize the risk of decomposition, especially when irrigation is stopped (Anonymous, 2016). A progressive mechanization journey can be seen in the development of groundnut harvesting techniques, which range from manual methods using tools such as the khurpi breed to modern approaches such as self-propelled machines, tractor-operated and groundnut diggers driven by animals (Fig. 3).

At the forefront of this evolution is the groundnut digger - a mechanical marvel designed for the precise extraction of groundnut plants from the soil during harvesting (Lakhani *et al*., 2024). Its main parts, which consist of a gearbox, gauge wheels, digging blade and rod chain conveyor, work together flawlessly to dig one or two groundnut rows at a time. Relatively soil-free, the ejected groundnut plants lined up in a straight line behind the device to be manually collected (Figs. 4 and 5). Agricultural machinery must be designed with careful consideration of physical criteria such as height, width, and canopy, number of plants per unit area, moisture content, soil strength, and bulk density in regard to operations such as harvesting, transportation, and processing. Frictional characteristics, which are important for work such as soil conveyance are also taken into consideration. These include the angle of the conveying route and the coefficient of friction.

Although, it increases productivity, mechanical groundnut harvesting has problems with pod damage. During late harvesting, there are significant (20–30%) pod losses as a result of in presence seed germination (Nautiyal *et al*., 2001). Additionally, considering of the immature pods and seeds, early harvesting of groundnut pods lowers yield, oil content and seed quality (Singh and Oswalt, 1995).

Studying the mechanical characteristics of groundnut plants is crucial to improving harvesting and postharvest procedures, which will eventually reduce financial losses. The performance of root crop harvesters is greatly impacted by critical machine characteristics such as forward speed, rake angle, blade geometry, operating depth and conveyor oscillation amplitude (Shen *et al*., 2023).

Understanding these variables is foundational to

(a) Handtools for manually digging **(b)** Animal drawn digger

(c) Self propelled digger **(d)** Tractor operated digger

Fig. 3 : Different groundnut digger tools and implement.

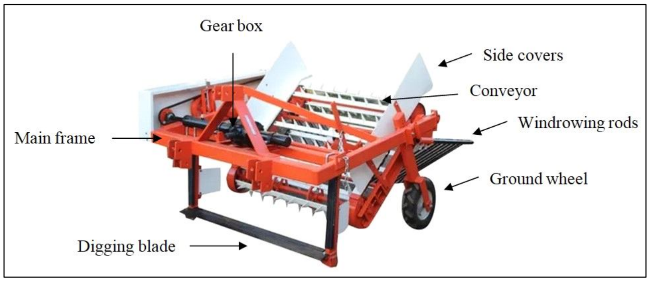

Fig. 4 : The components of a groundnut digger.

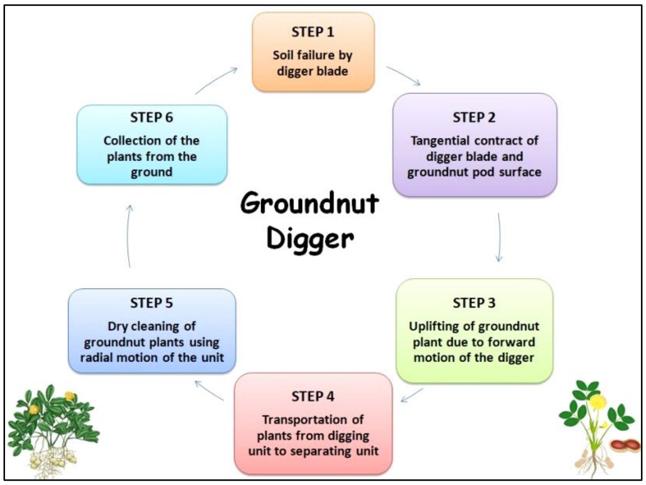

Fig. 5 : The different processes associated with mechanical groundnut digging.

ongoing efforts to develop and assess effective groundnut harvesting technologies. The objective of this study is to provide a thorough resource for scholars, decision-makers and experts in the field by analyze previous technological advancements, contemporary assessments, and their impact on food security.

Materials and Methods

To obtain relevant data on groundnut digger performance and design, a comprehensive search and selection procedure was used as part of the methodology used in this extensive study. A comprehensive investigation of important scholarly archives was carried out to ensure that a variety of perspectives and the latest developments were included. Reliable databases such as these were extensively used: Science Direct, Research Gate, IEEE Xplore, Springer and PubMed.

The search strategy involved the strategic use of specific keywords to identify relevant research papers. Keywords such as "groundnut digger design", "forward speed in groundnut harvesting", "digging depth in groundnut harvesting" and "blade types in groundnut diggers" were chosen to include various facets of groundnut digger design and operating parameters. An extensive, current and diverse analysis of the literature on groundnut digger design and performance depends upon this precise method of source selection and keyword usage.

Factors affecting the Performance of Groundnut Diggers

To further investigate the complex field of groundnut harvesting, one of the key areas of interest has become the best way for groundnut diggers to operate. A number of characteristics inside this farming environment have a significantly impact on the productivity and efficiency of groundnut diggers. The foundation of this inquiry is composed of the operational speed, rake angle, digging depth and digging blade. The objective of this study was to analyze the dynamics of these important components and to elucidate the critical role of these components in improving groundnut digger capabilities.

Operational speed

A significant factor affecting how well groundnut digger's function is operational speed. Numerous investigations have examined this aspect, offering perspectives on the ideal functioning conditions for these devices.

Afshin *et al.* (2014) investigated a vibrating digger and revealed that exposed pod loss can be decreased by using the minimum conveyor angle at the minimum forward speed. Similarly, Ibrahim *et al.* (2008) developed a multipurpose digger for harvesting root crops and evaluated it in groundnut harvesting at three levels of forward and three different slope angles, once using the vibrating movement and once not using it. Mishamandani *et. al.* (2014) conducted a comparative study on groundnut harvesting loss via mechanical and manual methods. According to the test results, the lowest percentage of loss was due to forward speed of 1.8 km/h and a soil moisture content of 19.9%. According to Ademiluyi *et al.* (2011) (cite the references) forward speed and the conveyor slope angle are two operational factors that significantly affect machine performance. Mareppa *et al.* (2014) carried out a thorough investigation of the operation of a self-propelled groundnut digger, considering factors such as moisture content, rake angle (15°) and forward speed (2 km/h). The significance of forward speed in accomplishing clean harvesting with a cassava harvester was emphasized by Obigol (1986). Ahmad and Shamsudeen (1987) examined a groundnut digger capability and highlighted that operating speed affects pod recovery. Ibrahim *et al.* (1989) studied a sugar beet digger and determined the best combinations of tilt angle, blade width, and forward speed to minimize tuber damage and maximize digging efficiency. Murugesan and Tajuddin (1995) examined the effectiveness of a tractor-drawn

Table 1 : Summary of recommended operational speed for different root crop harvesters by different researchers.

Focus	Recommended speed (km/h)	Key findings	Reference
Groundnut digger shaker	-	Identified optimal values for advance speed, rotational speed and blade angle	Verma and Garg (1970)
Cassava harvester	2.5 – 4.0	Emphasis on forward speed for clean harvesting operations and minimal tuber damage	Obigol (1986)
Groundnut digger	2.5	Impact of operational speed on pod recovery and harvesting efficiency	Ahmad and Shamsudeen (1987)
Sugar beet digger	3.5	Minimum root damage and highest efficiency at specific combinations of parameters	Ibrahim *et al*. (1989)
Vibrating digger	-	Increased unrecovered potatoes, decreased draft force with higher conveyor frequency	Kang and Handelson (1991)
Vibratory groundnut digger	2.4 & 4.8	Influence of soil type and tractor speed on draft force	Dawelbeit and Wright (1999)
Vibrating cassava root harvester	6.0	Field capacity and draft requirements in relation to operational speed	Gupta *et al*. (1999)
Rotary-type potato digger	1.59	Determined operational speed for best performance results	Yasin *et al*. (2003)
Groundnut digger	1.59	Increased unrecovered potatoes, decreased draft force with higher conveyor frequency	MohAnty *et al*. (2005)
Multipurpose digger (groundnut and potato)	2.3	Identified optimal values for advance speed, rotational speed and blade angle	Ibrahim *et al*. (2008)
Bullock drawn groundnut digger	1.9	Identified optimal values for advance speed, rotational speed and blade angle	Mishra (2009)
Groundnut digger	2.1	Optimized performance parameters for different engine RPM and blade oscillation frequencies	Munde *et al*. (2009)
Groundnut digger	3.79	Analysis of forward speed and digging depth on harvesting efficiency	Bhutada *et al*. (2010)
Groundnut digger	1.7, 2.5 and 3.3	The effect of forward speed was not significant for damaged pods loss, exposed pods loss, unexposed pods loss and undug pods loss	Afshin *et al*. (2014)
Groundnut digger	2.5	The performance of the digger was found to be better	Mareppa *et al*. (2014)
Tractor-operated digger	1.5–3.0	Identified optimal values for advance speed, rotational speed and blade angle	Aziz *et al*. (2014)
Onion digger	4	Exploration of digging depth and forward speed for efficient digging	Singh (2014)
Groundnut digger	2.0	Speed made significant difference (pd+0.05) on the harvesting efficiency and percentage damage	Bako *et al*. (2015)
Groundnut digger-shaker	3.8	Determined operational speed for best performance results	Vagadia *et al*. (2015)
Groundnut harvester	1.6	Determination of optimum working speed for effective performance	Saakuma *et al*. (2016)

Table 1 continued...

Table 1 continued...

Operational parameters	4.4	Effects of forward speed and conveyor inclination on potato lifting percentage	Kheiry *et al*. (2018)
Tubing lifting percentage	Up to 6.3	Improved lifting percentage, emphasizing optimal speed selection	Patel *et al*. (2018)
Digger cum shaker	2.41	Impact of tractor speed, digger angle, and conveyor speed on field efficiency	Jaiswal et al. (2018)
Soil potato separation in a digger	7.38	Optimization of vibration parameters considering amplitude, frequency, and unning speed of the separation sieve	Wei *et al*. (2019)
Groundnut digger	1.5 – 2.0	Impact of tractor speed, digger angle, and conveyor speed on field efficiency	Kavad *et al*. (2020)

Table 2 : Key findings on the rake angle.

Rake angle (degrees)	Impact on performance	Reference
10	Minimize the draft in groundnut digging operation	Suryawanshi *et al*. (2009)
10 - 20	Impact on operational capacity and production losses	Mareppa *et al*. (2014)
18 - 22	Enhanced digging efficiency and tuber exposure	Narender *et al*. (2019)

ridge turmeric digger and found relationships between tuber damage, tractor speed, and effective field capacity. Dawelbeit and Wright (1999) investigated draft force in a vibratory groundnut digger powered by a tractor, highlighting the important role that tractor speed and soil type play. Gupta *et al*. (1999) observed the importance of operating speed by observing the field capacity and draft needs of a shaped like an oscillating cassava root harvester. Mohanty *et al*. (2005) assessed the cost of harvesting groundnuts at various forward speeds with a sweep-type groundnut digger. Ibrahim and Attia (2011) investigated the forward speed and digging depth efficiency of operation of a potato harvesting equipment. To identify the maximum tuber exposure range, Kang and Handelson (1991) optimized the operating speed of a potato digger equipped with a spring-loaded anti-clod device. Bako *et al*. (2015) studied the performance of tractor operated groundnut harvester in Nigeria, which were evaluated at different speeds (2, 3, 4 and 5 km/h) with a constant penetration depth of 10 cm. They concluded that harvesting efficiency decreased as speed increased, although percentage damage increased. Verma and Garg (1970) developed a tractor mounted groundnut digger shaker and revealed that selection of proper pick-up-elevator speeds led to satisfactory groundnut harvesting. Mishra (2009) invented a ridger-type bullock-drawn groundnut digger and evaluated it for power requirements, effective field capacity, field efficiency, labor requirements, and pod losses, with an optimal speed of 1.9 km/h. Singh (2014) investigated the digging depth and forward speed of an onion digger, offering insights into improving these parameters for effective digging.

In summary (Table 1), these investigations highlight the importance of operating speed in maximizing the performance of various groundnut diggers. Researchers constantly stress the need for personalized changes, with results ranging from 1.4 to 6 km/h for maximum pod exposure and complex connections with characteristics such as field capacity, draft force and harvesting efficiency.

Groundnut digger rake angle

The rake angle, a pivotal factor in the performance of groundnut diggers has been extensively examined in the literature. Researchers have delved into the influence of this genus on the delicate balance between pod exposure and soil handling efficiency, contributing valuable insights into the optimization of this critical parameter.

Mareppa *et al*. (2014) and Mareppa *et al*. (2015) shed light on the significant impact of the rake angle on groundnut digger performance. Specifically emphasized the need to tailor the rake angle for optimal digging results, highlighting its role in minimizing damage while exposing pods effectively. Comparison studies Nrender *et al*. (2019) and Cunh *et al*. (2011), akin to those of have provided practical perspectives on different potato digger models, taking the rake angle into account. The literature collectively suggests that variations in rake angle significantly influence operational capacity, production losses, and cost effectiveness (Table 2).

Table 3. Key findings on digging depth.

Machinery	Digging depth (cm)	Key findings	Reference
Multipurpose digger	22	Comprehensive study on the interplay of digging depth and other parameters for optimal performance in a multipurpose digger	Ibrahim *et al*. (2008)
Multipurpose digger	15	Optimize harvesting depth of developed digger and find out efficiency, optimum speed affections of vibrating movement and tilt angle	Ibrahim *et al*. (2008)
Tiller drawn groundnut digger	10-15	Developed digger evaluated that field performance on fatigues work of hand pulling of groundnut pod and saved 11 to 13 % pods, which were lost in local method	Kad *et al*. (2008)
Potato harvesting machine	22	Investigation into the operational efficiency concerning digging depth, offering insights into optimal depth for peak performance	Ibrahim and Attia (2011)
Onion digger	7.62	Exploration of digging depth and forward speed for efficient onion harvesting, emphasizing the importance of depth control	Singh (2014)
Self-propelled groundnut digger	6.5-10	Investigated on different levels of speeds, angles and different types of soil moisture content	Mareppa *et al*. (2014)
Mounted groundnut harvester	10	Concluded on harvesting efficiency, speed of machine, effectiveness and percentage of speed on pod damage	Bako *et al*. (2015)
Animal drawn groundnut digger	15	Concluded that varying cutting depth significantly affect digging efficiency, exposed pods(%) and affect pod loss	Attanda and Adinoyi (2016)
Potato harvester	16 - 21	Exploration of optimal digging depth for efficient potato harvesting, providing insights into depth-related outcomes	Kheiry *et al*. (2018)
Small potato digger	24	Analysis of forward speed and digging depth on harvesting efficiency, contributing to the broader understanding of these factors	Nasr *et al*. (2019)

These findings collectively underscore the importance of the rake angle in the nuanced optimization of groundnut digger performance.

Digging/harvesting depth

Researchers have extensively investigated the impact of digging/harvesting depth on the performance of groundnut harvesting machinery. Bako *et al*. (2015) evaluated the best digging depth for effective groundnut harvesting, providing important insights into the link between depth and harvesting results. Attanda and Adinoyi (2016) studied the relationship between digging depth and harvesting efficiency, offering information on how depth influences the quality of harvested potatoes. Ibrahim *et al*. (2008) conducted a thorough investigation on the interaction between digging depth and other factors for optimal performance in a multipurpose digger. Singh (2014) researched the digging depth and forward speed for effective onion harvesting, emphasizing the significance of depth management in obtaining the best outcomes. Ibrahim *et al*. (2008) added to our understanding of digging depth in a multipurpose digger, stressing its importance in obtaining peak performance. Vagadia *et al*. (2015) explored the effect of digging depth on groundnut digger performance, providing insights into the depth-digging efficiency connection. Saakuma *et al*. (2016) evaluated the impact of forward speed and digging depth on harvesting efficiency, providing additional insight into these aspects in the context of groundnut harvesting (Table 3).

All of these studies illustrate the importance of digging/harvesting depth in determining the efficiency and quality of groundnut harvesting. Optimal digging depth is a critical aspect in reducing pod damage, increasing efficiency, and achieving optimal performance in various types of pods harvesting machines. Understanding and managing digging depth are critical factors in improving the overall efficiency of groundnut harvesters.

Table 4 : Summary of key findings.

Blade type	Impact on performance	Reference
Varied blade designs	Optimization of cutting efficiency and crop damage mitigation	Hyde (1986)
Soil-potato separation blade	Investigation into the influence of blade design on soil-potato separation	Vatsa *et al*. (1996)
Two row digger blades	Blade was tested and compared with other existing traditional blade and found superior in all aspects.	Tiwari and Jethva (2001)
Diverse blade types	Examination of the role of blade design in a potato harvesting machine	Younis *et al*. (2006)
Straight, inverted V and crescent blades	V-shaped digger blade proves to be instrumental in minimizing draft	Suryawanshi *et al*. (2009)

Blade types in groundnut diggers

Several studies have evaluated the effect of blade type on the performance of agricultural machines. Tiwari and Jethva (2001) conducted research on blade design in groundnut diggers, with the aim of increasing cutting efficiency while minimizing crop damage. Suryawanshi *et al*. (2009) reported that the V-shaped digger blade is useful for reducing draft. According to Amin *et al*. (2014), the nose shape blade provides the highest effectiveness in lifting carrots. Younis *et al*. (2006) investigated the impact of blade design in a potato harvesting machine and highlighted the need to choose appropriate blade types for various soil and crop conditions (Table 4).

The literature indicates the importance of specific methods based on unique aspects impacting blade performance while designing and operating groundnut diggers.

Conclusion

Groundnut harvesting, a pivotal agricultural task, demands meticulous attention to optimize yield, quality, and operational efficiency. With the culmination of this extensive review on groundnut diggers, several key recommendations emerge, offering valuable insights for farmers and practitioners:

Operational Speed Precision

To achieve optimal performance, maintain an operational speed between 1.5 and 6 km/h. This accuracy maintains the complex equilibrium between efficiency and pod protection during the harvesting procedure.

Rake Angle Optimization

A suitable rake angle of 15-30° is a significant factor. This ideal range not only improves harvesting effectiveness but also facilitates proper soil pulverization while minimizing draft, resulting in similar interactions between the digger and the field.

Digging depth mastery

The optimal digging depth, which ranges from 8 to 19 cm is identified as a critical factor for attaining a high percentage of pods lifted with minimal damage. This invisible technique identifies the variation in soil conditions and pod properties.

Influence of Blade selection

The adoption of a V-shaped digger blade proved helpful in reducing the draft. These guidelines emphasize the importance of blade design for reducing resistance and improving overall efficiency of groundnut diggers.

When these recommendations are combined, it becomes clear that the performance of groundnut diggers is completely linked to a variety of parameters. The combination of optimal operating speed, digging depth, and blade configuration yields an effective approach for groundnut harvesting. These findings move beyond conceptual problems and provide practical suggestions for machine design and selection. Because groundnut harvesting involves more than just a mechanical operation, but rather a precise arrangement of different aspects, these tips emphasize the importance of making educated decisions. By following these insights, farmers can handle the challenges of groundnut harvesting with greater precision, making not only timely completion, but also maintaining of product quality. Finally, this review contributes to the evolving landscape of agricultural practices, where efficiency and sustainability intersect for an abundant harvest.

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