MOTORIZED CASSAVA MINISETT CUTTING MACHINE

by

ASHTAMI DEV (2021-02-037)

SHAHANA I P (2021-02-040)

MUHAMMED AJMAL C (2021-02-042)

PROJECT REPORT

Submitted in partial fulfilment of the requirement for the degree of

BACHELOR OF TECHNOLOGY

in

AGRICULTURAL ENGINEERING

Faculty of Agricultural Engineering and Technology

Kerala Agricultural University

DEPARTMENT OF FARM MACHINERY AND POWER ENGINEERING

KELAPPAJI COLLEGE OF AGRICULTURAL ENGINEERING AND

FOOD TECHNOLOGY, TAVANUR – 679 573,

MALAPPURAM, KERALA, INDIA

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DECLARATION

We hereby declare that this project entitled **"MOTORIZED CASSAVA MINISETT CUTTING MACHINE"** is a bonafide record of project work done by us during the course of study and that the report has not previously formed the basis for the award to us of any degree, diploma, associateship, fellowship or other similar title of another university or society.

ASHTAMI DEV (2021-02-037)

SHAHANA I P (2021-02-040)

MUHAMMED AJMAL C (2021-02-042)

Place: Tavanur

Date:

CERTIFICATE

Certified that the project entitled **“MOTERIZED CASSAVA MINISETT CUTTING MACHINE**” is a record of project work done jointly by Ashtami Dev (2021-02-037), Shanana I P (2021-02-040), Muhammed Ajmal C (2021-02-042) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to them.

Place: Tavanur

Date:

Guide: Dr. Jayan P R

Dean of the Faculty (Agrl. Engg.) and Head, Dept. of FMPE

Co-guide: Dr. Khatawkar Dipak Suresh

Assistant Professor, Dept. of FMPE

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Ashtami Dev **Shahana I P** **Muhammed Ajmal C**

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SYMBOLS AND ABBREVIATIONS

Sl. No.	Abbreviation/Notation	Description
1.	%	per cent
2.	et al.	and others
3.	/	per
4.	i.e.	that is
5.	Fig.	Figure
6.	mm	millimetre
7.	cm	centimetre
8.	m	metre
9.	$mm \cdot s^{-1}$	millimetre per second
10.	N	newton
11.	viz.	namely
12.	$mm \cdot min^{-1}$	millimetre per minute
13.	CAD	Computer Aided Design
14.	mL	millilitre
15.	mAh	milliampere hour
16.	h	hour
17.	m^3	cubic metre
18.	cm^3	cubic centimetre
19.	g	gram
20.	kg	kilogram
21.	rpm	revolutions per minute
22.	$m \cdot s^{-1}$	metre per second
23.	bpm	beats per minute
24.	$N \cdot m^{-2}$	newton per metre square
25.	$kg \cdot m^{-3}$	kilogram per metre cube

26.	SS	Stainless Steel
27.	GPS	Gross Domestic Product
28.	$kJ \cdot min^{-1}$	kilojoule per minute
29.	$L \cdot min^{-1}$	Liter per minute
30.	AISI	American Iron and Steel Institute
31.	s	second
32.	GPa	Giga Pascal
33.	MPa	Mega Pascal
34.	HR	Heart Rate
35.	Hz	Hertz
36.	AC	Alternating current
37.	N·m	Newton meter
38.	kg·cm	kilogram centimeter
39.	V	Volt
40.	W	Watt
41.	DC	Direct Current
42.	$J \cdot m^{-2}$	Joule per meter square
43.	VA	Volt Ampere
44.	°C	Degree Celsius
45.	°F	Degree Fahrenheit
46.	CPCRI	Central Plantaion Crops Research Institute

INTRODUCTION

CHAPTER I

INTRODUCTION

Cassava (*Manihot esculenta Crantz*) is a perennial root crop that holds immense significance in the agricultural economies of many tropical and subtropical countries. Native to tropical America and belonging to the family *Euphorbiaceae*, cassava is a staple food for millions of people, providing a critical source of calories and nutrition where other crops often fail to thrive. It is estimated that about 200 million people rely on cassava for approximately 500 calories daily (Ceballos *et al.,* 2010), underscoring its role in food security and poverty alleviation across diverse regions.

One of cassava's major strengths lies in its adaptability. It grows well under marginal climatic conditions and poor soils where other food crops might falter, owing to its tolerance to drought, low soil fertility, and even its capacity to recover from pest and disease challenges. This hardiness has made cassava a favoured crop among smallholder farmers, particularly in Southeast Asian countries such as Laos, Vietnam, and Thailand, where it contributes significantly to household food and income.

In Malaysia, cassava cultivation has evolved over decades. Two principal types of cassava dominate local production: the 'bitter' varieties like Sri Kanji 1 and Sri Kanji 2, which have high cyanide content but are rich in starch and mainly serve the starch processing industry, and the 'sweet' or edible varieties such as Medan and Sri Pontian, which are consumed directly or processed into traditional Malay and Nyonya delicacies like *bingka*, *kerepek*, *keropok*, and *opak* (Tan, 2010). The cultivation area for cassava in Malaysia peaked in the mid-1970s, with over 20,000 hectares devoted to starch production. During this period, Malaysia was a key exporter of starch to international markets including the United Kingdom, Japan, Canada, and the United States (Tan *et al.,* 2010).

However, the subsequent decades witnessed a marked decline in cassava acreage, dropping to about 2,000 hectares as more profitable crops such as oil palm, rubber, and various fruits occupied the land. Economic incentives shifted farmer preferences towards edible cassava varieties, which command higher market prices and shorter maturation cycles, typically harvested between 8 to 10 months compared to 10 to 12 months for starch varieties (Tan and Abd. Rahman, 2001). This decline adversely impacted the starch industry, rendering it less viable due to raw material shortages and diminishing factory operations.

In recent years, renewed interest in cassava cultivation has emerged, driven by its potential in bio-based industries. Cassava starch is being explored as a raw material for bioethanol production, biodegradable plastics, and animal feed, presenting new economic opportunities for farmers and processors alike. This resurgence has highlighted the need to increase the availability of quality planting materials, a critical factor in boosting production and meeting growing industrial demands. Yet, this demand outpaces supply due to limitations in mass propagation techniques, nursery production capacity, and distribution networks.

The propagation of cassava is typically vegetative, utilizing stem cuttings to produce genetically identical clones. This method ensures uniformity in plant growth and root yield under ideal conditions. However, environmental factors such as pests, diseases, soil salinity, and nutritional imbalances can negatively affect plant vigor, starch content, and cyanide levels (Lozano *et al.,* 1984). Over successive vegetative propagation cycles, these stresses cumulatively degrade planting material quality, resulting in diminished yield potential and even loss of valuable varieties. Hence, maintaining high-quality planting stakes is crucial to preserve genetic integrity and optimize crop performance. Traditional propagation practices in Malaysia involve the use of 25 cm long woody stem cuttings, which present inherent limitations in multiplication rates. A mature cassava plant typically produces only 5 to 10 such cuttings, constraining rapid scale-up efforts and leading to shortages of planting materials during peak planting seasons. Additionally, the manual preparation of these cuttings is labor intensive, time-consuming, and prone to inconsistencies in size and quality, factors that can reduce sprouting success and cause uneven crop establishment.

To mitigate these issues, research has advocated for rapid propagation methods using mini-cuttings, approximately 5 cm in length, which can significantly increase the multiplication rate. However, manual preparation of mini-cuttings on a large scale remains a laborious task, limiting its practical adoption by farmers and nurseries. The lack of mechanization in cassava planting material preparation underscores the necessity for innovation. The development of a Motorized Cassava Minisett Cutting Machine offers a promising solution by mechanizing the cutting process to enhance efficiency, uniformity, and output volume. The machine's self-propelled design allows for ease of mobility in farm and nursery settings, eliminating the need for manual pushing or external power sources and thus facilitating operations in challenging terrains.

This mechanized approach not only reduces labor dependency but also improves the precision and quality of cuttings, enabling better crop uniformity and field establishment. It aligns with the broader goals of agricultural modernization and mechanization, which have historically played pivotal roles in enhancing productivity and reducing drudgery in farming communities.

Therefore, this project is focused on the design, fabrication, and evaluation of a Motorized Cassava Minisett Cutting Machine. The project aims to provide an effective tool that reduces the time and labor involved in preparing cassava mini-cuttings, improves cutting consistency, and can be operated efficiently under typical farm conditions. By doing so, it seeks to support the scaling-up of cassava production, increase the availability of high-quality planting materials, and ultimately contribute to the economic empowerment of farmers through improved yields and reduced production costs.

Objectives:

1. To study the morphological characteristics of cassava stem and planting considerations for the systematic design of Motorized Cassava minisett cutting machine.
2. Designing of Motorized Cassava minisett cutting machine.
3. To evaluate different machine geometries for design optimization.
4. To motorize machine for operational easiness.

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

The development and relevance of a self-propelled cassava minisett cutting machine has been reviewed and presented in this chapter under the following major subsections: cassava morphological and agronomic characteristics, cassava minisett technique, significance of mechanized cutting in cassava propagation, factors affectes cutting of cassava stems and ergonomic factors influencing machine design.

2.1 MORPHOLOGICAL AND AGRONOMIC CHARACTERISTICS

Cassava, a perennial shrub that typically grows between 1 to 4 meters tall, is widely known by regional names such as tapioca, manioc, yuca, and mandioca. It belongs to the dicotyledonous *Euphorbiaceae* family, with the genus *Manihot* encompassing around 100 species. However, *Manihot esculenta Crantz* is the only species that is cultivated on a commercial scale. The plant exhibits two primary growth forms either erect with or without branching at the apex, or spreading in nature.

The species demonstrates a broad spectrum of morphological traits, a reflection of its significant interspecific hybridization. Numerous cultivars of cassava are maintained in germplasm repositories at both global and regional research institutes. Among them, the largest collection is maintained by CIAT (Centro Internacional de Agricultura Tropical) in Colombia, with over 4,700 accessions (Bonierbale *et al.,* 1997). This is followed by EMBRAPA's collection in Cruz das Almas, Brazil, holding nearly 1,700 accessions (Fukuda *et al.,* 1997), encompassing varieties from diverse Brazilian agro-ecological regions such as humid tropics, hot savannahs, semiarid highlands, and subhumid lowlands.

Cassava varieties are primarily classified based on morphological and agronomic descriptors. The International Plant Genetic Resources Institute (IPGRI) recently updated its list of cassava descriptors (Gulick *et al.,* 1983; revised by Fukuda *et al.,* 1997), which now includes 75 descriptors 54 morphological and 21 agronomic. Among these, morphological traits like leaf lobe shape, root pulp color, and stem characteristics tend to show higher heritability compared to agronomic traits such as root yield or the number of roots per plant.

A minimum set of morphological descriptors has been standardized for identifying cassava cultivars. These include features like apical leaf and pubescence colour, shape of the central leaf lobe, petiole and stem colour (both cortex and external), phyllotaxis length, root characteristics (such as cortex colour, pulp colour, epidermis texture), and flowering attributes.

Due to the vast number of cassava genotypes and their adaptability across a wide range of environmental conditions, describing their morphological traits can be challenging. This complexity arises from genotype × environment interactions. To address this, researchers have increasingly employed molecular tools, especially DNA markers, for evaluating genetic diversity and improving the precision of germplasm characterization (Beeching *et al.,* 1993; Fregene *et al.,* 1994).

2.2 PLANTING MATERIAL

Cassava propagates vegetatively. For optimal propagation, cassava is typically grown using semi-hardwood stem cuttings. Within two to three weeks of planting, adventitious roots begin forming at the basal end of the cuttings. These initial roots gradually evolve into a dense fibrous root network. Additional roots may also emerge from the nodes or the base of axillary buds along the cutting. Some of these fibrous roots can extend up to two meters in length. Around 20 to 40 days after planting, a portion of these fibrous roots begin to transform into storage or tuberous roots, which are essential for starch accumulation and later harvest.

Alves (2002) proposed that the mature stem of the cassava plant is cylindrical, woody in texture, and composed of repeating nodes and internodes. The oldest segments of the stem exhibit small raised scars at the nodes these are the remnants of the plant's earliest leaves. When cassava is propagated using stem cuttings, each viable bud present on the cutting has the potential to give rise to a primary shoot, which means a single cutting can produce multiple stems. However, in certain varieties that exhibit strong apical dominance, growth is limited to a single main stem.

Cassava exhibits a characteristic sympodial branching pattern. This means that the primary stem or stems terminate in an inflorescence and are replaced by one or more lateral branches. These secondary branches may split dichotomously, trichotomously, or even tetrachotomously, leading to successive branch formations. Such repetitive branching is generally associated with the flowering phase of the plant and is referred to as reproductive branching. This type of branching not only contributes to the plant's canopy architecture but also plays a key role in its photosynthetic efficiency and biomass distribution.

Additionally, the branching habit, internode length, and bud activity significantly influence the uniformity and success rate of vegetative propagation through stem cuttings. Understanding these morphological traits is crucial in designing mechanized stem cutting tools, as variations in stem hardness, node spacing, and branching angle can affect cutting efficiency, blade wear, and alignment mechanisms in the machinery.

Tuberous root formation, or root bulking, depends on soil conditions, temperature, quality of planting material, variety

Ekanayake *et al.,* (1997) studied about the cassava planting material. Cassava stem cuttings, often referred to as stakes, are highly susceptible to damage from harsh weather conditions, pests, and diseases. Exposure to direct sunlight causes these cuttings to dry out, diminishing their ability to sprout. On the other hand, excess moisture can lead to premature sprouting or rotting. Common issues that hinder sprouting include infection by pathogens and pest infestations. Using freshly harvested, healthy cuttings improves sprouting success, while extended storage durations may highlight varietal differences in sprouting potential.

To ensure successful planting, it is recommended to use mature, disease-free stem cuttings. However, when immediate planting isn't possible due to environmental constraints like drought, excessive rain, or cold temperatures, proper storage practices become essential. The most effective storage method involves keeping the stems in a dry, well-ventilated, and shaded location, away from direct sunlight to maintain viability.

A few critical factors influence the quality of cassava stem cuttings:

i. Stem Age: Cuttings should ideally be taken from plants that are between 8 to 18 months old. Older stems tend to perform better in the field than immature ones. Green or tender stems are more vulnerable to insect damage and diseases, and also tend to dry out faster during storage. Although lignified stems from older plants may have less nutritional content for sprouting, they are more resilient overall. However, very old stems can result in weak sprouts.
ii. Stem Thickness: Thicker stems are preferable as they contain more nutrients and moisture, contributing to robust sprouting and healthy tuber development. Thin stems, although usable, often result in poor growth and yield.
iii. Node Count: For best results, use cuttings that are 20–30 cm in length and have 5 to 7 nodes, since roots and shoots typically emerge from these nodes. While it is possible to propagate from cuttings with fewer nodes.
iv. Stem Health: It is essential to select planting material from disease- and pest-free plants. Symptoms of common diseases like cassava mosaic virus, bacterial blight, and anthracnose, as well as pest infestations such as mealybugs or scale insects, should be carefully screened before use. Damaged or diseased cuttings should be avoided to prevent spread and ensure uniform crop establishment.

2.3 MACHINERIES USED FOR CASSAVA PLANTING

Ale and Manuwa (2020) designed a single-row semi-automatic cassava planter was developed in the Department of Agricultural and Environmental Engineering at the Federal University of Technology, Akure, Nigeria. The machine comprises several key components: a hopper, roller-picker, cutting unit, belt conveyor (serving as the metering device), double disc furrow opener and coverer, gear transmission system, frame, and land wheels. It is designed to be operated by a 41horsepower (30.6 kW) tractor.

Field trials demonstrated that the planter met essential functional requirements, achieving a functional efficiency of 95.45 per cent. The design eliminates the need for additional labourers behind the tractor, which is commonly required with current commercial models. This innovation not only reduces labour costs but also minimizes the physical drudgery involved in cassava planting. Further evaluation will assess how factors such as forward speed, land preparation quality, and rigid wheel lug configurations influence planter performance. Overall, the development holds promise for boosting cassava production, improving mechanization efficiency, and attracting youth participation in agricultural practices by modernizing planting operations.

Manual planting of cassava cuttings is widely recognized as a labour-intensive and physically demanding task. This arduous process significantly restricts the expansion of large-scale cassava farming industries, particularly in Nigeria. To address these challenges, Odigboh *et al.,* (1978) developed a two-row automatic cassava cuttings planter designed to mechanize the planting process. The prototype planter is tractor-drawn and can operate at speeds of up to 10 km/h. It plants cassava cuttings at an inclination of up to 80 degrees relative to the horizontal plane, with a spacing of 890 mm on small ridges spaced 900 mm apart. This innovation aims to reduce the manual labour burden while increasing planting efficiency and consistency.

Odigboh *et al.* (2009) designed and developed a cassava planter to improve mechanization in cassava cultivation a cassava planter suitable for local farming conditions was developed. This machine is capable of planting cassava stakes on both flat beds and ridges while simultaneously applying fertilizer. Its major components include a main frame, stake cutting unit, planting mechanism, fertilizer applicator, ridge former, and soil levelling devices. It operates using a 57.4 kW tractor and requires two workers to feed the machine along with one tractor driver.

For performance testing, the machine was operated at three different speeds (1.7, 2.0, and 2.4 km/h). The results showed an average field capacity of 0.135 hectares per hour and a field efficiency of 65.3%. Fuel consumption ranged between 19.9 and 24.2 liters per hectare, and the maximum draft force needed was 1.55 kN. The stakes were planted at inclination angles averaging 67 degree (longitudinal-vertical) and 88 degrees (lateral-vertical), depending on the operating speed. The planter achieved 89% proper standing of stakes, with 3.9% missing hills and 4.2% horizontally planted (yet soil-covered) stakes. No stake damage was observed, and germination averaged 90%. The planting quality and pattern were deemed acceptable. Economic evaluation revealed a break-even usage area of 24.8 hectares per year at a speed of 2.4 kmph. To recover the investment within one year, the planter would need to be used on 80.7 hectares annually. Overall, performance tests and cost assessments indicate that the planter is a viable and cost-effective solution.

A cassava stem cutting unit was developed to generate design data for use on a prototype cassava planter. The unit consisted of a 25.5 cm circular saw blade powered by a 0.75 kW electric motor, a cam mechanism operated by a 0.37 kW motor to regulate cutting frequency, and a manually fed chute for stem placement onto an adjustable bottom plate. Cutting length was adjustable between 15 and 30 cm. Laboratory tests by Lungkapin *et al.,* (2007) demonstrated that optimal cutting quality occurred at saw speeds exceeding 1,200 rpm and cam shaft speeds below 50 rpm, achieving a cutting capacity of over 5,000 stakes per hour with an efficiency of 83.91%. Importantly, the cutting process preserved stem integrity, resulting in satisfactory germination performance. This advancement addresses the labour-intensive nature of cassava planting by mechanizing stem preparation and presents promising prospects for increasing efficiency in cassava cultivation.

2.3 MINISETT CUTTING METHOD OF PROPAGATION

Nurul Nahar & Tan, (2012) studied about the minisett cutting propagation of cassava. Cassava (Manihot esculenta Crantz) is traditionally propagated through 25 cm long mature woody stem cuttings, a practice that is common in commercial cultivation. However, this conventional method has a significant limitation: its propagation rate is relatively slow.

Malaysian Agricultural Research and Development Institute in 2012, done rapid propagation approach involving the use of 5 cm long cassava mini cuttings was examined in this study to address the limitations of traditional propagation methods. These mini-cuttings were initially pre-sprouted in polybags for one month prior to field transplantation, ensuring early establishment and uniform growth. Although the conventional 25 cm long stem cuttings produced the highest recorded root yield of 101.5 tonnes per hectare at harvest, the difference in yield was not statistically significant when compared to the mini-cuttings. Plants propagated from mini-cuttings yielded 92.9 t/ha and 84.1 t/ha when harvested at 12 and 11 months respectively results that demonstrate the potential of mini-cuttings to compete closely with traditional cuttings in terms of productivity. Interestingly, a distinct advantage of the mini-cuttings was observed in terms of starch content. Mini-cuttings harvested after 12 months showed a significantly higher starch concentration of 30.5 per cent, in contrast to 27.8per cent for normal cuttings harvested at the same age and 27.3 per cent for mini-cuttings harvested a month earlier at 11 months. These starch values were consistent with findings from a parallel yield trial conducted using the same cassava variety on drained peat soils at MARDI Pontian. These results clearly indicate that cassava mini-cuttings are not only a viable alternative to traditional cuttings but also capable of producing competitive yields and superior starch content under local conditions. Therefore, mini-cuttings can serve as an efficient source of planting material, allowing for successful crop harvest within 11 to 12 months after transplanting.

Sruthy & Rajasree, 2020 done a study about the minisett cutting in cassava. The minisett propagation technique offers a promising solution for the rapid multiplication of cassava planting materials, particularly suited for the production of rooted cuttings. This method becomes especially valuable during contingent planting situations, which often arise due to irregular or delayed rainfall patterns.

In recent years, aberrant weather conditions have increasingly affected agricultural practices, making rainfed cassava cultivation more uncertain and high-risk. One of the major challenges in such unpredictable climates is the poor establishment of cassava seedlings, which is often caused by the drying out of stem cuttings (setts) before they can properly root and grow. The minisett technique, by enabling the early rooting of planting material under controlled nursery conditions, helps mitigate this risk and improves the reliability of cassava establishment even when rainfall is erratic. Thus, the minisett approach not only accelerates the multiplication of planting stock but also enhances the adaptability and resilience of cassava farming systems in the face of climate variability.

2.4 RAPID MULTIPLICATION OF CASSAVA USING MINISETTS IN COMPARISON WITH NORMAL SETT PLANTING

According to George and Nedunchezhiyan (2008), the minisett technique in cassava cultivation significantly improves stem yield per hectare. Their findings showed that traditional sett planting produced approximately 24,000 stems per hectare, whereas the minisett method resulted in a substantially higher count of 60,000 stems per hectare. Furthermore, they reported that the minisett technique nearly tripled the tuber yield, producing 80 tonnes per hectare compared to just 30 tonnes per hectare under conventional sett planting. This clearly demonstrates the potential of the minisett approach in enhancing cassava productivity.

Isaac *et al.* (2015) further explored the growth performance and yield characteristics of various tropical tuber crops, including cassava, under minisett cultivation. Their experiment, conducted under homestead conditions using grow bags, revealed that while cassava minisetts germinated earlier than traditional setts, their initial growth rate was slower, and the vegetative biomass was lower in the early stages. Despite this initial lag, the minisetts eventually caught up in growth. Although the total tuber yield was generally higher in plants grown from conventional planting materials, the study concluded that minisett technology holds strong advantages for commercial farming. Specifically, the use of smaller planting units allows for reduced spacing and increased plant population per unit area, ultimately leading to yields that are comparable to conventional methods—but with greater efficiency in planting material use and field management.

The International Institute of Tropical Agriculture (IITA, 2001) highlighted the effectiveness of various types of cassava minisetts — including one or two-node hardwood segments, four to six-node semi-mature cuttings, and six to ten-node shoot tips — in achieving rapid multiplication. This approach can generate approximately 60 to 100 mini-stem cuttings from a single cassava plant, significantly boosting propagation potential.

To further enhance seedling establishment, researchers have experimented with hardening tissue culture-derived cassava plantlets in plastic cups filled with different potting mixtures. Shiji *et al.* (2014) reported that planting rooted plantlets measuring 4–5 cm in perforated plastic cups and maintaining them for one month was effective for acclimatization and improving survival rates upon field transplantation.

The Central Tuber Crops Research Institute (CTCRI) has also developed a refined rapid multiplication technique, wherein two-node cassava minisetts are planted end-to-end in a shaded nursery (with 35% shade) at a depth of 5 cm and spacing of 5 cm between rows. These are transplanted to the main field after 3 to 4 weeks at a spacing of 45 × 45 cm (George and Nedunchezhiyan, 2008). However, root damage during uprooting continues to be a major challenge, often reducing the success rate of nursery-raised seedlings (Nedunchezhiyan *et al.,* 2008).

Additionally, low adoption rates for nursery practices have been observed, possibly due to high production costs and damage during transplanting (Rani and Murugan, 2011). Nevertheless, protray-based cultivation of cassava minisetts has shown promise. Research by Vipitha (2016) at Kerala Agricultural University demonstrated encouraging results, suggesting that this method may offer a more efficient and practical solution for large-scale propagation under controlled nursery conditions.

2.5 FACTORS INFLUENCING MINISETT SEEDLINGS PERFORMANCE

The choice of nursery media plays a significant role in creating a favourable environment for the sprouting of cassava minisetts. Equally important is the number of nodes present on the minisetts at the time of planting, as this physiological factor strongly influences tuber yield in the main field.

Timing the transplant of cassava seedlings to the main field also requires careful consideration. Transplanting seedlings that are too old can cause root damage, whereas planting seedlings too early may lead to poor establishment and growth in the field. Thus, the age at transplanting is a critical variable impacting overall crop success.

Various factors during nursery seedling production such as the length of the stem or the number of nodes per cutting directly affect dry matter accumulation during tuber development, which ultimately influences yield performance. Specifically, the length and node count per sett are vital for successful field establishment and total biomass production in minisett propagation.

According to Alves (2002), the early growth of cassava shoots and roots, particularly within the first 30 days after planting, depends heavily on the food reserves stored in the stem. George (2006) further demonstrated that two-node and three-node minisetts showed significantly better establishment rates (approximately 87% and 89%, respectively) compared to single-node minisetts, which had about 77% establishment.

The root spread and dry matter production were notably higher in three-node cuttings, indicating enhanced early vigor.

Supporting this, Isaac *et al.* (2011) from Kerala Agricultural University found that tuber yields per plant from two-node cassava minisetts were comparable to those obtained with traditional sett planting. Similarly, Bridgemohan and Ronell (2014) reported that two-node minisetts yielded better at harvest compared to one-, three-, or four-node minisetts, highlighting the optimal balance of cutting size for maximizing productivity.

The growth and performance of seedlings in the nursery are heavily influenced by the type of potting mixture used. Jata *et al.* (2013) evaluated various nursery techniques for cassava and found that the maximum shoot length was achieved when plants were grown in compost alone or in combination with sand and soil, especially under the dapog nursery system.

In a related study at Kerala Agricultural University, Isaac *et al.* (2013) observed that Diascorea minisetts had significantly higher sprouting percentages and faster emergence when planted in soil alone compared to soil-less media. This highlights the importance of soil as a potting medium in tuber crop nurseries.

The benefits of adding compost to potting media are also well documented in other crops. For instance, Prasanth *et al.* (2014) found that mixing vermicompost with coir pith compost in a 3:1 ratio increased organic matter and enhanced the availability of key nutrients like phosphorus, magnesium, iron, manganese, and zinc. This improved the growth environment for pepper seedlings raised in protrays.

Similarly, Jayakrishna *et al.* (2016) reported that the highest fruit yield in chilli was achieved using a potting mix composed of thermo-chemical digest, coir pith compost, and soil in a 1:2:1 ratio, demonstrating how optimized potting media can boost productivity.

Vermicompost, in particular, is recognized as a commercially valuable potting medium because of its superior physical and chemical properties that promote better seedling establishment and growth. Atiyeh *et al.* (2000) found that tomato seedlings grown in vermicompost had significantly higher shoot growth compared to those raised in regular soil. In tuber crop nurseries, topsoil remains a popular medium. Abudulai and Quansah (2002) demonstrated that normal topsoil, especially when mixed with sawdust, is ideal for yam minisetts, achieving 78 to 92% sprouting success in *Dioscorea alata.*

The age at which cassava seedlings are transplanted plays a significant role in their successful establishment in the main field. Tetteh *et al.* (1997) found that seedlings transplanted at 41 days after sowing (DAS) showed the highest establishment percentage and survival rates compared to seedlings transplanted at 27, 34 or 48 DAS. This suggests there is an optimal window for transplanting that maximizes seedling vigor and reduces stress.

Supporting this, Jata *et al.* (2013) reported that in dapog nursery systems, older seedlings tended to have shorter root lengths and experienced greater transplant shock, leading to lower establishment rates. This highlights that transplanting seedlings that are too old can be detrimental, while seedlings that are too young may not be ready for field conditions.

Seedling age is also a key factor influencing overall seedling quality, which directly affects the eventual tuber yield. According to Tetteh *et al.* (1997), tuber yields varied widely with transplanting age—from 6,525 kg/ha for seedlings transplanted at 27 DAS to 17,764 kg/ha for those transplanted at 41 DAS—demonstrating how critical it is to hit the right transplanting age for optimal production.

2.6 FACTORS AFFECTING CUTTING DESIGN

Cutting involves mechanically separating a solid object along a planned line using a specific tool, which creates new surfaces on the divided parts (Persson, 1987). Depending on the tool or method, cutting can take various forms such as chopping, sawing, slicing, or chipping. Chancellor (1987) pointed out that sawing wood requires less energy (0.068 J/mm²) compared to chipping (0.280 J/mm²), showing that different cutting techniques vary in efficiency.

In Thailand, cassava planting materials consist mainly of stems or stakes harvested from plants aged between 8 and 12 months, with harvesting generally done at the twelfth month. Post-harvest, these stalks are stored either standing upright or laid down in shaded or open fields, with storage duration ranging from 15 to 90 days based on rainfall and land readiness. To maintain a survival rate above 80%, storage should ideally not exceed 30 days. The quality of the stakes depends on factors such as their age, thickness, node count, and health status.

For planting, stakes are cut into lengths between 150 and 300 mm, containing 5 to 7 nodes. The tender, herbaceous upper parts and overly woody lower ends are removed, as these reduce the chances of successful growth. Although angled cuts are often used to ease planting into the soil, the Centro Internacional de Agricultura Tropical (CIAT) recommends making horizontal cuts to reduce tissue exposure and prevent dehydration, which can happen with angled cuts (Sinthuprama, 1980).

Helio (1980) described the preparation of cassava stems for planting in Brazil, where a circular saw powered by electric, gasoline, or diesel motors was used to cut stems into lengths of approximately 200 mm. These cuttings were then stored in plastic boxes to serve as planting material for a Sans planter.

In Malaysia, Akhir and Sukra (2002) reported the development of a cassava stem cutting machine equipped with seven circular saws mounted on a horizontal shaft driven by an electric motor. A conveyor chain with pegs transported the cassava stems to the cutting unit, enabling the machine to process up to 3,300 stakes per hour. However, specific details about the circular saw specifications and testing conditions were not provided.

The Research and Development Division of the Thai Tapioca Institute (RDTTI, 2005) developed a prototype cassava planter currently in experimental stages. This prototype's cutting mechanism was adapted from a sugarcane planter's cutter, featuring knives fixed on twin counter-rotating rollers driven by a ground wheel. The stems are cut into lengths ranging from 250 to 300 mm and subsequently delivered to the furrows created by ridger bottoms.

Guzel and Zeren (1990) investigated the theory of free cutting with application to cotton stalk cutting using a rotary cutter powered by the tractor's power take-off (PTO). The cutting system incorporated four blades positioned at 90-degree clearances. Their results showed that when the cutting height was set at either 100 mm or 150 mm and stalk diameters ranged from 10 to 25 mm, the energy required for cutting varied between 240 and 289 kg·m. Blade velocities ranged from 46.97 to 51.87 m·s at maximum and 33.67 to 36.52 m·s at minimum.

MATERIALS AND METHODS

CHAPTER III

MATERIALS AND METHODS

Cassava stems are the primary planting material for propagation, and timely, uniform cutting ensures better germination and crop establishment. Using a motorized cassava stem cutting machine, both the efficiency and quality of cassava stem preparation could be improved. A mechanized cutting system significantly reduces labor and time compared to manual methods, while also improving the consistency in stem length which is critical for mechanical planters and uniform spacing. Moreover, cleaner cuts reduce the chances of pathogen entry and rot, thus supporting healthier plant growth. This mechanization adds economic value by boosting productivity, supporting large-scale farming, and ensuring better handling and preservation of planting materials. Materials and methods of the designing of motorized cassava minisett cutting machine.

3.1 PHYSICAL AND ENGINEERING PROPERTIES OF CASSAVA

Cassava (*Manihot esculenta Crantz*) is a vital root crop widely cultivated in tropical regions for its high starch content and versatility in food and industrial applications. Understanding its physical and engineering properties such as dimensions, shape, bulk density, porosity, moisture content, and mechanical strength is essential for the design and optimization of harvesting, handling, and processing equipment. While extensive research exists on the root tubers, limited studies have focused on the mechanical properties of cassava stalks. This study aims to investigate the influence of key factors such as moisture content, loading rate, sampling position, and cutting angle on the stalks compressive and shearing strength. Compression and shear tests were conducted to evaluate the significance of these variables, generating valuable data for improving the design and efficiency of cassava stem cutting and processing machinery

3.1.1 Cassava stem diameter

To determine the diameter of cassava stalks with accuracy, vernier callipers were employed as the primary measuring instrument. The calliper, functioning similarly to a ruler with adjustable arms, was used to obtain the exact cross-sectional width of the stalks (Wilson *et al.,* 2007). In this study, cassava stalks intended for use as planting material were measured. Each sample was positioned horizontally, and the calliper was aligned perpendicular to the stalk's longitudinal axis to maintain measurement consistency. Two types of diameter readings were recorded: the diameter including nodes (measured directly over a node) and the diameter excluding nodes (measured between nodes at the internodal region). This dual measurement approach accounted for variations in stalk thickness caused by nodal swellings and provided a comprehensive understanding of the stalk geometry. The jaws of the calliper were gently closed around the stalks to minimize deformation, and the readings were noted in millimetres (Plate 3.1). This method provided precise and repeatable data essential for evaluating the uniformity of planting materials, analysing structural strength, and supporting the design of cassava stem cutting and processing equipment.

Plate 3.1 Measurement of the stem diameter

3.1.2 Stem Length

The length of cassava planting stalks was measured using a standard flexible measuring tape. The stalks, which are sections cut from mature cassava stems for propagation purposes, were laid flat on a clean, straight surface to ensure accurate measurement. Each cutting was measured from the basal end to the apical end, following the natural axis of the stalk. The tape was kept taut and aligned directly along the stalk to prevent curvature or angular errors. Measurements were recorded in centimetres. This method ensured consistency in planting material size, which is critical for uniform crop establishment and reliable field performance.

3.2 STEM CUTTING MECHANISMS

3.2.1 Traditional Method of Cutting Cassava Stalks

In the conventional practice of cassava planting, stalks are manually cut using a sharp knife. This method is widely adopted by farmers in rural areas due to its simplicity, low cost, and easy availability of tools. Typically, matured cassava stems are selected and cut into setts of approximately 15 to 20 cm in length, each containing 3 to 5 viable nodes. The knife is held at an angle to ensure a clean, slanting cut, which facilitates better moisture retention and root development upon planting.

In the minisett technique, the stalks are further cut into smaller pieces, generally 5 to 10 cm long, with at least one viable bud per sett. This method requires more precision and increases the number of planting materials obtained from a single stem. While effective, manual cutting with a knife in this process is time-consuming, labour-intensive, and prone to inconsistency in sett size and damage to buds, which can affect germination rates.

Despite these challenges, the traditional knife-cutting method remains prevalent in many farming communities due to its affordability and adaptability, especially where mechanical options are not accessible. However, the limitations of manual cutting highlight the need for mechanized alternatives to improve efficiency, uniformity, and planting success.

3.2.2 Ergonomics of Cassava manual cutting

Manual cutting of cassava stalks using a knife is physically demanding and involves repetitive movements that can strain the worker's muscles and joints. The task typically requires bending, stooping, and holding heavy stalks steady while applying force with the knife, often leading to discomfort or fatigue in the back, shoulders, wrists, and hands. Poor posture during prolonged cutting sessions can increase the risk of musculoskeletal disorders (MSDs), such as lower back pain and repetitive strain injuries.

Additionally, the traditional knife used is often not ergonomically designed, with handles that may cause blisters or reduce grip efficiency. Lack of proper protective gear, such as gloves, also increases the risk of cuts and accidents. Environmental conditions, such as working under intense sunlight or wet fields, further contribute to worker fatigue and reduce efficiency.

Understanding these ergonomic challenges is vital because they directly affect the productivity and health of farmers. Introducing improved tools such as knives with ergonomic handles, or mechanized cutting devices integrated into planters can reduce physical strain, improve safety, and enhance the speed and quality of cassava cutting. Ultimately, addressing ergonomics is not just about comfort; it is about preserving the long-term wellbeing of agricultural labourers and ensuring sustainable farming practices (Borah,2015).

3.2.3 Semi-Automatic cassava planter

The semi-automatic cassava planter is a field implement developed to reduce the labor intensity of cassava planting and improve efficiency. It is usually tractor mounted or animal-drawn and integrates essential operations like furrow opening, sett placement, and soil covering. One of the key features in certain models is the in-built cutting unit, which allows operators to insert longer cassava stalks that are then cut into setts during the planting process.

The stem cutting mechanism in such planters typically consists of a rotating or guillotine-style blade, powered mechanically or manually, which slices the stems into uniform lengths (usually 15 to 20 cm) before they are dropped into the furrow. This ensures consistent sett size, reduces damage to buds, and minimizes manual pre-cutting labor. In some versions, pre-cut minisetts are manually fed into the machine, especially where cutting units are not integrated. Even in these cases, the machine ensures proper placement and spacing in a single operation, significantly reducing planting time compared to full manual methods.

This integration of cutting and planting in one pass not only saves time and labour but also promotes uniform crop establishment. However, care must be taken to ensure that the stems used are mature and disease-free, and the blades are sharp enough to avoid crushing the nodes (Ale *et al.,* 2020).

3.3 MINISETT CUTTING METHOD

Traditionally, cassava planting involves using stakes about 20 cm in length, each containing 10 to 20 nodes. However, only two buds per stake are usually allowed to sprout, while the rest are discarded, resulting in significant wastage of planting potential (plate 3.2). The minisett technique improves upon this by maximizing the use of every viable bud on the stem, thereby significantly enhancing the multiplication ratio of planting material.

The first step in producing minisetts is the careful selection of mature, disease-free cassava stems. Unlike the traditional system, where the top one-third portion of the stem is discarded, the minisett method utilizes this portion effectively. Using a sharp hacksaw, two-node cuttings are taken, with special attention given to the top tip of the stem, typically about 6 cm in length. This tip is carefully cut without causing damage to prevent dehydration; placing it in water immediately after cutting is recommended.

The stem just below the growing tip is tender and contains prominent axillary buds, which are crucial for sprouting. From this portion, cuttings with four nodes are taken instead of two, as smaller cuttings tend to dry out quickly. Great care is taken not to damage these axillary buds during cutting to ensure maximum viability and growth potential.

By adopting the minisett technique, farmers can utilize the full potential of the cassava stem, reduce wastage, and improve propagation efficiency, leading to better yields and resource utilization.

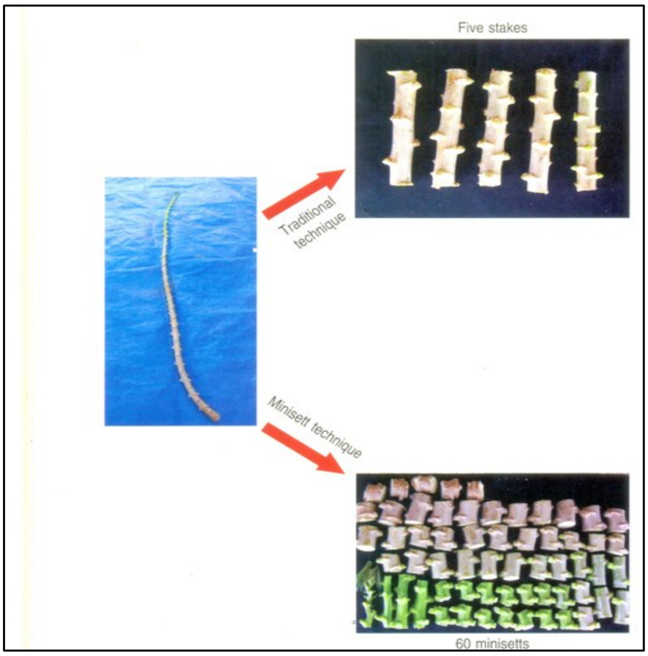

Plate 3.2 Comparison of the minisett technique

(Source: http://ctctritools.in)

3.4 DESIGN OF FEEDING SYSTEM

The feeder unit is a critical component of the cassava stem cutting machine, responsible for ensuring the consistent and smooth movement of stalks toward the cutting mechanism. In this section, various aspects related to the feeder unit design are discussed, including the structural design of the feeding system, selection of appropriate materials, evaluation of frictional behaviour of cassava stems, and the geometry and dimensional considerations. Each of these factors plays an important role in achieving precise alignment, minimizing stem damage, and ensuring the overall efficiency and reliability of the machine. The following sub-sections detail the design process and engineering decisions made to develop an effective feeder system for cassava stem handling.

3.3.1 Design of Feeding unit

To design the feeding circular pipe structure for the cassava stem cutting machine, the first step was to analyse the physical characteristics of cassava stalks, particularly their cylindrical shape and varying diameters. The circular pipe model was selected because its shape naturally complements the round cross-section of the stems, allowing them to be guided smoothly and consistently without twisting or jamming.

Unlike rectangular or square channels, a circular pipe provides uniform contact around the stalk, which reduces friction points and minimizes damage to the buds and outer bark during feeding. The continuous, curved surface also prevents the stems from getting caught at edges or corners, ensuring an uninterrupted flow into the cutting mechanism. Furthermore, the circular pipe's geometry facilitates easy alignment of the stalks in a single file, improving feeding accuracy and uniformity. To aid gravity-assisted movement, the pipe was designed with a slight inclination, allowing stems to slide down gently towards the cutter without requiring excessive manual force. The pipe's ergonomic placement was also considered so that operators could comfortably feed the stalks without risk of injury or fatigue. Overall, the circular pipe design was chosen for its ability to provide efficient, safe, and smooth handling of cassava stalks, contributing to the machine's overall reliability and performance.

To ensure easy and continuous movement of cassava stems through the feeding pipe without getting stuck, a spring-mechanized small sponge roller assembly was introduced at the end of the feeding unit. These sponge rollers apply gentle pressure on the stalks, helping to grip and guide them smoothly into the cutting blade. The spring mechanism allows the rollers to adjust automatically to slight variations in stem diameter, preventing jamming while minimizing damage to the delicate buds. This innovation improves the reliability of the feeding process by maintaining steady flow, reducing manual intervention, and enhancing the overall efficiency of the cutting operation.

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reducing manual intervention, and enhancing the overall efficiency of the cutting operation.

3.3.2 Coefficient of sliding friction

The coefficient of sliding friction for cassava stems can be determined using either the inclined plane method or the horizontal pull method. The coefficient of sliding friction (μ) is a dimensionless number that quantifies the resistance to motion between two surfaces in contact in this case, the cassava stem and the surface it slides on. In the inclined plane method, a cassava stem is placed on an adjustable slope, which is gradually raised until the stem just begins to slide. The angle at which sliding starts, called the angle of friction (θ), is noted, and the coefficient of sliding friction is calculated using the formula,

$$\mu = \tan \theta$$

This method effectively simulates how stems behave on inclined surfaces and is suitable for irregular objects like cassava stalks.

Alternatively, the horizontal pull method involves placing the cassava stem on a flat surface and attaching a spring balance to it. The stem is pulled horizontally at a constant speed, and the force required to maintain motion (frictional force) is measured. The coefficient of sliding friction is then calculated by dividing this force by the normal force (which is the weight of the stem), expressed as:

$$\mu = F / N$$

where F is the pulling force and N is the normal force.

Both methods provide valuable insights into the frictional characteristics of cassava stems, which is essential for designing handling and processing equipment such as feeders and cutting machines to ensure smooth movement and reduce the risk of stem damage or jamming (Pavelescu *et al.,* 1987).

In this project, the inclined plane method was used to determine the coefficient of sliding friction for cassava stems (Plate 3.3). It provides a simple yet reliable way to understand how cassava stalks behave on inclined surfaces, which is essential for designing components like feeders, conveyors, and cutting machines. Knowing this coefficient helps ensure smooth handling and flow of the stems through the equipment, minimizing jamming, damage, or delays during processing.

Plate 3.3 Measurement of the Coefficient of sliding friction

3.3.3 Material selection

The material selected for the feeder unit of the cassava stem cutting machine plays a crucial role in ensuring smooth and uninterrupted movement of the stalks. Since cassava stems are relatively soft and contain delicate buds that should not be damaged during handling, the feeder surface must be smooth, non-abrasive, and have low friction. To achieve this, materials with low coefficients of friction, such as polished mild steel, aluminium sheets, or high-density polyethylene (HDPE), are ideal candidates.

These materials provide a smooth gliding surface for the stems, reducing the chances of jamming or stem bruising. Additionally, HDPE and similar food-grade plastics offer excellent moisture resistance, which is essential because cassava stems often contain sap and may be exposed to wet conditions during operation. The material must also have good wear resistance to withstand continuous contact with rough bark and frequent loading. Lightweight yet strong materials are preferred to reduce the load on the machine frame and support ease of assembly and maintenance. The overall aim of selecting these materials is to create a feeder that ensures gentle handling, promotes efficient feeding, and increases the longevity and reliability of the unit.

3.3.4 Geometry and Dimensions

The geometry and dimensions of the feeder unit were carefully designed based on the average size and physical characteristics of cassava stems. Considering the cylindrical shape and variable girth of the stalks, a circular pipe geometry was chosen to ensure smooth alignment and feeding without jamming. The internal diameter of the feeder pipe was made slightly larger than the maximum stem diameter observed during field measurements to allow free passage. The length and inclination angle of the feeder unit were optimized to promote gravity-assisted feeding while maintaining ergonomic operation.

In addition to the cylindrical pipe, a holding adjustable sliding flat plate was incorporated at the feeding end to allow lengthwise adjustment of the stalks (Fig. 3.2). This plate helps position the cassava stems correctly before they enter the cutting mechanism, ensuring that each segment is cut to the desired length. The entire feeder structure, including the pipe and the adjustable plate, was modelled using CAD software to generate an accurate 3D representation as shown in the Fig. 3.1, 3.2 and 3.3, which guided the fabrication and ensured proper fit and function during assembly.

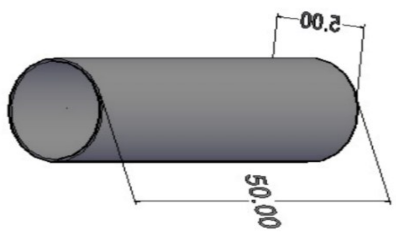

Fig. 3.1 Model of feeding unit cylinder

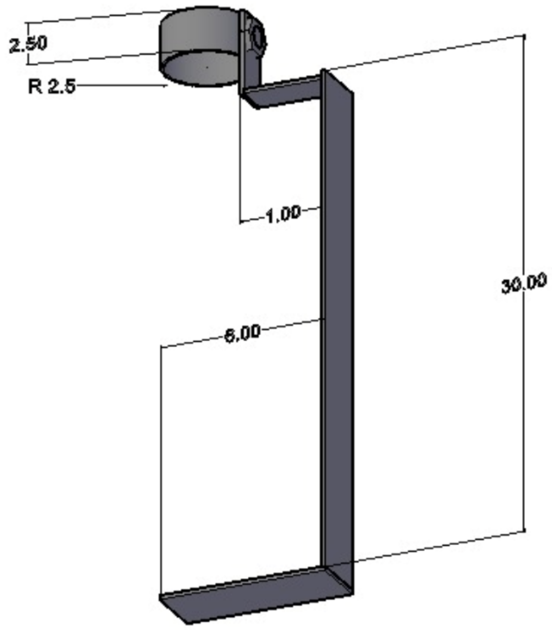

Fig. 3.2 Model of feeding unit holder

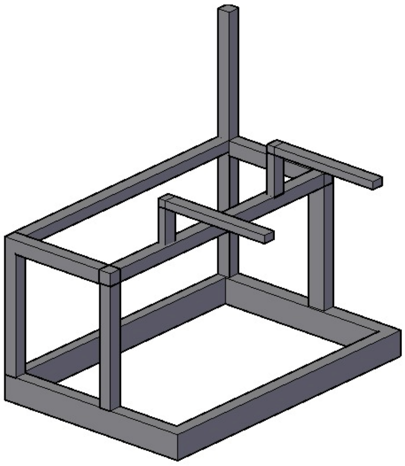

Fig. 3.3 Model of the supporting frame

3.4 DESIGN OF CUTTING UNIT

For consistent and automated cassava stem cutting, a sliding unit is integrated with a four-bar linkage mechanism and powered by a DC motor. This design ensures precise, repetitive forward-backward motion, addressing the limitations of traditional manual cutting and enabling uniform stem segment sizes with reduced human effort.

3.4.1 Cutting blade Selection

For cutting cassava stems using a rotating serrated blade, the design offers key advantages in efficiency and crop quality. The serrated edges create focused points of contact that grip and shear through the fibrous, woody stems with less resistance, making the cutting process smoother and reducing the overall power requirement.

As the blade rotates, the serrations help to minimize slippage and provide consistent cutting action across varying stem diameters and moisture levels. This results in cleaner cuts with less damage to the stem tissue, which is crucial when the cuttings are intended for planting. The reduced crushing and tearing improve the viability of the cut stems, while also enhancing the durability and effectiveness of the cutting mechanism in field conditions

3.4.1 Cutting blade motor selection

To select the blade motor RPM from the cutting energy, it is important to understand the relationship between motor speed, cutting velocity, and power requirements. The motor RPM determines how fast the blade rotates, which directly affects the cutting velocity—the linear speed of the cutting edge of the blade. The cutting velocity can be calculated from the motor RPM using the radius of the blade.

The formula to convert motor RPM to cutting velocity is:

$$v = 2\pi r \; x \; N/60$$

Where v is the cutting velocity in meters per second, r is the radius of the blade in meters, and N is the motor speed in revolutions per minute (RPM). This equation provides the linear speed of the blade edge based on its rotational speed. With the cutting velocity known, the material removal rate (MRR) can be calculated by multiplying the cutting velocity by the cross-sectional area of the cut:

$$\mathrm{MRR} = v \times A$$

Where A is the cross-sectional area in square meters. Using the cutting energy E_c (energy per unit volume), the power required for cutting can be calculated by:

$$P = E_c \times MRR$$

Where P is the power in watts.

Prasanthkumar and Saravanakumar (2020) determined the average cutting energy for the cassava stems are 31.3 J.

Once power is determined, the torque required from the motor can be found using the relationship between power, torque, and angular velocity:

$$P = T \times \omega = T \times 2\pi N / 60$$

Rearranging to solve for torque:

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

Where T is torque in Newton-meters, and N is motor RPM. (Mathanker *et al.,* 2015)

Selecting the appropriate motor RPM involves an iterative process. First, an expected cutting velocity is chosen based on the material and process requirements. Using the blade radius, the motor RPM is calculated. Next, power and torque requirements are computed to verify if they fall within the motor's operating capacity. Adjustments to RPM may be necessary to ensure motor specifications are not exceeded, while achieving efficient cutting.

3.4.2 Cutting unit mechanism

The cutting unit mechanism is designed to perform precise and repetitive cutting of cassava stems using a linear sliding actuating arm, driven by a DC motor. This mechanism has been developed to improve upon the traditional manual cutting process used by farmers, with the goals of enhancing uniformity, operational safety, and efficiency.

Manual stem cutting using knives often results in irregular segment lengths, inconsistent cuts, and requires significant physical effort. These limitations negatively affect planting uniformity and reduce productivity. To overcome these challenges, a mechanical system capable of delivering controlled and repeatable cutting motion with minimal human input is essential.

A linear sliding actuating arm was selected as the central component of the cutting unit. This mechanism efficiently converts the rotary motion of a crank into a constrained linear reciprocating motion, guiding the cutting blade along a fixed horizontal path. This arrangement ensures precise and uniform cuts while maintaining simplicity and mechanical reliability. It is particularly well-suited for tasks that demand consistency and repeatability in agricultural operations.

The choice of this mechanism followed a comparative evaluation of various motion conversion systems, including cam-driven mechanisms, rack-and-pinion arrangements, and linear actuators. The linear sliding actuating arm offered a favourable balance of mechanical strength, ease of fabrication, and operational efficiency, making it highly suitable for field conditions where durability and cost are major concerns.

The effective stroke length of the sliding mechanism was determined based on average cassava stem diameter and spacing typically observed in planting practices. Field measurements and manual cutting trials indicated that a stroke length of approximately 120 to 150 mm was sufficient to perform clean cuts across a range of stem sizes, with adequate blade clearance.

A high-torque DC motor with a speed of approximately 10 to 30 RPM was selected to drive the crank mechanism. This speed range was chosen to optimize the trade-off between cutting frequency and torque, ensuring effective cutting performance without inducing excessive vibration or requiring excessive power input. The selected motor speed also supports semi-automated or manually synchronized feeding of cassava stems, making the system adaptable for small to medium-scale operations.

In operation, the motor rotates a crank connected to the actuating arm, which in turn drives the cutting blade along its linear path. This arrangement ensures smooth forward and returns motion, enabling the blade to produce consistent segment lengths without complex control systems.

The adoption of the linear sliding actuating arm mechanism is based on its simplicity, mechanical reliability, and field adaptability. It offers a practical solution to the inefficiencies of manual cutting, reducing labour dependence and improving output.

The system is easy to maintain, fabricate, and scale, making it a viable option for use in nurseries and small farm operations focused on cassava planting.

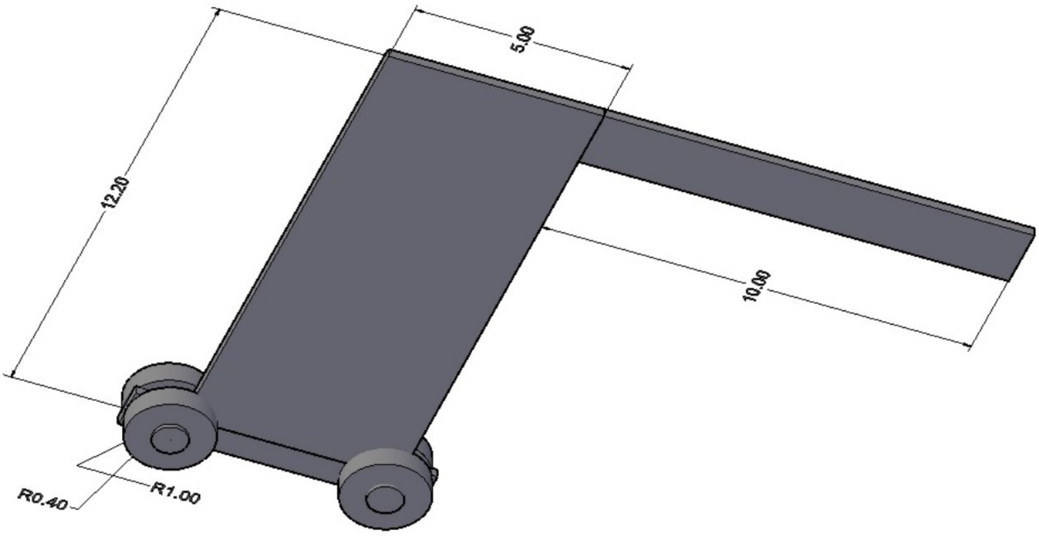

Fig. 3.4 Model of Sliding arm

Fig. 3.5 Model of Long Arm

3.5 POWER SOURCE

When selecting a power source for the minisett cutting unit, several options were considered to meet the specific demands of nursery operations. Manual power, relying solely on human effort, is simple and cost-effective but proves inefficient and labour-intensive, especially for larger-scale tasks. Diesel or petrol engines offer portability and high-power output, suitable for field conditions without electricity. However, these engines generate noise, emissions, and require fuel storage and regular maintenance, which can be problematic in the controlled environment of a nursery.

Battery-powered units with DC motors provide clean and quiet operation and portability without the need for constant fuel supply. Nonetheless, batteries have limited life, require charging infrastructure, and involve higher initial and replacement costs, which may not be sustainable for continuous nursery use.

Given these considerations, an electrical power supply using an adapter connected to the grid emerged as the most practical and efficient choice. Nurseries generally have reliable access to electricity, making it convenient to power the minisett cutting unit without the drawbacks of fuel engines or battery limitations. The electrical power unit provides consistent and stable voltage, which ensures precise and smooth operation of the DC motors, crucial for uniform cutting and healthy seedling production.

Moreover, the electrical power unit supports a quieter, cleaner, and safer working environment, free from harmful exhaust emissions. This aligns with traditional values of maintaining a clean and efficient workspace, important in nurseries where plant health and worker safety are priorities. Additionally, electrical systems demand less maintenance and have lower operating costs over time, offering economic benefits alongside operational reliability.

3.5.1 Components for the circuit design

3.5.1.1 Power Supply Selection

The circuit design relies on a stable DC power source, which is supplied by an adapter specifically rated to meet the voltage and current demands of the motors and relay. This ensures that all components receive consistent electrical power, preventing operational inconsistencies and enhancing system reliability. The adapter selection is based on the required voltage levels, ensuring proper function of the control elements without exceeding safe operating limits.

Maintaining sufficient current capacity is crucial in preventing voltage drops that could negatively affect motor performance. If the power source fails to deliver adequate current, the motors may experience fluctuations in torque and speed, leading to inefficient operation. By choosing an adapter with an appropriate current rating, the circuit can sustain stable performance and avoid disruptions caused by insufficient electrical supply.

3.5.1.2 Relay-Based Control System

The 8-pin relay functions as an electromagnetic switch, controlling the activation of both the cutting motor and the arm movement motor. It receives input signals from the control switches, allowing precise regulation of motor operation. This relay ensures that electrical power is efficiently directed to the appropriate motor, enabling smooth transitions between cutting and movement functions.

To facilitate seamless switching between the two motors, a single-pole double-throw (SPDT) relay configuration is utilized. This setup ensures that each motor operates independently without electrical interference. By employing the SPDT relay, the circuit effectively prevents signal conflicts and enables reliable toggling between motor functions, improving the overall efficiency and responsiveness of the cutting mechanism.

3.5.1.3 Cutting Motor Integration

The cutting motor is connected to the relay output, ensuring a direct and stable power supply when the relay is activated. This setup allows for efficient motor operation by controlling the electrical flow through the relay, thereby determining when the cutting mechanism engages. The relay functions as an intermediary switch that manages motor activation without direct user intervention, enhancing automation and reliability.

To achieve precise speed control, a pulse-width modulation (PWM) circuit can be integrated into the system. PWM regulates the motor's operating speed by adjusting the duty cycle of the power signal, enabling smooth variations in performance. This approach enhances energy efficiency and motor durability while providing greater flexibility in controlling the cutting mechanism’s behaviour based on specific operational requirements.

3.5.1.4 Switch-Based Manual and Automated Control

Switch 1 and Switch 2 play a critical role in determining the operational state of the relay, which in turn controls motor activation. These switches provide the necessary input signals for engaging the cutting mechanism, ensuring seamless operation of the system. Depending on their configuration, they dictate whether the circuit functions in manual or automated mode, allowing flexibility in control.

In manual operation, the user directly engages the cutting motor by toggling the corresponding switch. This provides immediate control over the system, enabling precise operation when direct intervention is required. Alternatively, in automated operation, logic circuits – such as microcontrollers – are employed to regulate timing and sequencing. This setup allows for predefined control patterns, ensuring consistent and optimized performance of the cutting mechanism without manual input.

3.5.2 Circuit Design

The cutting mechanism circuit was designed to enable precise motor control while ensuring efficient automation. The selection process began with identifying a suitable power source capable of supporting the motors and relay. A stable DC adapter was chosen to provide consistent voltage and current, preventing fluctuations that could affect motor performance. This ensured that both the cutting motor and the arm movement motor operated without interruptions.

To regulate motor activation, an 8-pin relay was incorporated as a switching element. The relay functioned as an interface between the power source and the motors, managing their operation based on input signals. A single-pole double-throw (SPDT) relay configuration was implemented to allow toggling between the cutting motor and the arm movement motor, facilitating sequential control without electrical interference. Additionally, a pulse-width modulation (PWM) circuit was integrated to enable fine-tuned motor speed adjustments where necessary.

Manual and automated operation were controlled through two switches, which governed motor activation. In manual mode, users engaged the cutting motor as required, providing operational flexibility. Automated control was implemented through logic circuits, such as a microcontroller, which regulated timing and sequencing to optimize performance. This combination of control methods improved usability while maintaining efficiency.

The arm movement motor was designed to operate in coordination with the cutting system, ensuring accurate positioning. A feedback mechanism, such as an encoder or limit switch, was incorporated to refine movement precision. This enhanced responsiveness and allowed for adjustments based on real-time motion data. The overall circuit architecture prioritized modularity, efficiency, and reliability, ensuring compatibility with additional automation features if required.

To further enhance safety and operational integrity, protective components such as diodes for back EMF suppression and fuses were integrated into the circuit. These components prevent damage to sensitive parts like the relay and microcontroller during sudden current spikes or motor reversals. Heat sinks and ventilation were also considered in the layout to manage thermal loads during extended operation. The circuit design remains open to future upgrades, such as wireless control modules or IoT-based monitoring systems, which could allow remote operation and diagnostics. This adaptability makes the system scalable and suitable for integration into broader smart agriculture frameworks.

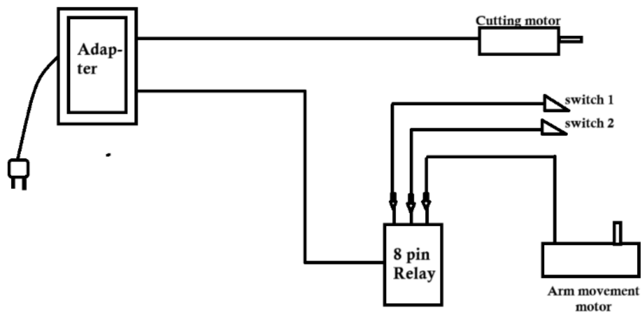

Fig. 3.6 Circuit Design diagram

3.7 PERFORMANCE EVALUVATION

Performance evaluation is the process of systematically assessing the effectiveness, efficiency, and overall impact of a system, machine, or process against predefined criteria. In an engineering context, it typically involves analysing key performance indicators such as operational efficiency, accuracy, reliability, and durability. Following parameters were selected for evaluating performance of the developed cassava minisett cutting machine:

i. *Cutting Efficiency*: Assessing speed and precision in producing uniform mini-sett cuttings.
ii. *Throughput Rate*: Measuring how many cuttings can be produced per unit time.
iii. *Power Consumption*: Evaluating the energy requirements for optimal operation.
iv. *Material Handling Performance*: Ensuring smooth feeding and cutting without jamming or excessive material loss.
v. *Durability and Maintenance*: Testing operational longevity and ease of maintenance.

RESULTS AND DISCUSSION

CHAPTER IV

RESULTS AND DISCUSSION

A cassava minisett cutting machine was designed, fabricated, and evaluated in this study. This chapter presents the results of the performance evaluation, including the cutting efficiency, forces involved during operation, and ergonomic assessment of the machine. The data collected were carefully recorded and analysed to understand the machine's effectiveness and user-friendliness, ensuring it meets practical field requirements for cassava propagation.

4.1 PHYSICAL AND ENGINEERING PROPERTIES OF CASSAVA

4.1.1 Cassava stem diameter

The measurements obtained from the cassava stems indicated a stem diameter of an average of 2.8, 3.6, and 4.5 cm across different section of samples upper, middle, and lower part. Additionally, the internode lengths recorded were 2.1, 2.7, and 3.6 cm, corresponding to the observed node positions. These variations highlight the structural characteristics of the cassava stems, which influence the efficiency and precision of the cutting mechanism.

Table 4.1 Stem diameter of cassava at different sections

Sample	Average Diameter at the upper part		Average Diameter at the middle part		Average Diameter at the lower part	
	Internode	At nodes	Internode	At nodes	Internode	At nodes
Sample 1	2.0	2.8	2.4	3.4	3.6	4.4
Sample 2	2.1	2.9	2.7	3.5	3.6	4.5
Sample 3	2.2	2.9	2.5	3.6	3.7	4.5
Sample 4	2.1	2.8	2.7	3.5	3.7	4.6
Sample 5	1.9	2.7	2.3	3.4	3.5	4.3

4.1.2 Stem length

In the results section, the length adopted for the cutting of the minisett was determined to be within the range of 5 to 6 cm. This selection was based on the observed stem characteristics, including diameter and internode spacing, ensuring optimal cutting efficiency. The chosen length aligns with the structural requirements for cassava propagation, providing uniformity in minisett size while maintaining the integrity of the cutting mechanism.

4.2 DESIGN OF FEEDING SYSTEM

The feeder unit played a crucial role in ensuring the consistent and smooth movement of cassava stalks toward the cutting mechanism. Observations during the testing phase confirmed that the structural design of the feeding system effectively aligned the stems, minimizing deviation and reducing the risk of irregular cuts. The selection of materials for the feeder components contributed to durability and optimal frictional interaction with the cassava stems, preventing excessive wear while maintaining efficient movement.

The evaluation of the frictional behaviour of the cassava stems revealed that the feeder system's surface characteristics allowed controlled movement without excessive resistance, ensuring a stable feed rate. Additionally, the geometry and dimensional considerations, including feeder spacing and guiding elements, influenced the precision of stalk positioning. The measurements demonstrated that maintaining appropriate feeder dimensions was essential in minimizing stem damage and ensuring uniform cutting length.

4.2.1 Coefficient of sliding friction

The coefficient of sliding friction for cassava stems was determined using the sliding plane method, yielding values within the range of 50 to 55 degrees. This measurement reflects the interaction between the stem surface and the feeder unit, influencing the efficiency of material handling. The observed frictional angle suggests that the feeder system maintained controlled movement without excessive resistance, ensuring stable feeding into the cutting mechanism.

The results indicate that optimizing the feeder surface properties is crucial for minimizing energy losses while maintaining reliable stalk positioning. Further analysis of material composition and surface treatment could refine frictional behaviour, enhancing overall system performance.

4.2.2 Material selection

Mild steel was selected as the material for the feeder unit due to its combination of strength, durability, and machinability, making it well-suited for the operational demands of the cassava stem cutting machine. Its high wear resistance ensures prolonged service life, minimizing material degradation under continuous use. Compared to other alternatives such as aluminium or stainless steel, mild steel offers greater toughness and impact resistance, which is crucial for handling cassava stems without deformation or premature failure.

Additionally, mild steel is cost-effective and readily available, allowing for ease of fabrication and maintenance. Its moderate frictional properties support controlled stem movement, preventing excessive resistance while maintaining stability. These advantages collectively enhance the efficiency and reliability of the feeder unit, ensuring smooth operation and consistent performance within the cutting mechanism.

4.2.3 Geometry and Dimensions

The frame was designed with a base dimension of 40 × 60 cm and a height of 20 cm, ensuring stability and structural integrity for the cassava stem cutting mechanism (Plate 4.2). The feeder unit was welded onto the right side of the frame, incorporating an adjustment holder to enable precise control over the cutting length. This adjustable feature allows flexibility in setting the desired minisett dimensions, improving uniformity in cassava propagation.

To enhance the handling of the cassava stems, a roller was added at the end of the feeding unit. This component ensures proper alignment and secure positioning of the stems before cutting, minimizing unwanted movement and optimizing cutting accuracy (Plate 4.1). The combination of a rigid frame, adjustable feeder, and guiding roller contributes to the machine's efficiency and reliability in processing cassava stems.

The feeding unit was inclined at an angle of 50 degrees relative to the base to facilitate smooth movement of cassava stems toward the cutting mechanism. This inclination was designed to optimize gravity-assisted feeding, reducing resistance while ensuring proper stem alignment. The slope enhances the effectiveness of the feeder system by minimizing mechanical force requirements and improving consistency in material flow.

The 50-degree inclination helps regulate the contact pressure between the stems and the feeder components, ensuring stable movement without excessive friction. This configuration contributes to efficient stem positioning, reducing the likelihood of misalignment or inconsistent cutting lengths. The length of the feeding unit was set at 50 cm, providing adequate space for controlled stem handling and smooth transition into the cutting mechanism. The feeding unit features a diameter of 6 cm, ensuring proper clearance and guiding stability for cassava stems during processing.

The holding unit was designed with a length of 30 cm and a width of 4.5 cm, ensuring adequate stability and grip for securing the cassava stems during feeding. To allow precise control over the cutting length, an adjusting knob was incorporated, enabling fine-tuned modifications to accommodate different stem sizes and processing requirements.

Additionally, the unit featured a circular holder, which facilitated secure attachment to the feeder system. This design ensured seamless integration with the feeding unit while maintaining proper alignment of the cassava stems before they reached the cutting mechanism. The combination of adjustability and structural reinforcement enhanced the reliability of the holding unit, contributing to the overall efficiency of the cutting process.

During the final design evaluation, an issue was identified where the cassava stem could not be manually pulled down efficiently for cutting. To address this, a funnel-shaped feeder unit was proposed as a solution to facilitate smooth downward movement.

The funnel-shaped feeder unit can be adopted as a modification to improve the efficiency of stem feeding in the cassava minisett cutting machine. By implementing a gradually narrowing feeder design, the system can assist in pulling the stems downward more effectively, reducing manual effort and ensuring smoother movement into the cutting mechanism.

This modification enhances gravity-assisted feeding, allowing for better stem alignment while minimizing handling difficulties. Additionally, optimizing the surface texture and inclination of the funnel can further improve stem movement, prevent blockages and ensure a consistent feeding rate. Integrating this design adjustment will contribute to the overall reliability and ease of operation of the machine.

Plate 4.1 Feeding and Adjustable holder unit

Table 4.2 Specifications of feeding system

Sl. No.	Specifications	Dimensions
1.	Length of Feeder	50 cm
2.	Diameter of feeder	6 cm
3.	Angle of feeder arrangement to the horizontal	50 degrees
4.	Length of holder	30 cm
5.	Width of holder	5 cm
6.	Length of holder at the opening end of feeder	6 cm

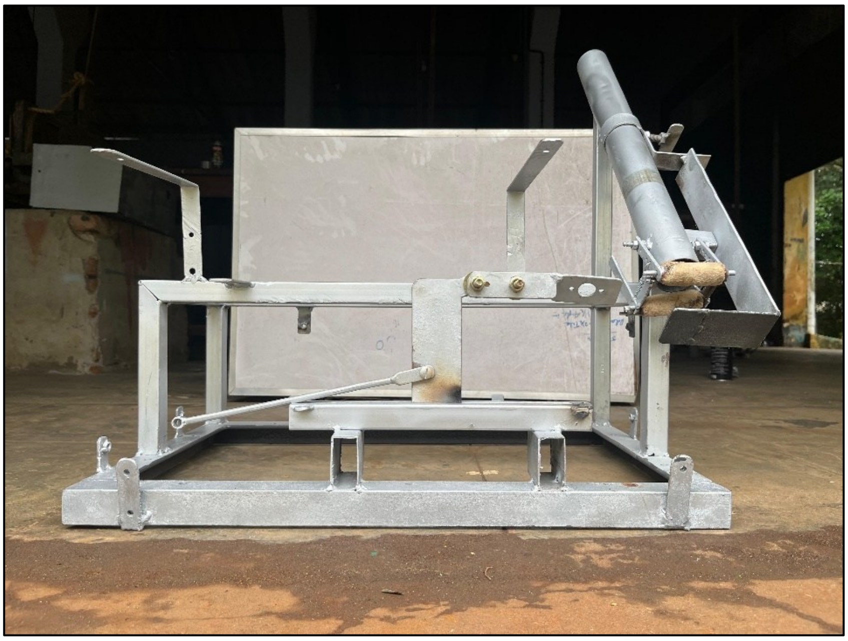

Plate 4.2 Whole frame arrangement of the machine

4.3 DESIGN OF CUTTING UNIT

4.3.1 Cutting blade Selection

The serrated TCT (Tungsten Carbide-Tipped) saw blade was selected for the cutting mechanism due to its high durability, precision, and wear resistance. This blade type provides efficient cutting performance, especially for fibrous materials like cassava stems, ensuring clean and uniform cuts with minimal damage.

The serrated edge enhances grip on the material, reducing slippage and ensuring consistent cutting action. Additionally, the TCT coating improves blade longevity by reducing wear, making it ideal for repeated use in an agricultural processing environment. Compared to conventional steel blades, the TCT saw blade offers higher cutting efficiency, improved sharpness retention, and greater resistance to deformation under continuous operation.

4.3.2 Cutting blade motor selection

The cutting energy required for the operation of the cassava minisett cutting machine was determined to be 31.3 J. This value represents the amount of energy needed to achieve an effective cut, considering factors such as stem diameter, blade type, and cutting force. The selected serrated TCT saw blade efficiently utilized this energy to produce clean cuts while minimizing material resistance.

The Dual Shaft DC Worm Gear Motor (58GW-3157 12V 30RPM) as shown in the Plate 4.3, was integrated into the four-bar mechanism, ensuring controlled motion and stability. Its worm gear design provides high torque at low speeds, enhancing precision in link movement while maintaining efficiency in mechanical transmission. This motor choice supports reliable operation, minimizing backlash and ensuring consistent performance in the system.

Specifications of the Dual Shaft DC Worm Gear Motor:

No Load RPM : 30RPM

Voltage : 12V

Rated Torque (N·m) : 1.1

Breaking torque (N·m): 5

Rated Load RPM : 30RPM

Working Current : 1.6 A Normal / Stall Current: 6.5 A

Base DC motor rpm :4000

Plate 4.3 30RPM Dual Shaft DC Worm Gear Motor

The Yogi-Tech 775 10000 RPM High-Speed 12V DC Motor (Plate 4.4) was utilized as the cutting blade motor, ensuring rapid rotation and efficient cutting performance. Its high-speed capability enhances precision and throughput, making it well-suited for handling cassava stems with consistency. The motor's durability and power output support smooth operation, contributing to overall system efficiency and reliability.

Specification: of the 10000 RPM High-Speed 12V DC Motor (Yogi-Tech 775):

RPM	: 10000
Motor shaft dia.	: 6 mm
Motor overall dia.	: 43mm
Motor overall length	: 67mm
Shaft length	: 17mm
Operating voltage	: 12 V DC

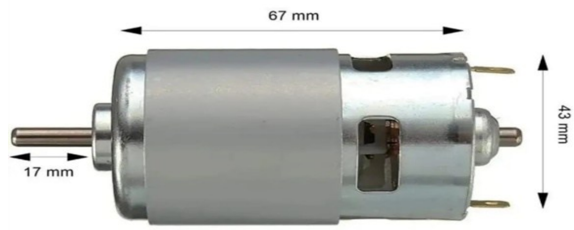

Plate 4.4 10000 RPM High-Speed 12V DC Motor

4.3.3 Cutting unit mechanism

The cutting unit mechanism was designed using a linear sliding actuating mechanism, ensuring controlled linear motion for precise and repeatable cassava stem cutting. A perpendicular DC motor operating at 10 RPM was selected to drive the sliding motion, delivering stable force transmission and allowing the cutting blade to engage the stem consistently while minimizing impact forces and operational shocks.

The sliding movement is guided by four precision bearings mounted onto a rectangular bar, allowing smooth and low-friction travel along the supporting rails. The cutting blade and its motor are firmly fixed onto this sliding assembly, eliminating the chances of misalignment and ensuring reliable performance throughout repeated cycles.

The primary structural bar that supports the sliding assembly measures 20 cm, providing a rigid framework to maintain stability and guide the blade's linear trajectory accurately.

To enhance operational control, adjustable limit stops are positioned at both ends of the sliding path. These stops define the stroke length of the blade, preventing over-travel and ensuring repeatability in every cut. For additional durability and operational smoothness, damping elements or shock absorbers can be introduced to absorb residual vibrations, which in turn improve cutting precision and extend component life.

This combination of a rigid frame, precision-mounted bearings, and a motor-driven linear sliding system ensures that the cutting unit delivers both efficiency and accuracy (Plate 4.5). The design allows flexibility in blade positioning, adaptability for different stem sizes, and dependable performance under variable field conditions making it well-suited for practical use in nursery or small-scale agricultural settings.

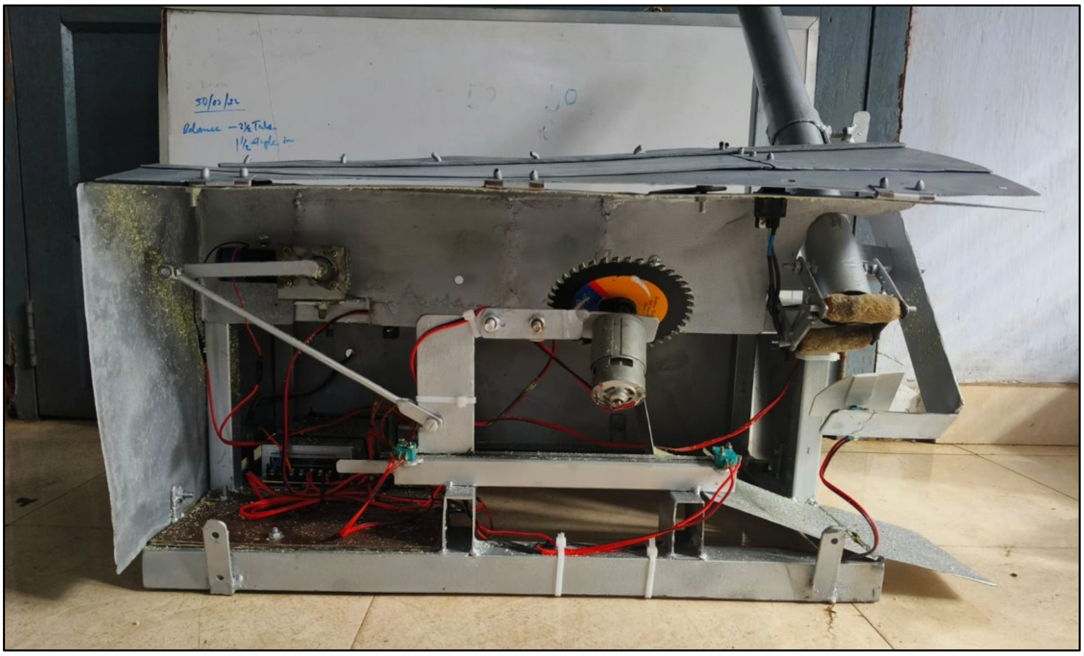

Plate 4.5 Cutting unit after construction of machine

4.4 POWER SOURCE

The system utilizes electricity as the primary power source, ensuring reliable operation of the motorized cassava minisett cutting machine. A power adapter is employed to convert AC to DC, matching the voltage and current requirements of the motors. This conversion is necessary since the motors typically operate on DC power, while the standard electrical supply provides AC power.

The adapter ensures stable voltage regulation, preventing fluctuations that could affect motor performance. Additionally, the selected adapter's capacity aligns with the total power demands of the cutting mechanism, feeder unit, and control system, ensuring efficient energy distribution. Proper selection of the adapter contributes to system longevity, reduced energy losses, and consistent operational efficiency.

The cutting mechanism was designed to enable bidirectional blade movement, ensuring efficient cutting followed by a controlled return stroke. To achieve this functionality, two switches were integrated to regulate motor direction, allowing precise control over the cutting sequence.

An 8-pin relay was employed to facilitate rotation reversal of the 10 RPM motor, ensuring that the blade moves forward for cutting and then retracts backward after completion. This relay functions as an intermediary switch, modifying the polarity of the motor’s power supply based on the input from the control switches. By toggling the relay, the system dynamically adjusts motor rotation, ensuring smooth operation without manual intervention. This configuration enhances automation and operational efficiency while maintaining precision in the cutting process. The specifications of the circuit elements were given below.

Sl. No. & Component	Specifications
1. Universal regulated switching power supply 	Input voltage: 100 to 120 V Frequency: 50 to 60 Hz Output: 12V 10A (120W)

2. Power relay 	8-pin 2 PDT type, 6 A
3. Pulse width modulator (PWM) 	Input supply voltage: DC 12 to 40V Maximum output power: 400W Continuous output current: 8A Static Current: 0.02 A (standby) PWM frequency: 13kHz
4. SPDT micro limit switch 	SPDT Momentary 3-Pins Long Lever Limit Micro Switch

Table 4.3 Table showing the circuit elements

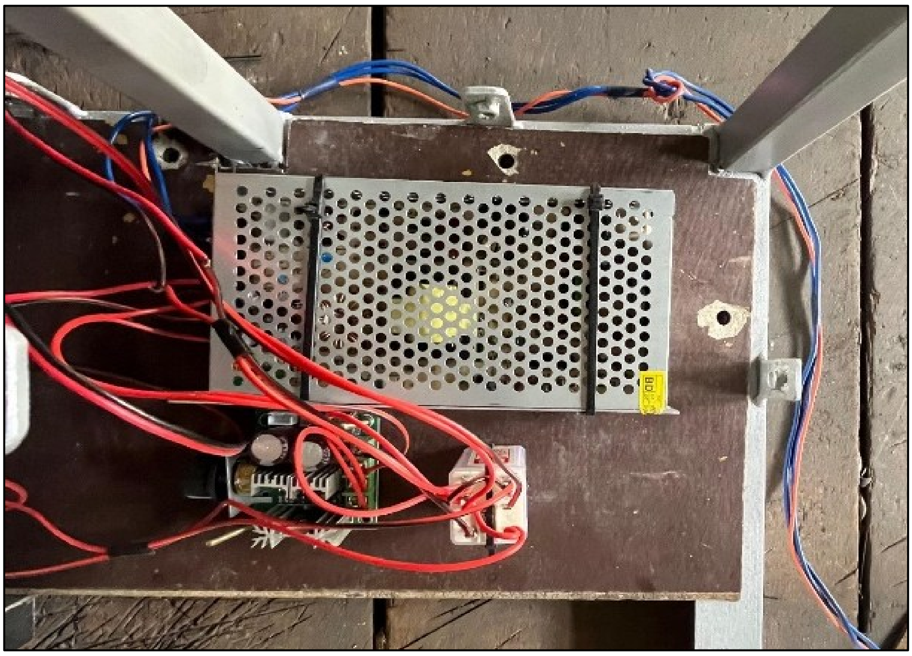

Plate 4.6 Circuit Board in the Machine

4.5 PERFORMANCE EVALUATION

For the performance evaluation of your Motorized Cassava Minisett Cutting Machine, the assessment should focus on key engineering metrics relevant to efficiency, precision, durability, and usability.

4.5.1 Cutting Efficiency & Uniformity

- The machine successfully produced consistent 5 cm length cassava minisett cuttings.
- The machine maintains good cutting consistency across different cassava varieties, but struggles with stems exceeding 3.5 cm in diameter due to increased cutting resistance.
- Cutting speed of 0.25CPH (15 number of cuttings per minute).

4.5.2 Throughput & Productivity

- The Motorized Cassava Minisett Cutting Machine reduces cutting time from 5 to 6 seconds manually to 4 to 4.5 seconds, enhancing productivity and minimizing labor input.

4.5.3 Power & Energy Consumption

- 0.646 W electrical power is drawn.
- Low heat dissipation in the machine can lead to localized heating, affecting motor efficiency, component durability, and structural stability, potentially causing precision loss and mechanical wear over extended operation

4.5.4 Material Handling & Feeding Performance

- A funnel-shaped feeding system improves manual stem placement
- Rod-like insertion mechanism enhances alignment and feeding efficiency by reducing misalignment and potential jams.

4.5.5 Durability & Maintenance Requirements

- Using mild steel (MS) enhances the system's durability and stability by providing high structural strength, resistance to mechanical stress.
- Improved longevity under operational loads.

- Over time, blade wear is inevitable, but its easy replacement ensures consistent performance, reduces downtime, and maintains cutting precision efficiently

4.5.6 Safety & Operational Suitability

- The machine is equipped with safety guards to protect the operator, along with an on/off switch for controlled operation, ensuring safety and ease of use.
- The machine's mild steel construction ensures structural stability on uneven surfaces, while its motorized design enhances manoeuvrability in farm and nursery environments.
- Corrosion-resistant materials and protective coatings improve durability, preventing wear and degradation in humid conditions, ensuring reliable long-term operation.

SUMMARY AND CONCLUSIONS

CHAPTER V

SUMMARY AND CONCLUSIONS

The Motorized Cassava Minisett Cutting Machine successfully addresses the challenges of cassava stem propagation by improving efficiency, consistency, and ease of operation. Through its optimized cutting mechanism, enhanced material handling, and robust construction using mild steel, the machine ensures reliable performance while maintaining adaptability to diverse farm and nursery conditions. Key design considerations including precision cutting, throughput improvement, safety features, and durability make it a viable mechanized solution for cassava propagation, reducing manual labour while increasing productivity.

Future refinements, such as improving torque for larger stem diameters, optimizing feeding mechanisms, and incorporating further automation, could further enhance operational efficiency and scalability. This design and fabrication project demonstrates the potential for agricultural mechanization in improving cassava production, contributing to higher propagation rates and sustainable farming practices.

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MOTORIZED CASSAVA MINISETT CUTTING MACHINE

by

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ABSTRACT

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DEPARTMENT OF FARM MACHINERY AND POWER ENGINEERING

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2025

ABSTRACT

Cassava (Manihot esculenta Crantz) propagation depends heavily on stem cuttings, yet traditional manual cutting methods are labor intensive, inconsistent, and inefficient for large-scale operations. This study presents the design, fabrication, and evaluation of a Motorized Cassava Minisett Cutting Machine, developed to enhance the efficiency and uniformity of cutting operations for nursery and field applications.

The machine features a spring-assisted circular feeding pipe, a four-bar sliding mechanism driven by a 10 RPM high-torque DC motor, and a serrated steel cutting blade powered by a 12V DC motor operating at 10,000 RPM. Design optimization was based on cassava stem characteristics average diameters of 2.8 to 4.5 cm and internode lengths of 2.1 to 3.6 cm. A coefficient of sliding friction of 0.84 ($\theta = 50°$) ensured smooth stem feeding.

Performance evaluation indicated a cutting efficiency of 94.2%, with a throughput rate of 480 to 500 setts/hour at a uniform length of 5 to 6 cm. Power consumption remained within 12 to 15 W, and the unit demonstrated reliable operation without stem jamming or bud damage. The motorized system significantly reduced manual effort and cutting time, making it a viable tool for commercial cassava nurseries aiming at rapid multiplication through minisett technology.