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Review Article

A Systematic Review of Enset (*Ensete ventricosum*) Sucker Propagation Techniques in Ethiopia

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Abstract

Enset (Ensete ventricosum), a staple food crop for over 20 million people in Ethiopia, plays a crucial role in the country's food security and agricultural systems. This systematic review aims to provide a comprehensive overview of the current practices, limitations, and prospects of enset sucker propagation techniques in Ethiopia. Traditional propagation methods, such as the use of suckers and corm pieces, have been the primary means of enset cultivation for generations. However, these techniques face challenges, including low success rates, disease susceptibility, and limited availability of quality planting materials. Modern propagation techniques, such as tissue culture and micropropagation, offer promising solutions to overcome these limitations by producing disease-free, genetically uniform suckers at a faster rate. Environmental factors, including temperature, humidity, soil quality, and water availability, significantly influence the success of enset sucker propagation. Additionally, genetic factors, such as cultivar selection and diversity, play a crucial role in determining the resilience and adaptability of enset plants to various agroecological conditions. Despite the challenges, successful case studies and best practices demonstrate the potential for optimizing enset sucker propagation through the integration of traditional knowledge and modern biotechnological approaches. Future research should focus on further understanding the complex interplay of environmental and genetic factors, developing region-specific propagation guidelines, and promoting the adoption of improved techniques among smallholder farmers. By addressing these aspects, Ethiopia can enhance the productivity and sustainability of enset cultivation, thereby strengthening food security and supporting the livelihoods of millions of people in the region.

Keywords: *Enset, Sucker propagation, Ethiopia, Vegetative propagation, Sustainable agriculture, Ensete ventricosum.*

Introduction

Enset (*Ensete ventricosum*), a member of the banana family (Musaceae), is indigenous to Ethiopia and plays a crucial role in food security, particularly in the densely populated southwestern highlands (Genene & Mekbib, 2016). The Ethiopian highlands rely on enset as the basis of their social and economic system, and it is primarily grown as a perennial crop (Merga *et al.*, 2019). Enset cultivation, processing, and utilization are embedded in traditional culture, conserving diverse enset genotypes (Borrell *et al.*, 2018). Farmers maintain many enset landraces, which exhibit a wide range of morphological, biological, and agronomical diversity (Yemataw *et al.*, 2017). The choice of enset planting material is largely based on farmers' cultural practices, and suckers are propagated through vegetative means from corm or pseudostem suckers (*et al.*, 1995). The traditional vegetative propagation techniques are low-input, simple, cheap, and effective; thus, they have remained in use even in high-population-density areas (Haile *et al.*, 2021). Vegetative propagation is the most common means of enset sucker propagation in Ethiopia, and understanding the current practices and challenges is essential for developing strategies to improve the system (Afza *et al.*, 1996). Wild enset (*Ensete ventricosum*) is the closest relative to cultivated enset and a source of genetic diversity (Borrell *et al.*, 2020). Despite its significance, the exploitation of wild enset has been a conservation concern due to habitat destruction and the

unsustainable collection of planting materials (Haile *et al.,* 2021). Establishing new enset farms from the wild is difficult, as it takes many years for wild enset to flower (Tesfamicael *et al.,* 2020). Unlike cultivated enset, which flowers profusely, wild enset flowering is rare, and farmers have never observed it (Matheka *et al.,* 2019).

Background and Importance of Enset in Ethiopia

Ethiopia is the center of origin and diversity for enset (*Ensete ventricosum*), which is a staple food for more than 20 million people in the country (Genene & Mekbib, 2016). Enset-based farming system continues as one of the major agricultural systems in Ethiopia and provides food security for millions of people (Borrell *et al.,* 2020). Enset is a drought-tolerant, nutrient-rich, vegetatively propagated multipurpose crop. Enset dominates the farming systems in the southern and southwestern parts of Ethiopia with the presence of other crops and livestock (Merga *et al.,* 2019). Enset is a clonally propagated monoculture crop with the prevalence of multiple accessions per farm. The sudden collapse of enset in a locality puts farmers at risk for total loss of food (Baker and Simmonds, 1953). Sucker propagation is among the options to manage enset diseases (Kusse, *et al.*, 2021). However, unlike the advances in asexual propagation, very little is known about the prior research works regarding sucker propagation in enset(Mekuria, *et al.*, 2016).

Systematic review is a useful tool to give insight into what is known and unknown about a particular research area (Diro, *et al.,* 2004). Therefore, this review aims to provide a comprehensive overview of the prior research works in Ethiopia regarding enset sucker propagation techniques. It also highlights the research gaps and future directions for the consideration of researchers, policymakers, and funding agencies.

Purpose and Scope of the Review

Enset or false banana (*Ensete ventricosum*) is a perennial, monoecious, herbaceous, and traditional cash food crop of Ethiopia (Anteneh *et al.,* 2016). It belongs to the family of Musaceae, which is characterized by a pseudostem with a large rosette of entangled petioles, large leathery leaves with prominent midrib and reticulate venation, and starchy finger-like fruits (Yemataw *et al.,* 2016). Ethiopia is believed to be the center of origin and diversity for enset with diverse agroecological growing environments (Borrell *et al.,* 2018). Enset is a major staple food crop of over 20 ethnic groups in the southern, southwestern, and western parts of the country (Genene & Mekbib, 2016). The enset cultivation area in Ethiopia is about 495,964 hectares of land, with annual productivity of about 11,668,367 MT of enset biomass. Enset is a drought-resistant food security crop with a multipurpose value (Genene & Mekbib, 2016). The immature enset pseudostems and leaf parts are used for animal fodder and the corm, pseudostems, and leaf sheaths are sources for various household equipment and tools. Enset has a unique fermentation-based food preparation system (Yemataw *et al.,* 2016).

In Ethiopia, natural sucker propagation of enset is very low (less than 1%) due to the biotic and abiotic factors affecting flower and fruit set development (Yemataw *et al.,* 2017). From the 37 Musaceae family members, only enset and banana are diploid (2n=22) members, and the others are polyploid and aneuploid, thus making banana tissue-cultured suckers not suitable for enset (Genene & Mekbib, 2016). Enset sucker propagation is time-consuming and laborious, taking about 8-17 years from a sucker to an early maturity-producing sucker stage (Afza, *et al.,* 1996). During this period, many biotic and abiotic factors can kill enset plants and newly produced suckers (Taye, 2017). Recently, to diversify propagation techniques, biotechnological approaches on enset have been initiated, and research outputs on in vitro, micropropagation, somatic embryogenesis, infection and regeneration, and genetic transformation are documented (Matheka *et al.,* 2019). This review paper attempts to systematically review the currently available enset sucker propagation techniques and their research gaps and future research directions (Diro *et al.,* 2004).

Botanical Description of Enset

Enset (*Ensete ventricosum*) is a perennial herbaceous plant that plays a crucial role in the agricultural systems of Ethiopia, particularly in terms of its nutritional and economic significance (Kusse *et al.,* 2021). It is native to the Ethiopian highlands and is commonly referred to as the 'false banana' due to its resemblance to the banana plant (Genene & Mekbib, 2016). Enset is characterized by a large pseudostem, broad and elongated leaves, and a unique underground corm that serves as an important food source for local communities (Acero *et al.,* 2018). The plant can grow up to 10 meters tall, with its leaves reaching lengths of up to 3 meters. Enset plays a critical role in the agricultural practices of Ethiopia, where it is cultivated extensively for its edible corm and leaves (Genene & Mekbib, 2016). This versatile plant, known for its resilience to adverse climatic conditions, serves as a staple food source for many communities. Its unique characteristics, such as its high carbohydrate content and nutritional value, make it an essential crop for food security in the region (Yemata, 2020). These attributes not only contribute to its popularity among farmers but also highlight its potential role in enhancing agricultural resilience in Ethiopia (Getachew *et al.,* 2016). Furthermore, the unique botanical characteristics of Enset, such as its robust root system and adaptability to diverse climatic conditions, make it a vital crop for smallholder farmers (Borrell *et al.,* 2018). Understanding these features is essential for developing effective propagation techniques that can ensure the sustainability of Enset cultivation in Ethiopia (Diro, *et al.,* 2004). This understanding not only contributes to the academic knowledge of Enset but also aids farmers in optimizing their

practices, thus enhancing productivity and promoting food security in the region (Kusse, *et al.*, 2021). Furthermore, understanding the botanical characteristics of Enset, such as its growth habits, root structure, and environmental requirements, is essential for developing effective propagation techniques that can be implemented by local farmers (Diro, *et al.*, 2004).

Ecological Distribution and Importance

Enset (*Ensete ventricosum*) thrives in specific ecological zones of Ethiopia, where its growth is closely linked to various environmental factors such as altitude, rainfall, and soil type (Tesfamicael *et al.*, 2020). These factors contribute to the plant's ability to adapt to its environment, making it a crucial crop for food security in the highland regions (Genene & Mekbib, 2016). Enset is particularly resilient to drought, and its cultivation supports both local economies and biodiversity (Borrell *et al.*, 2018). This characteristic makes it a vital crop for food security, particularly in regions prone to climate variability (Borrell *et al.*, 2018). Furthermore, enset's ability to thrive in diverse ecological conditions underscores its significance as a staple food source in Ethiopia (Baker and Simmonds, 1953). This adaptability not only enhances food security but also supports the livelihoods of many rural communities (Genene & Mekbib, 2016). Enset's resilience to climate variability further emphasizes its role in sustainable agriculture (Borrell *et al.*, 2018). This adaptability allows enset to thrive in a variety of ecological conditions, making it a vital crop for food security in the face of changing climate patterns (Kusse, *et al.*, 2021). This resilience is particularly crucial for communities in Ethiopia, where enset serves not only as a staple food source but also plays a significant role in cultural practices and agricultural sustainability (Borrell *et al.*, 2018). Furthermore, the ecological distribution of enset is closely linked to its adaptability to various agroecological zones, which enhances its importance in sustaining food security and preserving local biodiversity (Borrell *et al.*, 2020). This adaptability allows enset to thrive in diverse conditions, making it a resilient crop that can contribute significantly to the livelihoods of rural communities in Ethiopia (Ayenew, 2016).

Sucker Propagation Methods

Sucker propagation methods for Enset (*Ensete ventricosum*) play a crucial role in the successful cultivation of this important Ethiopian crop, encompassing a variety of techniques that influence growth rates, plant health, and overall yield (Diro *et al.*, 2004). These methods range from traditional practices to modern techniques, each with its advantages and limitations (Nadeem *et al.*, 2019). For instance, vegetative propagation through suckers and tissue culture has gained popularity due to its efficiency and reliability in producing healthy suckers (Aighewi *et al.*, 2015). Furthermore, factors such as soil quality, water availability, and environmental conditions significantly impact the success of these propagation methods (Tolla, *et al.*, 2021). These factors play a crucial role in determining the overall health and vigor of Enset suckers, which are essential for successful cultivation (Afza, *et al.*, 1996). Understanding these factors enables researchers and practitioners to fine-tune propagation techniques, thereby enhancing the quality and yield of Enset crops essential for food security in Ethiopia (Diro, *et al.*, 2004). This understanding is crucial for developing sustainable agricultural practices that not only improve the propagation of Enset suckers but also contribute to the resilience of local farming systems against climate variability (Kusse, *et al.*, 2021).

Traditional Propagation Techniques

Traditional propagation techniques for Enset (*Ensete ventricosum*) have been utilized for generations in Ethiopia, relying primarily on vegetative methods that ensure the preservation of desirable traits and adaptability to local environmental conditions (zerihnun *et al.*, 2017). These techniques typically involve the use of suckers or offshoots from parent plants, which are carefully selected for their vigor and disease resistance (Martínez-Gómez *et al.*, 2008). Farmers often prefer these methods due to their simplicity and the ability to produce suckers that are genetically identical to the parent plant, thus maintaining the quality of the crop (Ashango, 2017). Additionally, traditional practices emphasize the importance of timing and environmental conditions to maximize success rates (Feng *et al.*, 2017). These factors play a critical role in ensuring the germination and establishment of healthy suckers, which are essential for sustainable cultivation practices. In traditional propagation techniques, factors such as soil quality, moisture levels, and temperature must be carefully managed (Vetrano *et al.*, 2020). Furthermore, the selection of healthy parent plants plays a significant role in the success of propagation, as it directly influences the genetic quality of the suckers produced (Hamill, *et al.*, 2009). Local knowledge and practices, often passed down through generations, contribute to optimizing these conditions for enset cultivation (Ashango, 2017). These traditional methods, which include techniques such as seed selection, transplanting, and soil management, play a crucial role in enhancing the growth and resilience of enset suckers (Karlsson *et al.*, 2014). By understanding the environmental conditions and local soil types, farmers can effectively implement these practices to improve yields (Borrell *et al.*, 2020). Additionally, incorporating traditional methods such as selecting the right seed varieties and utilizing local knowledge can further enhance the effectiveness of these propagation techniques (Masoni *et al.*, 2019). These techniques, rooted in centuries of agricultural practice, often result in suckers that are better adapted to local environmental conditions (Franco *et al.*, 2006). Furthermore, engaging with local farmers to gather insights about their experiences can lead to improved propagation strategies (Druege, 2020). This collaboration can enhance the understanding of the factors affecting sucker growth and survival rates, ultimately contributing to the development of more effective propagation techniques tailored to the local environment (Park *et al.*, 2021). By integrating traditional

knowledge with modern scientific approaches, researchers can identify the optimal conditions for enset sucker propagation (Mekuria, *et al.,* 2016). This may include examining soil types, moisture levels, and local climatic conditions that influence growth (Diro, *et al.,* 2004). Understanding these factors is crucial for optimizing propagation methods and enhancing sucker viability in diverse environments (Kusse, *et al.,* 2021). This knowledge not only aids researchers and practitioners in selecting appropriate techniques but also ensures that suckers can thrive in their native habitats (Franco *et al.,* 2006). Furthermore, examining the socio-economic implications of these traditional methods can offer insights into their sustainability and the role they play in local agricultural practices (Alexander *et al.,* 2009). This examination can highlight the efficiency of such techniques in enhancing sucker growth and ensuring a stable supply of Enset (Kudama *et al.,* 2022). Additionally, understanding these practices helps to identify potential areas for improvement and innovation within local farming systems (Kudama, *et al.,* 2022). This understanding can guide researchers and practitioners in developing more effective propagation strategies that enhance sucker survival and growth rates.

Modern Propagation Techniques

Modern propagation techniques for Enset (*Ensete ventricosum*) have gained prominence in Ethiopia due to their potential to enhance sucker production and improve crop yields (Karlsson *et al.,* 2013). These techniques, including tissue culture, sucker grafting, and micropropagation, offer significant advantages over traditional methods by increasing the number of viable suckers and ensuring their resilience against common diseases and environmental stresses (Abenezer, 2019). Moreover, these methods not only expedite the propagation process but also enable the production of genetically uniform suckers that exhibit desirable traits, such as faster growth rates and improved drought resistance (Corbineau *et al.,* 2023). This advancement represents a significant step forward in enhancing the overall productivity of Enset cultivation in Ethiopia (Genene & Mekbib, 2016). By incorporating modern propagation techniques, such as tissue culture and micropropagation, researchers and farmers can significantly improve the efficiency of sucker production (Tolla, *et al.,* 2021). These methods not only expedite growth rates but also enhance the genetic uniformity of the suckers, leading to more reliable yields (Birmeta *et al.,* 2022). This is particularly important in the context of Enset propagation, where maintaining uniformity can significantly impact the success of cultivation practices across diverse agroecological zones (Diro, *et al.,* 2004). Consequently, the implementation of modern propagation techniques, such as tissue culture and micropropagation, can enhance the efficiency of sucker production and ensure that high-quality plant materials are available to farmers (Birmeta *et al.,* 2022). These methods not only facilitate faster propagation but also help in the conservation of genetic diversity (Tolla, *et al.,* 2021). Furthermore, by adopting these advanced techniques, stakeholders can achieve a more sustainable and productive enset farming system, which is crucial for improving food security in Ethiopia (Kudama, *et al.,* 2022). This is particularly important in regions where enset serves as a staple food source, as it can help mitigate the impacts of climate change and enhance the resilience of local farming communities (Kusse, *et al.,* 2021). By adopting modern propagation techniques, farmers can increase sucker survival rates and improve overall yields, thereby ensuring a more sustainable food supply (Acevedo *et al.,* 2020). These techniques not only enhance the quality of the suckers but also contribute to the resilience of local agricultural systems in the face of climate change (Hampton *et al.,* 2016) As such, they play a crucial role in improving crop yields and ensuring food security for communities that rely heavily on enset cultivation (Borrell *et al.,* 2020). These techniques include the use of tissue culture, grafting, and innovative sucker management practices that enhance the growth and survival rates of enset plants (Diro, *et al.,* 2004). These techniques include the use of tissue culture, grafting, and innovative sucker management practices that enhance the growth and survival rates of enset plants (Crop Variety Register, 2023). Among these methods, tissue culture has emerged as a particularly effective way to produce disease-free suckers at a large scale, thereby ensuring a consistent supply of high-quality planting material (Struik, 2018). This technique not only allows for rapid multiplication of suckers but also minimizes the risk of contamination, which is a common challenge in traditional propagation methods (Tolla, *et al.,* 2021). Furthermore, advancements in bioreactor technology have enabled large-scale production, making it feasible for farmers to obtain sufficient quantities of suckers to meet their agricultural needs (Debnath, 2009). This method not only enhances the efficiency of sucker production but also improves genetic uniformity, which is crucial for successful cultivation (Tolla, *et al.,* 2021). Additionally, these techniques often incorporate advanced technologies such as tissue culture and hydroponics, which can significantly shorten the time required for germination and establishment of suckers (Nirmal, *et al.,* 2023).

Factors Affecting Sucker Propagation

Several factors significantly influence the sucker propagation of Enset, including environmental conditions, seed quality, and propagation techniques employed by farmers (Afza, *et al.,* 1996). These factors interplay to determine the success rate of sucker establishment, particularly in varying agro-ecological zones across Ethiopia (Mekuria, *et al.,* 2016). Understanding these factors is crucial for optimizing propagation techniques and enhancing the overall productivity of Enset cultivation (Genene & Mekbib, 2016). Key variables include soil quality, water availability, and temperature fluctuations, which can significantly influence sucker growth and survival rates. Additionally, factors such as the availability of quality seeds, pest management practices, and the knowledge and experience of farmers also play crucial roles in determining the success of propagation techniques. Moreover, environmental conditions such as soil quality, moisture availability, and temperature can significantly influence the germination and growth rates of Enset suckers

(Diro, *et al.*, 2004). Understanding these factors is essential for optimizing propagation strategies and ensuring the sustainability of Enset cultivation in Ethiopia (Karlsson *et al.*, 2014). By examining the interplay of environmental conditions, genetic diversity, and management practices, researchers can identify the most effective methods for enhancing sucker quality and survival rates (Borrell *et al.*, 2020). This analysis will provide valuable insights into the specific conditions that promote optimal sucker development, thereby contributing to sustainable agricultural practices and food security in the region (Farooq *et al.*, 2019). Understanding these factors is crucial for enhancing propagation success rates and ensuring the resilience of Enset cultivation in the face of environmental challenges (Borrell *et al.*, 2020). Factors such as soil quality, water availability, and temperature play a significant role in the development of healthy Enset suckers (Borrell *et al.*, 2020). Additionally, the timing of planting and the methods used for propagation must be carefully considered to optimize growth conditions (Mekuria *et al.*, 2016). Moreover, factors such as soil quality, water availability, and the choice of propagation technique can significantly influence the success rate of sucker establishment (Pali and Sharma, 2020). It is essential to evaluate these variables in the context of local environmental conditions to ensure the health and viability of Enset suckers (Afza, *et al.*, 1996). Understanding these factors can help in the development of optimized propagation strategies that are tailored to specific regions, ultimately leading to improved yields and sustainability of Enset cultivation (Kusse, *et al.*, 2021). By examining environmental conditions, such as soil type and moisture levels, as well as agronomic practices, researchers can identify optimal conditions for Enset sucker growth (Tensaye, *et al.*, 1998). This will not only enhance propagation efficiency but also support the adaptation of Enset cultivation to changing climatic conditions (Borrell *et al.*, 2020). Additionally, understanding these factors is crucial for developing robust strategies aimed at optimizing the growth conditions for Enset suckers, thereby ensuring sustainable agricultural practices (Kusse, *et al.*, 2021).

Environmental Factors

Environmental factors play a crucial role in the successful propagation of Enset suckers, influencing their growth, development, and overall productivity (Kusse, *et al.*, 2021). Several key environmental factors, including temperature, humidity, light availability, and soil conditions, significantly impact the germination and establishment of suckers (Kusse, *et al.*, 2021). These factors must be carefully monitored and optimized to enhance the success rates of Enset propagation efforts (Corbineau, *et al.*, 2023). Key environmental factors such as temperature, humidity, light intensity, and soil moisture significantly influence the germination and growth of Enset suckers (Diro, *et al.*, 2004). Understanding these parameters is crucial for developing effective propagation techniques that ensure high-quality suckers and successful establishment in the field (Karlsson *et al.*, 2013). These factors include temperature, humidity, soil composition, and light availability (Corbineau *et al.*, 2023). By examining how each of these elements influences sucker growth and survival, researchers can identify optimal conditions for propagation (Park *et al.*, 2021). These conditions may include factors such as temperature, humidity, light availability, and soil quality, which are crucial for the successful establishment of suckers in various environments (Park *et al.*, 2021). In particular, temperature plays a significant role in sucker growth, with optimal ranges varying for different stages of development (Corbineau, *et al.*, 2023). Furthermore, humidity levels can affect water availability, which is essential for the proper hydration of suckers (Park *et al.*, 2021). Light availability is another critical factor, as it influences photosynthesis and overall plant vigor (Raza *et al.*, 2023). Lastly, soil quality, including its nutrient content and pH, directly impacts root development and sucker health (Ayu *et al.*, 2021). These factors not only influence the growth rate of suckers but also their resilience to environmental stresses (Herrera *et al.*, 2015). Understanding these environmental factors is crucial for optimizing propagation techniques, as they determine the availability of crucial resources such as water and nutrients, which directly impact sucker development and survival rates (Franco *et al.*, 2006). Among these factors, temperature and humidity levels play a significant role in influencing the germination rates and growth patterns of Enset suckers (Corbineau, *et al.*, 2023). Variations in these environmental conditions can lead to substantial differences in the success of propagation methods employed across different regions of Ethiopia (Genene & Mekbib, 2016).

Genetic Factors

Genetic factors play a crucial role in the propagation of Enset (*Ensete ventricosum*) suckers, influencing traits such as growth rate, disease resistance, and adaptation to local environmental conditions (Tesfamicael *et al.*, 2020). These genetic factors can determine the success of propagation methods and ultimately influence the yield and quality of the harvested Enset plants (Kusse, *et al.*, 2021). Understanding the genetic diversity of Enset suckers is essential for selecting the most suitable varieties for cultivation in different regions of Ethiopia (Borrell *et al.*, 2020). This diversity can influence growth rates, disease resistance, and overall yield potential (Haile, *et al.*, 2021). Therefore, conducting comprehensive genetic analyses is crucial to identify traits that contribute to successful propagation methods (Hodson *et al.*, 2020) These analyses can reveal the genetic diversity present in Enset populations, which may influence their adaptability to different environmental conditions and ultimately enhance propagation success (Negash *et al.*, 2002). Understanding these genetic variations is crucial for developing effective propagation strategies that can leverage the inherent strengths of different Enset varieties, thereby promoting sustainable agricultural practices in Ethiopia (Getachew *et al.*, 2021). Furthermore, these genetic factors can influence traits such as disease resistance, drought tolerance, and growth rate, which are essential for enhancing the productivity of Enset cultivation (Kutoya *et al.*, 2021). These traits not

only contribute to the overall health and resilience of the plants but also play a crucial role in the adaptation of Enset to varying environmental conditions (Borrell *et al.*, 2020). Understanding the genetic diversity within Enset populations can aid in selecting superior genotypes for propagation (Altieri, 2004). This understanding is crucial for developing effective propagation strategies that enhance both yield and resilience against environmental stresses (Nurebo, 2017). By considering the genetic diversity present in Enset varieties, researchers can identify traits that contribute to superior growth and adaptability (Tesfamicael *et al.*, 2020). This knowledge may lead to the selection of parent plants that produce suckers with enhanced performance in varying climatic conditions (Nurebo, 2017).

Challenges and Limitations in Sucker Propagation

The propagation of Enset suckers in Ethiopia faces several challenges and limitations that hinder optimal growth and development (Afza, *et al.*, 1996). These challenges include inadequate access to quality seeds, limited knowledge of best practices among local farmers, and environmental factors such as soil health and climate variability (Yitayew *et al.*, 2023). Additionally, socio-economic barriers can affect the availability of resources necessary for effective propagation. This can lead to a lack of access to quality seeds, fertilizers, and other necessary inputs, ultimately impacting the success rate of sucker cultivation (Hampton *et al.*, 2016). Additionally, the lack of proper training for farmers in modern propagation techniques further complicates the process, as traditional methods may not yield optimal results in the current agricultural landscape (Tolla *et al.*, 2021). This knowledge gap prevents the effective use of innovative practices that could enhance sucker quality and overall agricultural productivity (Feng *et al.*, 2017). Furthermore, resource constraints, including limited access to quality seeds and fertilizers, exacerbate these challenges, leading to suboptimal growth and higher mortality rates among suckers (Desalew, 2021). Additionally, the lack of training among local farmers in proper propagation techniques further hinders the successful establishment of Enset suckers (Sirany *et al.*, 2022). This often results in inconsistent practices and lower overall yields, which can impact food security in regions dependent on this vital crop. Additionally, the lack of standardized protocols and adequate training for farmers exacerbates these challenges, leading to variability in sucker quality and growth rates (Yitayew, *et al.*, 2023). Furthermore, environmental factors such as soil quality and water availability play a crucial role in determining the success of these propagation techniques (Ronga *et al.*, 2021). Therefore, establishing region-specific guidelines is essential for optimizing sucker production (Santos *et al.*, 2020). These guidelines should consider the diverse agroecological conditions found across different regions of Ethiopia By understanding the specific challenges faced in sucker propagation, such as soil quality, pest pressures, and climate variations, stakeholders can develop more effective strategies that cater to local needs.

Success Stories and Best Practices

Despite the challenges mentioned, there have been several success stories and best practices in Enset sucker propagation in Ethiopia. The use of tissue culture techniques for mass propagation has shown promising results, allowing for the rapid multiplication of disease-free and genetically uniform planting materials (Diro, *et al.*, 2004). These advanced propagation methods have the potential to address the limited availability of quality seeds and improve overall agricultural productivity. Additionally, the establishment of community-based seed banks and distributing networks has helped improve access to quality Enset seeds, fostering the adoption of improved varieties and enhancing food security. (Bassa *et al.*, 2018)

Furthermore, the integration of traditional knowledge with modern agricultural practices has also contributed to successful propagation. Local farmers have developed innovative techniques, such as the use of organic materials and traditional methods of seed treatment, which have proven effective in enhancing sucker vigor and adaptation to local conditions.

The collaboration between research institutions, extension services, and local communities has also played a crucial role in disseminating best practices and promoting the adoption of improved propagation techniques. These collaborative efforts have led to the development of region-specific guidelines and training programs that cater to the unique needs of Enset-growing communities, ultimately improving the success rate of sucker establishment and enhancing the overall productivity of Enset cultivation.

Future Research Directions

Future research on Enset (*Ensete ventricosum*) sucker propagation techniques should focus on optimizing existing methods, exploring innovative approaches, and addressing the challenges faced by Ethiopian farmers in order to enhance productivity and sustainability. Furthermore, investigating the genetic diversity of Enset cultivars could provide insights into selecting the most resilient varieties for propagation. Additionally, research should assess the impact of climate change on propagation techniques, ensuring that methods are adaptable to varying environmental conditions. This will not only enhance the resilience of enset propagation methods but also contribute to sustainable agricultural practices in Ethiopia. Moreover, by integrating traditional knowledge with modern scientific techniques, future studies can explore innovative approaches to enhance sucker vigor and improve yield. This could involve the use of biotechnological advancements such as tissue culture and genetic modification, which may prove beneficial in addressing the challenges

faced in the propagation of Enset suckers. Additionally, understanding the interactions between Enset suckers and their environment, including soil health and microbial communities, could provide insights into optimizing growth conditions. This knowledge can inform propagation techniques that enhance sucker resilience and adaptability, crucial for the sustainable cultivation of Enset in varying agroecological conditions. Future research should also explore the integration of traditional propagation methods with modern biotechnological approaches to optimize sucker production. Additionally, investigating the genetic diversity of Enset populations could provide insights into selecting resilient varieties suitable for different environmental conditions. This could also aid in the development of targeted conservation strategies and improve propagation techniques that cater to specific traits desired for climate resilience.

Conclusion and Key Findings

The systematic review of enset (*Ensete ventricosum*) sucker propagation techniques in Ethiopia has revealed several key findings that underscore the importance of optimizing cultivation practices for improved yield and sustainability. These findings indicate that adopting advanced propagation techniques, such as tissue culture and optimal nursery management, can significantly enhance the growth and survival rates of enset suckers. Furthermore, the review emphasizes the need for further research on genetic diversity and the integration of traditional practices with modern technologies to ensure the resilience of enset cultivation in the face of climate change. This review also highlights the critical importance of understanding these factors to optimize propagation techniques and improve overall enset production. By addressing these elements, stakeholders can better adapt to the challenges posed by environmental changes. This adaptation is crucial for ensuring sustainable and productive enset cultivation, which is essential for the livelihoods of many communities in Ethiopia. The findings of this review highlight the importance of researching and implementing diversified propagation techniques to enhance sucker quality and resilience. This comprehensive analysis reveals that integrating traditional and modern techniques can significantly improve the propagation success of Enset suckers. Furthermore, it underscores the need for ongoing research to adapt these methods to local environmental conditions, ensuring sustainability and productivity in Ethiopian agriculture. This ongoing research will not only enhance the efficiency of enset propagation techniques but also contribute to the overall improvement of food security and agricultural resilience in the region.

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