

International Journal of Statistics and Applied Mathematics

ISSN: 2456-1452
Maths 2023; SP-8(6): 631-635
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<https://www.mathsjournal.com>
Received: 02-07-2023
Accepted: 04-08-2023

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Challenges and opportunities in tropical horticulture: A critical analysis

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Abstract

Tropical horticulture, thriving amidst a spectrum of climatic conditions and a rich tapestry of distinctive crops, poses a multifaceted landscape for agricultural pursuits. This article undertakes a critical examination of the inherent challenges and opportunities embedded in tropical horticulture. By delving into the intricacies that govern this dynamic domain, the analysis aims to elucidate the factors that underpin the triumphs and sustainability of horticultural ventures in tropical regions. In the backdrop of diverse climates and a plethora of unique crops, tropical horticulture stands as a vibrant and challenging arena for agricultural endeavours. This critical analysis navigates through the intricate nuances of tropical horticulture, seeking to unravel the complexities that define its trajectory. From the formidable challenges posed by unpredictable weather patterns, pest invasions, and soil fertility issues to the promising opportunities arising from biodiversity exploitation, market access, and technological innovations, the article provides a comprehensive exploration. The examination encompasses the multifaceted dimensions of tropical horticulture, shedding light on the delicate balance required for success and sustainability in these regions. By critically evaluating the landscape, this analysis not only underscores the hurdles that practitioners face but also unveils the potential avenues for growth and development. As tropical horticulture plays a pivotal role in global food production and economic prosperity, understanding and addressing its challenges while harnessing its opportunities are imperative for ensuring a resilient and sustainable future.

Keywords: Tropical horticulture, agriculture, biodiversity, food, crops

Introduction

Tropical horticulture emerges as a pivotal cornerstone in the global agricultural landscape, contributing significantly to food production, economic prosperity, and biodiversity conservation. This introduction provides a panoramic view of the unparalleled importance of tropical horticulture, underscored by its diverse array of crops and the intricate climatic conditions that characterize tropical regions ^[1]. At the nexus of agricultural innovation and sustainability lies the profound significance of tropical horticulture. The cultivation of diverse crops in tropical regions not only serves as a critical source of sustenance for local populations but also resonates on a global scale. Tropical horticulture contributes to the intricate web of global food security, economic stability, and environmental resilience. As we delve into this subject, we unveil the layers of impact that tropical horticulture imparts on the broader landscape of agriculture. A defining characteristic of tropical horticulture is the breath taking diversity of crops that find their home in these regions. From the succulent sweetness of tropical fruits to the vibrant hues of ornamental plants, the tropical palette is a canvas of biological richness. This introduction strives to capture the essence of this diversity, highlighting how a myriad of plant species intertwines with the unique climatic conditions of tropical areas, creating an agricultural mosaic unlike any other ^[2].

In the tapestry of global agriculture, tropical horticulture plays a vital role in meeting the burgeoning demands for food, nutrition, and livelihoods. The introduction sets the stage by illuminating how the cultivation of fruits, vegetables, ornamental plants, and other horticultural commodities in tropical zones not only addresses local needs but also has far-reaching implications for international markets and trade ^[3]. Delving into the rich tapestry of tropical horticulture, this section provides a brief yet insightful overview of the diverse crops

cultivated in these regions. From exotic fruits to unique ornamental plants, the tropical palette is a kaleidoscope of biodiversity. Simultaneously, the discussion explores the climatic intricacies, emphasizing the challenges and opportunities posed by the tropical climate on horticultural practices.

In the realm of tropical horticulture, climate variability emerges as a paramount challenge, exerting a profound influence on the cultivation practices and outcomes. This section delves into the intricate nuances of climate variability in tropical regions, examining the impact on crops, the unpredictability of weather patterns, and the adaptive strategies required to navigate this dynamic landscape ^[4]. A Shifting Paradigm Tropical horticulture operates within a climate characterized by variability, presenting both opportunities and obstacles for growers. The shifting patterns of temperature, precipitation, and extreme weather events pose challenges in predicting optimal planting and harvesting times. The delicate balance required for successful cultivation in the face of climatic variability necessitates a nuanced understanding of the region-specific conditions that influence crop growth ^[5]. The variability in tropical climates directly affects crop production, influencing yields, quality, and overall agricultural sustainability. Fluctuations in temperature and rainfall patterns can lead to periods of drought or excessive moisture, disrupting the delicate equilibrium essential for robust plant development. Understanding the intricacies of how climate variability impacts specific crops is pivotal for implementing adaptive measures that mitigate potential losses and enhance resilience. Extreme Temperatures and Weather Events Tropical horticulturists grapple with the challenge of extreme temperatures and unpredictable weather events, such as storms and cyclones. These occurrences can result in physical damage to crops, affecting not only the current harvest but also future yields ^[6]. The increased frequency and intensity of extreme weather events amplify the urgency for innovative strategies, resilient crop varieties, and sustainable agricultural practices to counter the adversities posed by climate variability. Addressing the challenges presented by climate variability demands proactive and adaptive strategies. This section explores the various approaches employed by horticulturists to enhance resilience, including the selection of climate-resistant crop varieties, precision irrigation techniques, and the integration of climate-smart agricultural practices. The pursuit of sustainable solutions is imperative to foster resilience and minimize the ecological footprint of tropical horticulture in the face of an ever-changing climate. As we scrutinize the intricacies of climate variability in tropical horticulture, the subsequent sections will delve deeper into additional challenges, unravelling the layers that shape the agricultural landscape of these vibrant regions ^[7].

Pest and Disease Management in Tropical Horticulture: Navigating Unique Challenges

Pest and disease management stands as a critical facet of tropical horticulture, presenting practitioners with distinctive challenges inherent to the diverse and dynamic tropical environments. In this section, we delve into the complexities of pest and disease control, exploring the unique challenges posed and the looming threat of emerging diseases and invasive species ^[8].

Unique Challenges in Pest and Disease Control: Tropical environments, with their warm temperatures and high

humidity, create a fertile ground for the proliferation of pests and diseases ^[9]. This subsection examines the specific challenges faced by horticulturists in combating these threats. The intricate interplay between environmental conditions and the life cycles of pests and pathogens necessitates tailored approaches for effective control. From the adaptability of pests to the tropical climate to the increased likelihood of disease outbreaks, understanding and mitigating these challenges are paramount for the sustainability of tropical horticulture. Tropical horticulturists grapple not only with existing diseases but also with the constant specter of emerging threats. The introduction of novel pathogens, often exacerbated by globalization and climate change, poses a substantial risk to crop health ^[10]. This subsection explores the dynamic nature of emerging diseases, emphasizing the need for vigilant surveillance, early detection, and rapid response strategies. The resilience of tropical horticulture hinges on the industry's capacity to stay ahead of the curve in anticipating and managing new disease challenges. The invasion of exotic pests and diseases further complicates pest and disease management in tropical horticulture. Invasive species, unhampered by natural predators, can wreak havoc on crops and ecosystems. This subsection addresses the challenges posed by invasive pests and diseases, emphasizing the importance of stringent biosecurity measures and international collaboration. The constant vigilance required to prevent and control invasive species underscores the dynamic nature of pest and disease management in the tropics ^[11]. The multifaceted challenges of pest and disease management call for integrated and sustainable approaches. This section explores strategies such as integrated pest management (IPM), biological control methods, and the development of resistant crop varieties. The synthesis of traditional knowledge with modern advancements in technology and genetics plays a pivotal role in fostering resilient horticultural systems capable of withstanding the intricate challenges presented by pests and diseases in tropical environments ^[12].

Soil Quality and Fertility

The soil, a fundamental cornerstone of agricultural ecosystems, plays a pivotal role in tropical horticulture. This section scrutinizes the challenges associated with soil quality and fertility in tropical environments, exploring issues related to degradation and nutrient imbalances. Additionally, it outlines strategies for sustainable soil management, essential for fostering resilient and productive horticultural systems. Tropical regions, despite their inherent biodiversity, are susceptible to soil degradation—a critical challenge for horticulturists. This subsection delves into the multifaceted issues encompassing soil degradation, including erosion, loss of organic matter, and declining fertility. Nutrient imbalances, often exacerbated by intensive agricultural practices, further compound the challenges. Understanding the intricacies of these issues is essential for devising targeted interventions that address the root causes of soil degradation and promote a balanced nutrient profile. Sustainable soil management is imperative for maintaining the long-term health and productivity of horticultural systems in tropical regions ^[13]. This section explores a range of strategies aimed at mitigating soil degradation and fostering nutrient-rich soils. Implementation of conservation tillage practices, cover cropping, and agroforestry are highlighted as approaches that promote soil health. Additionally, organic amendments and the use of green manure contribute to restoring and enhancing soil fertility, reducing dependence on synthetic inputs.

Advancements in technology have paved the way for precision agriculture, a powerful tool for optimizing soil management. This subsection explores how precision agriculture techniques, such as sensor-based nutrient management and satellite imaging, enable horticulturists to tailor their interventions according to the specific needs of the soil. This targeted approach not only enhances nutrient use efficiency but also minimizes environmental impacts, fostering a more sustainable and ecologically friendly soil management paradigm. The complexities of soil management in tropical horticulture necessitate a collaborative and knowledge-sharing approach. This section discusses the importance of community engagement, farmer education programs, and the dissemination of best practices. Empowering local communities with the knowledge and tools for sustainable soil management not only enhances the resilience of horticultural systems but also contributes to broader environmental conservation efforts ^[14].

Water Scarcity and Management

Water, a finite and indispensable resource, assumes paramount significance in tropical horticulture. This section navigates the challenges posed by water scarcity in tropical regions, examining the need for efficient irrigation practices and outlining strategies for water conservation and sustainable water management. Tropical horticulture often contends with the pressing issue of water scarcity, aggravated by erratic rainfall patterns and increasing demands from a burgeoning population ^[15]. This subsection scrutinizes the challenges arising from insufficient water availability for crop cultivation. It explores the repercussions on crop yields, soil health, and overall agricultural sustainability. By understanding the nuances of water scarcity, horticulturists can design targeted interventions to alleviate the impacts and build resilience in the face of fluctuating water availability. Efficient irrigation practices play a pivotal role in mitigating the effects of water scarcity in tropical horticulture. This section delves into innovative irrigation techniques, including drip irrigation, precision irrigation, and rainwater harvesting. By optimizing water use efficiency and minimizing wastage, these practices contribute not only to increased crop yields but also to the conservation of this precious resource. The exploration of cutting-edge irrigation technologies underscores the dynamic nature of water management in tropical horticulture ^[16].

Water conservation emerges as a cornerstone of sustainable horticultural practices in water-scarce tropical environments. This subsection investigates strategies such as soil moisture management, mulching, and agroecological approaches that enhance water retention in the soil. By fostering water-efficient ecosystems, horticulturists can mitigate the impacts of water scarcity, promoting both crop resilience and the long-term sustainability of agricultural landscapes. Beyond immediate conservation efforts, sustainable water management requires a holistic approach that considers the broader ecosystem ^[17]. This section explores the integration of water management into agro ecological systems, emphasizing the interconnectedness between water, soil, and crops. The adoption of climate-smart agricultural practices, coupled with community-driven water governance, plays a pivotal role in ensuring the sustainable utilization of water resources in tropical horticulture.

The culmination of successful cultivation in tropical horticulture is often met with challenges in the post-harvest phase. This section sheds light on the complexities of post-

harvest losses, scrutinizing the hurdles in transportation, storage, and distribution while exploring innovative technologies designed to minimize these losses and enhance the overall efficiency of tropical horticultural systems ^[18]. The journey from harvest to market presents a myriad of challenges for tropical horticulturists, with post-harvest losses often occurring during transportation, storage, and distribution. This subsection dissects the intricacies of these challenges, ranging from inadequate transportation infrastructure and temperature control issues to issues related to perishable nature of tropical produce. By identifying and understanding these challenges, horticulturists can strategize interventions that address the root causes and minimize losses, ensuring the maximum value is retained from the harvest.

In response to the challenges posed by post-harvest losses, innovative technologies have emerged as transformative tools in tropical horticulture. This section explores cutting-edge advancements, such as controlled atmosphere storage, modified atmospheric packaging, and cold chain logistics. These technologies not only extend the shelf life of perishable produce but also maintain quality during transportation, reducing losses and ensuring that crops reach consumers in optimal condition. The integration of information technology, such as real-time monitoring systems, further enhances precision and efficiency in post-harvest management ^[19]. The preservation of freshness and quality in tropical produce necessitates effective cold chain logistics. This subsection delves into the role of cold storage, refrigerated transport, and controlled atmosphere technologies in mitigating post-harvest losses. Additionally, preservation techniques, such as dehydration and vacuum packaging, contribute to prolonging the shelf life of tropical horticultural products. These innovations not only reduce losses but also open new avenues for market access, enabling horticulturists to tap into distant markets and optimize returns. Sustainable post-harvest practices extend beyond technological innovations ^[20]. This section explores community-based solutions, including the establishment of local processing units, farmers' cooperatives, and knowledge-sharing networks. Empowering local communities with the skills and infrastructure to manage post-harvest processes effectively not only reduces losses but also fosters economic resilience, ensuring that the benefits of tropical horticulture are retained at the community level.

Opportunities in Tropical Horticulture

Amidst the challenges inherent in tropical horticulture, a realm of opportunities awaits. This section explores the potential for leveraging biodiversity and crop diversity, shedding light on the unique opportunities that arise from the rich tapestry of plant species in tropical regions. A Horticultural Treasure Trove Tropical regions boasts an unparalleled wealth of biodiversity, offering a treasure trove of plant species with diverse attributes and genetic resources. This subsection delves into the opportunities presented by this rich biodiversity, emphasizing the cultivation of a wide array of crops, including indigenous and exotic varieties. The unique climatic conditions of the tropics provide an environment conducive to the growth of diverse fruits, vegetables, herbs, and ornamental plants ^[21]. By embracing this diversity, horticulturists can not only enhance the resilience of their systems but also tap into niche markets driven by consumer interest in exotic and locally adapted produce.

Indigenous Crop Knowledge and Traditional Practices

Tropical horticulture is deeply intertwined with indigenous knowledge and traditional farming practices. This section explores the opportunities inherent in tapping into the wisdom of local communities, leveraging their insights into crop cultivation, pest management, and sustainable agricultural practices. Integrating traditional knowledge with modern agricultural techniques not only enhances the sustainability of horticultural systems but also fosters a sense of community ownership and empowerment.

Market Access and Export Potential: The global demand for tropical horticultural products provides a significant opportunity for growers in tropical regions. This subsection delves into the potential for market access and export, emphasizing the importance of meeting international quality standards and leveraging certifications for organic and sustainably grown produce. By tapping into global markets, horticulturists can not only enhance their economic prospects but also contribute to the economic development of their communities.

Technological Advancements in Horticulture

Advancements in technology offer transformative opportunities for tropical horticulture [22]. This section explores the integration of technology, including precision agriculture, sensor-based monitoring, and blockchain for supply chain traceability. These technologies enhance productivity, optimize resource use, and provide valuable data for decision-making. Embracing technological innovations positions horticulturists to thrive in an increasingly interconnected and tech-driven global agricultural landscape.

Market Access and Export Potential in Tropical Horticulture: Navigating Global Opportunities

In the realm of tropical horticulture, the potential for market access and export stands as a beacon of economic growth and international recognition. This section illuminates the diverse opportunities available for horticulturists in tropical regions, exploring the avenues to access global markets and capitalize on the export potential of their agricultural produce. The global market has an insatiable appetite for the diverse array of tropical fruits, vegetables, ornamental plants, and herbs cultivated in tropical regions. This subsection delves into the factors driving the demand for tropical horticultural products, including the increasing appreciation for exotic and unique varieties, as well as the growing awareness of the health benefits associated with tropical produce. Understanding these market dynamics positions horticulturists to strategically align their production with global consumer preferences. To tap into international markets, adherence to stringent quality standards and certifications is paramount. This section explores the importance of meeting and exceeding global quality benchmarks, such as Good Agricultural Practices (GAP) and organic certifications [23]. By ensuring the safety, traceability, and sustainability of their products, horticulturists can in still confidence in international buyers, facilitating market access and establishing a reputation for premium quality produce.

Diversifying the range of horticultural products and exploring niche markets is a key strategy for market access. This subsection examines the potential for introducing unique or indigenous crops to global consumers, creating niche markets with distinct value propositions. By catering to specialized consumer preferences or addressing emerging trends in health

and wellness, horticulturists can carve out their niche in the competitive global marketplace. Efficient export logistics and supply chain management are critical components of successful market access. This section navigates through the complexities of export logistics, exploring strategies to minimize post-harvest losses, optimize transportation, and ensure timely delivery to international markets. Embracing technologies such as cold chain logistics and real-time monitoring enhances supply chain efficiency, contributing to the reliability and competitiveness of tropical horticultural exports [24, 26]. Establishing sustainable trade partnerships is fundamental for long-term success in global markets. This subsection delves into the importance of cultivating relationships with international buyers, distributors, and retailers. Collaborative initiatives, such as direct trade agreements and partnerships with global retailers, contribute to the sustainability of market access and foster mutually beneficial relationships.

Conclusion

In the intricate landscape of tropical horticulture, this exploration has unveiled a tapestry woven with challenges and opportunities, where the vibrancy of biodiversity meets the complexities of climate and the promise of global markets intertwines with the need for sustainable practices. As we conclude this journey, several key reflections emerge, underscoring the dynamic nature and potential of tropical horticulture. The challenges in tropical horticulture, from climate variability to post-harvest losses, demand innovative solutions. The resilience of horticulturists in navigating these challenges, adopting precision agriculture, and harnessing cutting-edge technologies reflects a commitment to sustainable practices. Through ongoing research, adaptation, and the integration of traditional wisdom with modern advancements, the sector stands poised to overcome hurdles and thrive in the face of adversity. The biodiversity inherent in tropical regions is a double-edged sword, presenting challenges but also offering a treasure trove of opportunities. The cultivation of diverse crops, tapping into indigenous knowledge, and preserving traditional practices not only enhances resilience but positions tropical horticulture as a beacon for sustainable and diverse agricultural systems.

Market access and export potential open doors to economic growth for horticulturists in tropical regions. By adhering to global quality standards, diversifying products, and building sustainable trade partnerships, the pathway to international markets becomes clearer. The ability to showcase the uniqueness and quality of tropical horticultural products positions growers to not only meet global demand but also contribute significantly to the economic prosperity of their communities. At the core of the future of tropical horticulture lies the commitment to sustainability. Sustainable soil management, water conservation practices, and community-based solutions exemplify the sector's dedication to environmental stewardship and social responsibility. The pursuit of sustainable practices is not merely a choice but an imperative for ensuring the longevity and vitality of tropical horticulture. The journey through tropical horticulture emphasizes the importance of collaboration and knowledge exchange. From community engagement to international trade partnerships, the interconnectedness of stakeholders in the horticultural ecosystem is evident. The continued exchange of knowledge, experiences, and best practices is fundamental for fostering a resilient and thriving tropical horticulture sector.

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