



Overview and challenges of citrus industry in Sergipe from 2010 to 2022

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Abstract

The Brazilian citrus industry is one of the country's most significant economic and social sectors, positioning Brazil as a global leader in this field. In the state of Sergipe, the citrus industry represents 3% of the Gross Domestic Product (GDP), playing a crucial role in the local economy, with citrus being one of the region's key agricultural products. Given this context, the objective of this study was to analyze the opportunities and challenges faced by Sergipe's citrus sector between 2010 and 2022. The analysis focused on production and commercialization data for sweet oranges, considering climatic, economic, and competitive factors that impact the sector. Data on planted areas, production, crop yield, prices, and rainfall indices were gathered from public research platforms, including the Brazilian Institute of Geography and Statistics (IBGE) and the Agricultural Development Company of Sergipe (EMDAGRO). Throughout the evaluated historical series, there were fluctuations in orange planted areas, with a reduction of 45%, and a 52% decline in fruit production, largely due to climatic conditions and phytosanitary issues. Despite these ongoing challenges, projections suggest a 0.5% increase in orange yield in the coming years. High international demand and changing consumption patterns for both the fruit and its juice, as seen during the COVID-19 pandemic, present an opportunity for local producers, provided that proper crop management practices are implemented to address the existing challenges.

Keywords: *Citrus sinensis* (L.) Osbeck, economy, planted area, sweet orange, yield

Introduction

The Brazilian citrus industry is one of the most important economic and social sectors in the country. Since 1980, Brazil has led global sweet orange (*Citrus sinensis* L. Osbeck) production, having surpassed the United States. In the 2022/23 season, Brazil accounted for 34.9% of global orange production and 76% of the world's orange juice output, maintaining its position as the leading exporter (USDA, 2024; FAO, 2024). Sergipe plays a notable role in this context, contributing 5.9% of Brazil's citrus cultivation area and 2.3% of national sweet orange production. The state also produces 13.9 thousand tons of 'Tahiti' lime and 6.5 thousand tons of mandarins. Citrus represents about 3% of Sergipe's GDP and is concentrated in 11,000 family-run farms across 14 municipalities in the southern region, covering approximately 32,255 hectares (SECC, 2022; IBGE, 2023).

Sergipe's citrus industry is crucial to its export

trade balance, with frozen concentrated orange juice being a major export—generating around USD 101.1 million in 2023. The state's oranges are competitive in the market due to lower production costs and reduced pest and disease incidence compared to Brazil's Southeast. For instance, while the citrus belt in São Paulo and parts of Minas Gerais suffers from a 44.35% infection rate of Huanglongbing (greening disease) - leading to the annual eradication of millions of trees - Sergipe has remained free of the disease. This success is attributed to effective phytosanitary barriers, which have supported the industry's continued growth (Bassanezi et al., 2020; Fundecitrus, 2025).

The average citrus yield in Sergipe is 13.81 tons per hectare, though farms using appropriate technologies can reach 40 to 45 tons per hectare, with a productive lifespan of 10 to 15 years (Panta & Sobrinho, 2019; EMDAGRO, 2024). However, the citrus industry

faces significant challenges, particularly the reliance on climatic conditions, with water scarcity being a major concern, especially in the southern and central-southern areas of Sergipe. Additionally, price fluctuations, largely influenced by production in major global hubs such as the citrus belt of São Paulo, Brazil, and Florida, USA, present another obstacle (SECC, 2022).

The increasing competition from various beverage options, including those based on other fruits, has also emerged as a significant challenge for the citrus industry in Sergipe. These complex and interrelated factors call for effective strategies to ensure the sustainability and growth of this vital sector for the regional economy (Da Silva et al., 2016; Neves et al., 2020). Considering this, the objective of this study was to analyze the opportunities and challenges faced by the citrus sector in Sergipe between 2010 and 2022. The analysis focused on data related to orange production and commercialization in the state, with particular emphasis on the climatic, economic, and competitiveness factors affecting the sector.

Material and methods

Data on areas designated for citrus cultivation (expressed in 1×10^3 hectares), fruit production (1×10^3 tons), and yield (tons per hectare) for Sergipe's orange production from 2010 to 2022 were collected. Additionally, for economic analysis, the average annual prices of oranges sold fresh in the state from 2014 to 2023 were gathered and analyzed. Information on Brazilian orange juice exports, expressed in tons, was also collected for the period between 2010 and 2023.

Moreover, annual rainfall records were obtained for the period from 2010 to 2022, using data from the meteorological station located in Itabaianinha, SE, in the center-south region, near the main orange-producing municipalities of the state. The collected data and information were derived from scientific and technical articles related to the citrus sector, as well as variables analyzed from historical series available on public platforms provided by the the Brazilian Institute of Geography and Statistics (IBGE), the Secretariat of Foreign Trade (SECEX), and the Sergipe Agricultural Development Company (EMDAGRO).

Data organization and analysis were conducted using Microsoft Excel® 2016, where descriptive statistical analyses were performed to calculate average results. The data were visually represented through graphs that included trend lines to enhance the understanding of the information. This method offers a robust approach to

grasping the complexities and evolution of citrus farming in Sergipe throughout the period of the historical series under analysis.

Results and discussion

Historically, the citrus industry has played a crucial role in the state of Sergipe, serving as a significant source of income and employment, especially in the fresh fruit market. In addition to making a substantial contribution to the state's GDP, orange production and sales provide economic opportunities for thousands of families (de Amorim et al., 2018). However, between 2010 and 2022, the area dedicated to orange cultivation in Sergipe fluctuated, ranging from 54,733 to 30,314 hectares (Figure 1).

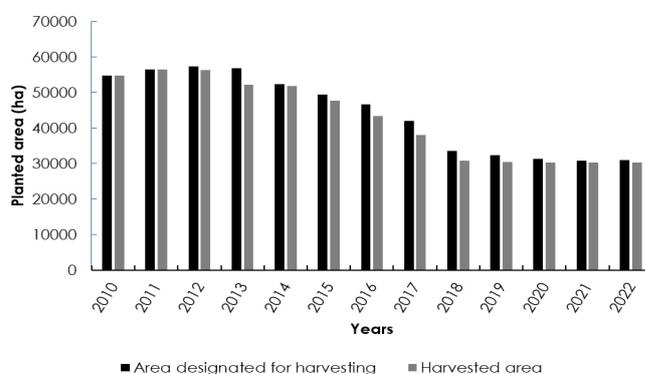


Figure 1. Orange harvested area and area designated for harvesting in the state of Sergipe, from 2010 to 2022. Source: Prepared by the authors based on IBGE data, 2023.

Several factors contributed to these variations, including climate change, a shift towards other agricultural activities such as livestock, sugarcane, and corn cultivation, and the significant phytosanitary pressure caused by the incidence of crop pathogens (Panta & Sobrinho, 2019). Among the main phytosanitary challenges threatening orange production in Sergipe are pests like the citrus blackfly (*Aleurocanthus woglumi*), citrus orthezia (*Praelongorthezia praelonga*), and the snow scale (*Unaspis citri*), as well as diseases such as CVC (Citrus Variegated Chlorosis), caused by the bacterium *Xylella fastidiosa*, postbloom fruit drop (*Colletotrichum acutatum*), and gummosis (*Phytophthora* spp.) (Neves et al., 2017). These conditions demand continuous phytosanitary control and management efforts from producers to ensure orchard health and yield.

In Sergipe, 30,314 hectares are dedicated to orange cultivation, representing 32.5% of the planted area in the Northeast and 5.3% nationwide. In comparison, in 2010, this area totaled 54,733 hectares, accounting for a more substantial share of 43.8% in the Northeast and

6.5% nationally (IBGE, 2023). Over the years, there has been a significant reduction in the total area designated for orange cultivation both in Brazil and the Northeast, decreasing from 125,068 hectares in 2010 to 93,095 hectares in 2022 (Figure 2).

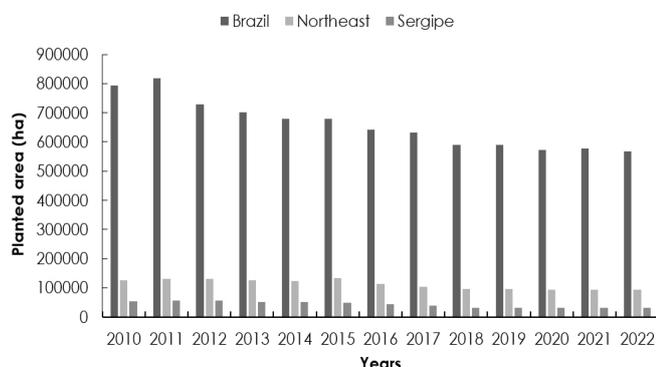


Figure 2. Planted area of orange trees in Brazil, the Northeast, and Sergipe from 2010 to 2022. Source: Prepared by the authors based on IBGE data, 2023.

The Brazilian citrus industry constantly faces threats due to the widespread occurrence of pests and diseases, leading to a significant increase in pesticide use to maintain production potential. The direct and indirect costs of phytosanitary treatments in citrus have risen considerably, accounting for more than 40% of production costs (Andrade et al., 2014). Over the past decade, diseases such as citrus canker, CVC, sudden death, and HLB have resulted in the eradication of millions of trees in the citrus belt of São Paulo and the triangle Minas Gerais regions (Belasque Junior et al., 2017; Neves et al., 2020). The lack of adequate resources to address these issues has exacerbated phytosanitary problems in citrus cultivation, with significant economic, social, and environmental consequences (Costa et al., 2021).

In Sergipe, most citrus producers are family farmers, making this activity a vital socioeconomic contributor to the state. However, the current challenge for stakeholders in the state's citrus production chain is to ensure the sustainability of citrus farming. Each new pest introduced to citrus crops increases production costs, posing a threat to the sustainability of the sector (MAPA, 2023).

The decline in agricultural production in Sergipe's orchards coincides with the emergence of the citrus blackfly, one of the most destructive pests in citrus cultivation. The direct and indirect damage caused by this pest hampers plant development and production, while also restricting trade in affected areas. In an already difficult scenario, losses were exacerbated by the

severe water crisis that struck the region in 2012, creating a combination of adverse factors that led to one of the most significant crises faced by the sector (Panta & Sobrinho, 2019).

The orchards are primarily concentrated in the southern region of the state, where citrus production has faced increasingly adverse weather conditions in recent years (Passos et al., 2019). In 2012, there was a sharp decline in rainfall, with the annual total reaching only 752.30 millimeters (mm), a reduction of 36.26% compared to the previous year. Although rainfall rebounded in 2013, reaching 1,432.40 mm, subsequent years experienced another decrease, with rainfall dropping to around 858.00 mm in 2016. The 12-year average reveals a value of 1,036.96 mm (Figure 3). Citrus plants require between 600 and 1,200 mm of water annually. Data from different regions show that citrus water consumption ranges from 1.5 mm per day in winter to 3.2–4.7 mm per day in summer (Cintra et al., 2000).

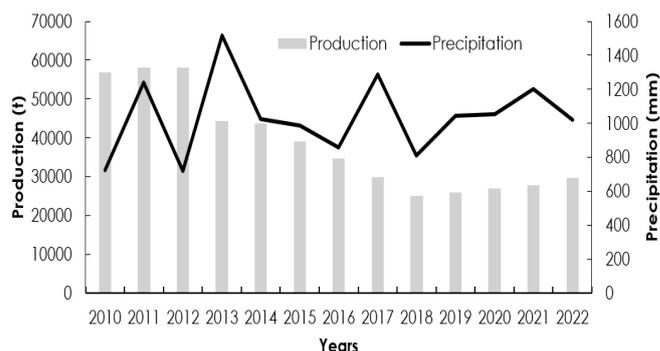


Figure 3. Annual rainfall index and orange production in the southern region of Sergipe from 2010 to 2022. Source: Prepared by the authors based on BDMEP/INMET data. Station: Itabaianinha - SE (OMM: 83195). Period analyzed: 01/01/2010 to 30/12/2022.

It is important to emphasize that the climate significantly impacts the Northeast region, where agriculture is predominantly rainfed. In this context, rainfall plays a crucial role in determining both crop production and quality (Panta & Sobrinho, 2019). During the evaluation period, orange production in Sergipe experienced a substantial decline. In 2010, the state produced 805,962 tons, but by 2022, production had fallen to 418,814 tons, marking a significant reduction of 51.9% (Figure 4).

This trend was also reflected in the Northeast's citrus production, which decreased from 1,875,669 tons in 2010 to 1,149,467 tons in 2022. The decline in citrus production since the 1990s, beyond phytosanitary issues, is driven by a series of aggravating factors that have intensified in recent years (Vidal, 2024). These factors

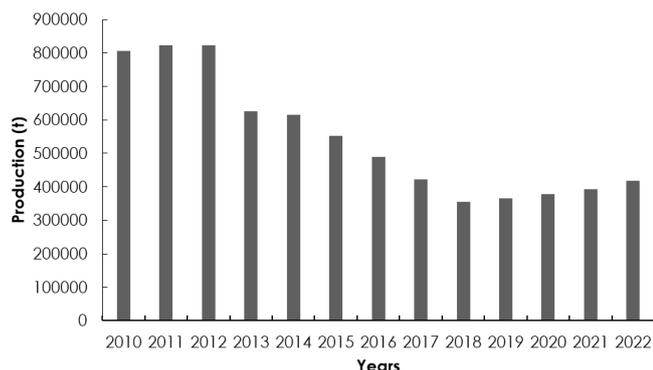


Figure 4. Orange production in the state of Sergipe from 2010 to 2022. Source: Prepared by the authors based on IBGE data, 2023.

include global market conditions, particularly the decline in demand for concentrated juice, the aging of orchards, low yield, producer debt, and lack of organization. Additionally, the expansion of the citrus industry in São Paulo, the ineffectiveness of government measures to revive the sector, and the absence of collective entities that genuinely represent and defend the interests of citrus growers have further contributed to this challenging scenario (Belasque Jr. et al., 2017; Graham et al., 2024).

Citrus cultivation, as Carvalho et al. (2019) emphasizes, plays a crucial role in supplying fruit to the processing industry. The dynamics of this sector are distinct, with small farmers exerting a significant influence on land use practices. However, the agricultural modernization process in the state has been selective, primarily benefiting medium and large farmers due to financial institutions' lower perceived risk in supporting these larger operations. As a result, fewer small farmers have been able to benefit from modern production policies (Vasconcelos, 2015).

In 2022, orange yield in Sergipe ranked 13th nationally, a performance influenced by the rainfall regime, the age of the orchards, and pest pressures in these areas (SECC, 2022). The average yield in the state reached 13.82 t ha^{-1} (Figure 5), which contrasts with the higher yield observed in other citrus-producing states. In São Paulo, the average yield was significantly higher at 36.44 t ha^{-1} , while Minas Gerais recorded 28.02 t ha^{-1} , and Paraná achieved 31.45 t ha^{-1} (IBGE, 2023).

The disparity in orange production between the Southeast and Northeast regions of Brazil has intensified since 2013. However, in the past five years, orchard yield in Sergipe has shown a notable increase, rising from 354,960 tons in 2018 to 418,814 tons in 2022, representing a growth of 17.98%. This trend indicates a significant and positive recovery in the state's citrus industry (Figure 6).

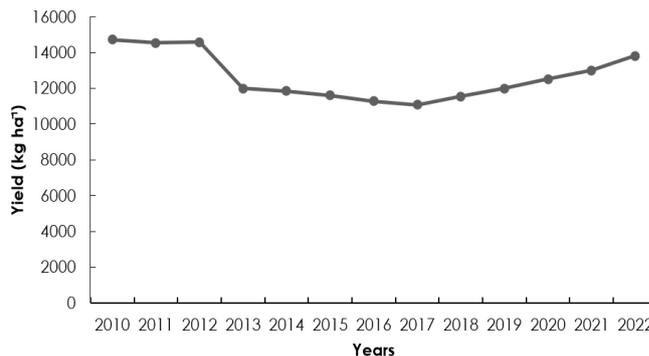


Figure 5. Orange yielded in the state of Sergipe from 2010 to 2022. Source: Prepared by the authors based on IBGE data, 2023.

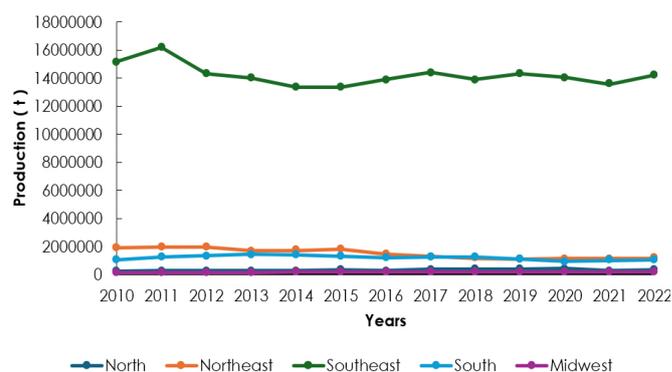


Figure 6. Orange production in Brazilian regions from 2010 to 2022. Source: Prepared by the authors based on IBGE data, 2023.

Most of the national orange production is concentrated in the Southeast region, accounting for 80% of the total. However, this share has gradually declined over time, primarily due to the increasing incidence of pests and diseases in the region. In contrast, the Northeast has consistently maintained its contribution throughout the analyzed period. The South region, while having a smaller share compared to the Northeast, still contributes more than other regions, where citrus production remains limited (SECC, 2022).

According to the 2017 Agricultural Census, Sergipe has 93,275 agricultural establishments, of which 11,000 are dedicated to orange cultivation, representing 9% of the total. Fourteen municipalities in Sergipe lead in this area, accounting for 99% of the establishments and the same percentage of orange production in 2020. These municipalities cover more than 24% of the state's territorial area (Figure 7).

Analyzing the distribution of agricultural establishment areas producing oranges in these municipalities, it is observed that more than 65% of them have areas smaller than 5 hectares, with particular emphasis on Riachão do Dantas (91%), Boquim (86%), and Pedrinhas (82%). This highlights the predominance



Figure 7. Citrus production region of Sergipe: 14 producing municipalities located in the central-southern region. Source: Prepared by the authors based on IBGE data, 2023.

of citrus production in Sergipe by small farmers (Panta & Sobrinho, 2019).

The citrus market is divided between products destined for industrial processing and fresh consumption. In Sergipe, production is primarily concentrated on the Pêra cultivar, which serves both markets. Higher-quality oranges are destined for fresh consumption, while lower-quality oranges are directed to the processing industry, where they fetch significantly lower prices (Azevedo, 2003). In 2023, the price per ton of superior quality oranges reached R\$ 886.00, compared to R\$ 508.00 paid to producers for fruit destined for processing, representing a 57% price difference (EMDAGRO, 2024).

The commercialization of oranges in Sergipe faces challenges that significantly impact the citrus production chain. The processing market is highly concentrated, characterized by vertical integration and privileged control of market information. This structure forces farmers to become price takers, putting downward pressure on their profit margins and exposing them to the risks of fluctuating industry prices (Turra et al., 2014).

Despite the difficulties in recent years, projections from the Ministry of Agriculture and Livestock (MAPA, 2023) forecast an increase in orange production over the next decade. It is estimated that production, which stood at 16.8 million tons in the 2022/2023 harvest, will rise to 17.7 million tons by 2032/33, with an average annual growth rate of 0.5% over the next ten years (Brazil, 2023).

The sale of oranges (in tons) between farmers, industries, and intermediaries, intended for fresh consumption, has shown an increasing trend in average annual real prices in recent years (Figure 8).

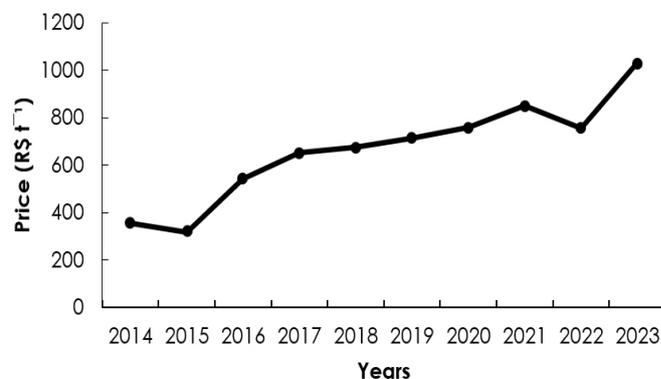


Figure 8. Average annual price of fresh oranges commercialized for table consumption in the state of Sergipe (non-deflated prices). Source: Prepared by the authors based on EMDAGRO data, 2024.

The increase in the value of fruit sales is primarily attributed to the scarcity of supply during the off-season, as citrus growers face severe phytosanitary challenges, such as HLB, along with climate issues caused by El Niño-induced heat waves. These factors are expected to reduce orange production in the coming years in the major citrus-growing states (Geraldini, 2023). In some regions of São Paulo, a 40.8 kg box of 'Pera' sweet oranges is being traded for R\$ 100.00 (fresh market), the highest price recorded by the Center for Advanced Studies in Applied Economics (Cepea) since the historical series began in October 1994.

Citrus plants affected by HLB, a disease linked to the bacterium *Candidatus Liberibacter* spp. and transmitted by insect vectors (psyllids), suffer from severe physiological disorders, leading to production losses of up to 60% compared to healthy trees (Hu et al., 2021; Dala-Paula, 2019). This disease is now widespread across the citrus-growing regions of São Paulo, Minas Gerais, Mato Grosso do Sul and Paraná, as well as in Argentina, Colombia, Paraguay, most Central American and Caribbean countries, Mexico, and the United States. In the citrus belt of São Paulo and the southwestern region of Minas Gerais alone, an estimated 90.36 million trees are contaminated, representing a significant portion of the total 203.74 million orange trees in the entire citrus belt (FUNDECITRUS, 2025).

To date, there are no reports of HLB in citrus orchards in Sergipe. However, it is essential for citrus producers to remain vigilant by conducting regular

inspections of their orchards. Emdagro plays a strategic role in preventing the introduction of this disease into the local citrus industry. Its efforts include phytosanitary inspections in nurseries and orchards, monitoring of commercial areas, installation of traps at key locations, and strict supervision of cargo transit through sanitary barriers. In 2021, a total of 10,632 loads were certified, enabling interstate citrus trade and ensuring that producers can trade freely without restrictions in other states (EMDAGRO, 2024).

In 2020, a decline in the supply of oranges from Florida (USA), Brazil's main competitor in the international market, was observed. This shortage is likely to support continued North American imports of Brazilian juice. Additionally, in the same year, the National Supply Company (CONAB) analyzed fruit prices at Brazilian Supply Centers (CEASA). For sweet oranges, there was a notable 30.04% increase in prices at the São Paulo General Warehousing and Wholesale Company (CEAGESP). This rise was driven by high demand during the early months of social isolation due to the COVID-19 pandemic, as consumption habits shifted, with consumers seeking vitamin C-rich fruits for their perceived benefits in boosting immunity (Panta & Ferreira, 2021).

The dynamics of sales in wholesale produce markets also changed because of the pandemic. There was a decline in transactions, largely due to reduced demand caused by the closure of bars and restaurants. However, an increase in purchases from supermarkets and fruit and vegetable stores was observed. This shift was driven by growing demand for these establishments, as the pandemic altered consumption patterns, leading to a greater focus on healthy foods (Panta & Ferreira, 2021).

Exports of orange juice and its derivatives in Sergipe have fluctuated in recent years, with significant declines recorded since 2019. In 2020, there was a 46% drop in exports of frozen orange juice. On the other hand, in 2021 a 56% increase in orange essential oil exports was observed (SECC, 2022).

From July to December, during the first six months of the 2023/2024 harvest, Brazilian orange juice exports totaled 543,768 tons of FCOJ (SECEX, 2024). This represented a 7.25% reduction compared to the same period in the previous harvest, when 586,297 tons were exported. Despite the decline in volume, revenue from foreign sales reached US\$1.3 billion, marking a 20.7% increase compared to the US\$1.1 billion generated between July and December 2023 (Figure 9).

Juice export performance reflects the fourth

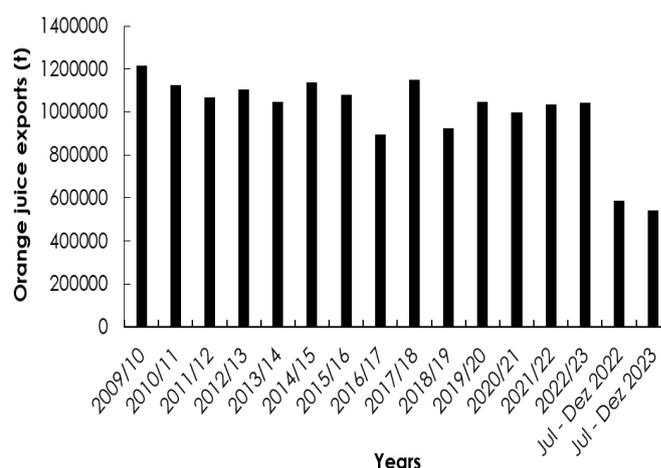


Figure 9. Evolution of Brazilian orange juice exports, in tons, from 2010 to 2023. Source: Prepared by the authors based on SECEX data, 2024.

consecutive decline in orange production. The 2023/2024 orange harvest is estimated at 307.22 million boxes of 40.8 kg each. The United States, experiencing a continued decline in production, dropped to the sixth-largest orange producer globally in the 2022/23 season. Brazilian production also remains below average, creating a particularly challenging scenario for product supply (Vidal, 2024).

Given the complexity of the citrus scenario in Sergipe and the Northeast, there is an urgent need for adaptive strategies to address fluctuations driven by climatic, phytosanitary, and economic factors. The optimistic projections of increased production and prices, along with the absence of HLB in Sergipe, provide the region with competitive advantages. This underscores the importance of policies and practices that foster resilience and sustainability in the regional citrus industry.

Conclusions

Given the complexity of the citrus industry scenario in Sergipe and the Northeast, there is a clear and urgent need for adaptive strategies to address fluctuations influenced by climatic, phytosanitary, and economic factors. Optimistic projections for increased production and prices, combined with the absence of HLB in Sergipe, provide the region with competitive advantages. This context highlights the importance of policies and practices that promote resilience and sustainability in regional citrus farming.

Acknowledgements

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