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Citrus Culture in Bhutan

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Abstract

Mandarin orange production and trade data were analyzed using semi-logarithmic trend analysis to evaluate growth rates and trends in mandarin orange production and trade. Results indicated a positive trend in mandarin orange production and yield, reflecting the resilience and adaptability of Bhutanese farmers despite challenges such as the *Citrus tristeza virus* (CTV) and *Candidatus Liberibacter asiaticus* (CLas). However, a declining trend in harvested areas raises concerns about constraints such as diseases or shifting agricultural priorities. Import trends revealed a growing demand for citrus products domestically, necessitating efforts to enhance domestic production capacity. While export values demonstrate growth, stagnant export quantities underscore the need to boost production, quality, and market positioning. Overall, the citrus industry in Bhutan demonstrates modest growth potential, but strategic interventions such as micro-budding and high-density planting are essential to address the challenges and unlock its full economic potential. This study provides valuable insights for policymakers and stakeholders to formulate targeted interventions in sustaining and enhancing the citrus sector's contribution to economy.

Keywords: citrus, cultivation, mandarin, oranges

Introduction

Bhutan, known for its diverse agroecological zones, serves as a significant locus for cultivating a varied spectrum of horticultural crops. Historically, the cultivation of mandarin oranges has been concentrated in the subtropical foothill regions, notably in districts such as Dagana, Sarpang, Pemagatshel, Samtse,

*Corresponding author: cdorji51@gmail.com Received: August 6, 2024 Accepted: November 25, 2024 Published online: December 31, 2024 Tsirang, and Chukha. However, recent developments have witnessed an expansion of mandarin orange cultivation across 19 out of the nation's 20 districts, with Bumthang being the sole exception as of 2023 (National Statistics Bureau, 2024). By 2022, citrus cultivation had spread across a significant 2,579 hectares of agricultural land, making it a prominent farming practice in the country (FAO, 2024).

Typically grown at elevations ranging from 300 to 1,650 meters above sea level, mandarin oranges in Bhutan are commonly referred to as 'local mandarin' (*Citrus reticulata* Blanco.), representing a singular variety (Dorji & Yapwattanaphun, 2011). With over 22,000 citrus farms, each featuring varying numbers of trees per farm, ranging from 3 to 900 (Sanderson et al., 2019), Bhutan exhibits

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significant engagement in citrus cultivation. Studies on the genetic diversity of mandarin accessions in Bhutan have revealed considerable variability among collected germplasms (Dorji & Yapwattanaphun, 2015).

From a national perspective, the commercial cultivation of mandarins assumes precedence. Serving as a primary fresh fruit export, Bhutanese mandarins are prominently featured in markets in Bangladesh and India, thereby contributing substantially to the economy through export-generated revenue. The evolving transportation infrastructure, coupled with expanding road networks and burgeoning trade relations with neighboring nations like India and Bangladesh, presents a growing market for further amplifying commercial citrus production (Kheerajit et al., 2018).

Despite the esteemed status of mandarin oranges as a leading export commodity, characterized by seasonal appeal, environmental purity, and distinctive flavor profiles, the production process in Bhutan grapples with a multitude of challenges across its value chain. These challenges encompass issues such as suboptimal productivity, escalating production costs, inefficiencies in input delivery systems, transportation bottlenecks, infrastructural deficiencies, and inadequacies in market information systems (Gyeltshen et al., 2015). Additionally, the country faces challenges such as the impact of Candidatus Liberibacter asiaticus (CLas) causing losses below 1200 m above sea level (ASL) (Ghosh et al., 2021), and the decline in orange productivity due to Citrus tristeza virus (CTV) infections (Ghosh et al., 2022).

Notably, Bhutan's national yield of 3.9 tons per acre falls significantly short of the average yields of 6 tons per acre observed in countries such as Thailand and Taiwan, primarily attributable to limited technology adoption and adherence to traditional management practices, particularly within citrus orchards; these challenges persist despite the steady demand for Bhutanese mandarins (Dorji et al., 2016). This study examines Bhutanese mandarin orange cultivation trends from 1961 to 2022, focusing on areas, production, and yield. It also analyzes import and export volumes of mandarin oranges between 2004 and 2023.

Materials and Methods

Data

Time series data from 1961 to 2022 (62 years) regarding the area, production, and yield of mandarin oranges of Bhutan were sourced from Food and Agriculture Organization website (FAO, 2024), and the data on import and export from 2004 to 2023 (20 years) were obtained from annual trade statistics published in ministry of finance website (MoF, 2024). For this study, yield in 100g per hectare, area in hectares, and production in metric tons are used.

Analytical technique

The semi-log trend function was utilized in this study to forecast the growth rates of mandarin orange cultivation in Bhutan from 1961 to 2022, as well as to analyze import and export trends from 2004 to 2023. This approach is particularly effective in capturing the exponential growth patterns often observed in agricultural data, providing a more accurate representation of crop production growth rates compared to linear models (Kumar & Singh, 2014). This method is commonly utilized in agricultural research to analyze trends and growth rates concerning harvested area, production, and yield (Ammani, 2015). This study utilized the following semi-logarithmic function (Abid et al., 2014):

$\ln Z = \beta_0 + \beta_1 X + e$

Where,

Z = dependent variable (area, yield, production, import, and export);

- X = trend over specific period;
- β_1 = coefficient of trend;
- ln = natural logarithm;
- e = error term;

The coefficient of trend (β 1) quantifies the

consistent proportional alteration in Z corresponding to a specific absolute shift in the value of the regressor X.

$\beta_1 = \frac{relative \ change \ in \ regressand}{absolute \ change \ in \ regressor}$

To find the percentage change or growth rate in Z caused by an absolute change in X, multiply the relative change in Z by 100. This is also known as the semi-elasticity of Z with respect to X, represented by 100 times β 1. It provides the instantaneous rate of growth (IGR). To calculate the compound growth rate (CGR) over a period, take the anti-log of β 1, subtract 1, and multiply the difference by 100.

$CGR = [antilog \beta_1 - 1] \times 100$

If the trend coefficient (β 1) is positive and statistically significant, it indicates growth acceleration. Conversely, if β 1 is negative and statistically significant, it suggests growth deceleration. A statistically insignificant β 1 suggests stagnation in growth. All statistical tests were conducted using EViews version 12.

Results

Production analysis: harvested area, production, and yield trends

The semi-log model analysis for the orange harvested area, production, and yield revealed a negative trend coefficient for orange harvested area, although it was not statistically significant. The decline in orange harvested area began in 1993, when it stood at 7526 hectares, and has since dwindled to 2579 hectares by 2022. Figure 1 illustrates the trends in orange harvested area, production, and yield. The harvested area experienced a declining trend, with CGR and IGR recorded as -0.410 and -0.411, respectively.

In contrast, both production and yield coefficients showed positive trends, indicating significant increases compared to the early years of data collection. Specifically, the CGR and IGR for production were recorded as 1.146 and 1.139 respectively, while for yield, they stood at 1.563 and 1.551 respectively. Despite a steady growth in orange production until 2012, reaching 63,609 tons, there has been a subsequent decline, although production remains higher than in the initial years of data collection. Table 1 presents the growth rates and trends for orange production, area, and yield in Bhutan from 1961 to 2022.

Import and Export Analysis: Quantity and Value Trends

The analysis of import and export trends provided valuable insights into market dynamics. Import data indicated a positive correlation between import quantity and time trend, signifying a rise in import quantities over time. Both import quantity and value showed positive associations with the time trend, with CGR and IGR recorded at 10.673 and 10.141 for quantity, and 23.045 and 20.738 for value, respectively. Figure 2 illustrates the trends in orange and export quantity and value.

Conversely, there was a downward trend in export quantity over time, reflected by a negative correlation with the time trend. The CGR and IGR for export quantity stood at -3.206 and -3.259, respectively. In contrast, export value showed an upward trajectory over time, indicating that Bhutanese Mandarin oranges commanded higher prices over the years. The CGR and IGR for export value were recorded at 4.443 and 4.347, respectively. Table 2 presents the growth rates and trends for orange import and export quantity and values from 2004 to 2023.

Discussions

The citrus industry in Bhutan has seen modest growth compared to earlier years of data collection, evidenced by positive trends in mandarin orange production and yield. The increase in production and yield underscores the resilience of Bhutanese farmers and their capacity to



Figure 1: Trends in orange harvested area, production, and yield

adapt to evolving agricultural practices. This growth is remarkable given the diverse agroecological zones of Bhutan and the challenges posed by diseases such as CTV, which affects 71.11% of citrus-growing regions with five major identified strains (Ghosh et al., 2022), as well as CLas. Despite facing various challenges, the citrus industry in Bhutan has showcased remarkable resilience, playing a vital role in contributing BTN 573,725,604 to the area in Bhutan is largely attributed to the initial use of unhealthy saplings during commercial orchard establishment, causing slow tree death in major growing regions, although recent expansion into a few districts has partially recovered losses. Commercial mandarin orange orchards were established in the 1960s and experienced rapid expansion during the 1970s, using saplings from unprotected nurseries at altitudes below 400 meters in India and Bhutan

Parameter	Production	Area	Yield	
β2	0.011	-0.004	0.016	
F(p-value)	18.306(0.0001**)	3.653(0.06)	139.417(0.000**)	
t-statistic	4.279	-1.911	15.473	
Instantaneous Growth Rate (%)	1.14	-0.411	1.551	
Compound Growth Rate (%)	1.146	-0.41	1.563	
Durbin-Watson stat	0.42	0.42 0.505		
SE	0.003	0.002	0.001	
SD	0.425	0.31	0.313	

Table 1: Growth rates and trend for orange production, area, and yield in Bhutan (19961-2022)

*Statistically significant statistics at $\alpha = 5\%$ **Statistically significant statistics at $\alpha = 1\%$

nation's economic growth in 2023 (Department of Revenue and Customs, 2023).

However, amidst the modest growth in production and yield, it is imperative to address the disparities in harvested area trends. The declining trend in orange harvested area raises concerns about potential constraints on land availability or shifts in agricultural priorities. The reduction in mandarin orange harvested until the late 2000s (Om et al., 2021). Mandarin orange production has also steadily declined from 63,609 tons in 2012 to 18,466.6 tons in 2022, although the decrease is insignificant compared to earlier years. Understanding the underlying factors driving this trend is crucial for devising targeted interventions aimed at sustaining and enhancing citrus cultivation areas. Moreover, efforts to mitigate the impact of diseases and pests on citrus orchards are essential to safeguarding the productivity and viability of orange cultivation in Bhutan.

The dynamics of Bhutan's mandarin orange export market underscore the evolving challenges faced by local growers over time. The trends in both export quantity and value paint a vivid picture of the hurdles encountered by Bhutanese farmers in meeting demand and maximizing profit margins. Over the years, while export values have shown a promising upward trajectory, the export quantities have remained relatively stagnant. This incongruity suggests a potential mismatch bedomestic demand, it also underscores a worrying dependence on imported citrus products. To ensure the long-term sustainability of Bhutan's citrus industry, it's essential to enhance domestic production through advanced methods such as micro-budding and high-density planting.

Micro-budding facilitates rapid propagation, allowing for high-density planting and fruit production within two years of microbudding (Skaria, 2000). Micro-budded trees are found to produce fruit 1-2 years earlier than T-budded citrus trees, offering reduced costs and early yields that can aid in plant dis-



Figure 2: Trends in orange import and export quantity and value.

tween market demand and production capacity. However, it also hints at an opportunity for farmers to capitalize on higher prices for their produce.

In parallel, Bhutan's import market for citrus products has experienced a consistent growth trend, fueled by factors such as population expansion, urbanization, and shifting consumer preferences. Notably, imports of mandarin oranges have surged dramatically, increasing by 452.34% from 71.51 tons in 2004 to 323.51 tons in 2023. This surge in imports signifies both an opportunity and a challenge. While it broadens consumer choices and meets ease management and facilitate high-density orchards for shorter cycles to mitigate disease pressure (Skaria & Hanagriff, 2009). Highdensity orchards can yield positive economic returns up to 12 years after planting, though they require a higher initial investment due to the greater number of trees needed (Skaria & Tao, 2000). By implementing such targeted interventions, Bhutan can reduce its reliance on imports and reinforce the resilience of its citrus industry. Such initiatives not only address immediate market needs but also contribute to broader goals of economic growth and food security.

Parameter	Import (Quantity in Ton)	Import (Value in BTN)	Export (Quantity in Ton)	Export (Value in BTN)
β2	0.101	0.207	-0.033	0.043
F(p-value)	39.825(0.000**)	160.419(0.000**)	12.108(0.0027**)	20.232 (0.000 ^{**})
t-statistic	6.311	12.666	-3.48	4.498
Instantaneous Growth Rate (%)	10.141	20.738	-3.329	4.347
Compound Growth Rate (%)	10.673	20.045	-3.206	4.443
Durbin-Watson stat	1.076	0.897	1.25	1.196
SE	0.016	0.016	0.009	0.01
SD	0.723	1.294	0.304	0.353

Table 2: Growth rates and trend for orange import and export quantity and values (2004-2023)

*Statistically significant statistics at $\alpha = 5\%$ **Statistically significant statistics at $\alpha = 1\%$

Conclusion

The citrus industry in Bhutan has shown modest growth and resilience over the years, particularly in the production and yield of mandarin oranges. Despite facing challenges such as diseases like CTV and CLas, Bhutanese farmers have demonstrated adaptability and perseverance, contributing significantly to the nation's economy through citrus cultivation. However, concerns arise from the declining trend in harvested area, suggesting potential constraints such diseases or shifts in agricultural priorities that need to be addressed. Efforts to mitigate the impact of diseases and pests on citrus orchards are crucial for sustaining productivity and viability.

The export market dynamics reveal both opportunities and challenges. While export values have shown growth, export quantities have remained stagnant, indicating a potential mismatch between demand and production capacity. In contrast, the import market for citrus products has surged, emphasizing the need to bolster domestic production to reduce dependence on imports.

Strategic interventions such as microbudding and high-density planting are essential to address these challenges and unlock the full economic potential of the citrus industry in Bhutan. Such targeted efforts aimed at enhancing cultivation practices, mitigating disease impact, and improving market access can further propel the growth of the citrus sector, ensuring its sustainability and contribution to Bhutan's agricultural and economic development.

This study provides valuable insights for policymakers and stakeholders to devise effective strategies tailored to the unique dynamics of the Bhutanese citrus industry.

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