

A comprehensive study on current status of black pepper in India: Insights on area, production, yield and trade pattern

Tamanna Arif^{1*}, Shreeshail Rudrapur², Sudheesh Kulkarni¹ & Vijayakumar Narayanpur¹

¹University of Horticultural Sciences, Bagalkote, Karnataka.

²Navsari Agricultural University, Waghai, Gujarat.

Email: tamannaarif10@gmail.com

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Abstract

Black pepper (*Piper nigrum* L.) is a significant spice crop with considerable economic importance in India. This study presents a comprehensive analysis of the status of black pepper in India, analyzing growth and stability of black pepper cultivation across different states, assessing trends in production, productivity, and trade, and evaluating the impact of these factors on India's agricultural economy. By examining data from 2018-19 to 2022-23, through a detailed examination of statistical data and trends, the research provides a holistic view of the black pepper industry in India. Considering the Indian scenario, Karnataka, Kerala and Tamil Nadu are the leading producers of black pepper in the country. Black pepper production exhibited high instability, with an index of 14.01, and notable fluctuations were also found in export quantities (12.30) and import values (21.72). The findings reveal the challenges and opportunities within the sector, highlighting the key factors influencing production and trade.

Keywords: Black pepper, India, production, productivity, economics

Introduction

Black pepper (*Piper nigrum* L.), esteemed as the "King of Spices," has been an integral part of India's agricultural landscape and trade heritage for centuries. Revered for its pungent flavor and therapeutic properties, black pepper has historically held a pivotal position in the spice trade, contributing significantly to India's economy. The country's diverse agro-climatic conditions provide an ideal environment for black pepper cultivation, particularly in the southern states of Kerala, Karnataka, and Tamil Nadu. This study aims to explore the current status of black pepper in India, offering a comprehensive analysis of cultivation areas, production trends, productivity levels, and

export-import patterns, thereby providing a holistic view of the sector's dynamics.

Beyond its culinary significance, black pepper has extensive medicinal uses. Rich in bioactive compounds, particularly piperine, black pepper exhibits a range of pharmacological properties, including anti-inflammatory, antioxidant, and antimicrobial activities (Meghwal and Goswami, 2012). Piperine enhances the bioavailability of various nutrients and drugs, making it a crucial component in medicinal formulations to improve the efficacy of treatments (Srinivasan, 2007). Black pepper also plays a role in gastrointestinal health by stimulating digestive enzymes and increasing gut motility, which aids in digestion and

nutrient absorption (Platel & Srinivasan, 2004). Additionally, it has been studied for its potential anti-cancer properties, as piperine can inhibit the proliferation of cancer cells and induce apoptosis (Yaffe *et al.*, 2015). Furthermore, black pepper is utilized in traditional medicine systems like Ayurveda and Chinese medicine to treat ailments such as colds, coughs, and respiratory disorders, owing to its warming and expectorant properties (Pruthi, 1993). Overall, black pepper's diverse applications underscore its importance not only as a spice but also as a valuable therapeutic agent.

India's black pepper industry, bound with its cultural and economic fabric, faces a myriad of challenges and opportunities. The cultivation of black pepper is largely concentrated in and around the Western Ghats, a region known for its rich biodiversity and conducive climate. However, the industry has encountered significant fluctuations in production and productivity due to factors such as climate change, pest and disease outbreaks, and socio-economic pressures.

Traditionally, black pepper cultivation was predominantly carried out using conventional methods passed down through generations. However, recent years have seen a gradual shift towards modern agricultural practices, driven by the need to enhance yield and meet the growing demands of both domestic and international markets. The adoption of high-yielding varieties, integrated pest management strategies, and sustainable farming techniques has become increasingly prevalent. This study examines these developments, highlighting their implications for productivity and sustainability in the black pepper industry.

In the global market, India has long been recognized as a major exporter of black pepper. Nevertheless, the country's position in the international trade landscape is continually influenced by competitive pressures from other producers. In recent years, the global black pepper sector has undergone substantial structural and competitive changes, driven by shifts in production geography, technological adoption and export orientation. India's relative position in the international market has been challenged by the rapid expansion

and productivity gains in countries such as Vietnam, Brazil and Indonesia. Recent global statistics indicate that these competing countries have achieved higher yield levels and more stable export performance due to large-scale adoption of improved planting material, intensive crop management and strong market integration. According to the secondary data reported by the Food and Agriculture Organization, global production growth during the last decade has been largely driven by Southeast Asian and South American producers, whereas production growth in India has remained comparatively slow. This research details on India's export-import patterns, shedding light on the intricacies of trade dynamics, major export destinations, and the economic value generated through black pepper exports. Furthermore, it explores the reasons behind India's black pepper imports, despite being one of the top producers, to understand the balance between domestic demand and supply.

With this backdrop the present study was undertaken to examine the growth and stability in area, production, productivity and export of black pepper. The findings aim to inform strategies that can enhance the resilience and competitiveness of India's black pepper sector in the face of global challenges.

Materials and methods

The study focused on the black pepper production and trade of India, as well as globally. The analysis is based on secondary information on area, production, productivity and export-import parameters that have been made available by various agencies and government departments. To analyze the global production of black pepper, data from 2018-19 to 2022-23 were utilized. The growth rate of variables of interest was computed using the compound annual growth rate (CAGR) of the area, production, productivity, and export of black pepper. The function is represented as follows:

$$Y_t = ab^t e^{ut}$$

Where, Y = Area /production /productivity/ export
a = Intercept b = Regression coefficient

'a' and 'b' are the parameters to be estimate t = time period Ut= Disturbance term in year 't'. The equation (1) was transformed into a log-linear form for easier estimation. The standard error of the growth rate was estimated and tested for its significance using the Student's t-test.

To measure the variability in the area under cultivation, production, productivity, and export of black pepper, the coefficient of variation (CV) was employed. The CV is calculated using the following formula:

$$CV = \frac{\text{(Standard deviation (s))}}{\text{(Mean(X))}} \times 100$$

To obtain the Instability index, the CV was multiplied by the square root of the difference between unity and the coefficient of multiple determination. This approach allowed for a detailed analysis of growth rates and instability in major parameters of black pepper cultivation.

Results and discussion

Area, production and productivity of black pepper

India: The growth and stability of black pepper cultivation over a five-year period (2018-19 to

2022-23) reveals a notable expansion in the area under black pepper (Table 1). In 2018-19, the area under cultivation was 244.60 thousand hectares. By 2022-23, this area had increased to 304.52 thousand hectares, reflecting a robust annual growth rate of 5.49 percent. This significant increase underscores the growing importance and investment in black pepper cultivation during this period.

Despite the expansion in cultivation area, the production levels of black pepper remained relatively stable, showing no significant changes over the five years. However, a concerning trend was observed in the productivity of black pepper. The productivity decreased markedly from 0.56 metric tonnes per hectare in 2018-19 to 0.30 metric tonnes per hectare in 2022-23. This decline in productivity translates to a negative growth rate of 13.85 percent per annum. Contrary to this, Paul (2023) observed positive growth in productivity.

The performance of the three major states involved in black pepper cultivation, *viz.* Karnataka, Kerala and Tamil Nadu, also showed considerable variation.

Karnataka: Table 2 depicts the key trends in black pepper during the period under study. The area under black pepper cultivation experienced a significant increase in the state.

Table 1. Trends in area, production and productivity of black pepper in India

Year	Area ('000 ha)	Production ('000 tonnes)	Productivity (tons/ha)
2018-19	244.60	137.40	0.56
2019-20	257.83	106.77	0.41
2020-21	309.34	140.64	0.45
2021-22	283.96	95.32	0.34
2022-23	304.52	90.15	0.30
Mean	280.05	114.05	0.41
SD	28.38	23.60	0.10
CV	10.14	20.69	25.29
R ²	0.68	0.54	0.87
Instability index	5.75	14.01	8.94
CAGR	5.49	-9.12	-13.85
Significance	10%	NS	5%

In 2018-19, the area under cultivation was 148.38 thousand hectares. By 2022-23, this had expanded to 211.98 thousand hectares, reflecting a robust annual growth rate of 9.20 percent. This substantial growth highlights the increasing importance of black pepper farming in Karnataka during this period. However, the productivity of black pepper showed a decline. Productivity decreased from 0.63 metric tonnes per hectare in 2018-19 to 0.24 metric tonnes per hectare in 2022-23, resulting in a negative growth rate of 20.31 percent per annum. The decline in productivity indicates the presence of several challenges that might be affecting black pepper farming in Karnataka. These challenges could include issues such as soil degradation, pest infestations, climate change impacts, or suboptimal farming practices. Addressing these challenges through improved agricultural practices, pest management, and soil health initiatives will be crucial to enhancing the productivity and sustainability of black pepper cultivation in Karnataka. The results were found to be in mixed findings of Deekshit *et al.* (2024) where they found positive growth rates in area, production and productivity.

Kerala: The growth and stability in the area, production, and productivity of black pepper in Kerala during the study period is depicted in Table 3. The data shows a decline in the area under black pepper cultivation. In 2018-19,

the area under cultivation was 82.76 thousand hectares, which decreased to 76.16 thousand hectares by 2022-23, reflecting an annual decline rate of 2.41 percent. This reduction in the cultivation area indicates a potential shift in agricultural practices or economic factors affecting black pepper farming in Kerala. The results are in line with the findings of Paul (2023). There was also a noticeable decline in black pepper production over the years, with the highest production recorded in 2019-20 at 37.25 thousand tonnes. This peak in production was an anomaly, as subsequent years saw a continuous decrease. The yield per hectare did not show improvements during this period. This stability in productivity, despite fluctuations in the cultivation area and overall production, suggests that the existing farming practices maintained a consistent output per unit area, though not sufficient to counterbalance the overall decline in production.

Tamil Nadu: The growth and stability in the area, production, and productivity of black pepper in Tamil Nadu over the five-year period from 2018-19 to 2022-23 are depicted in Table 4. The data indicates a positive trend in the area under black pepper cultivation increasing from 5.64 thousand hectares in 2018-19, to 7.41 thousand hectares by 2022-23. This growth demonstrates a rising interest and investment in black pepper farming within the state.

Table 2. Trends in area, production and productivity of black pepper in Karnataka

Year	Area ('000 ha)	Production ('000 tons)	Productivity (tons/ha)
2018-19	148.38	94.14	0.63
2019-20	160.77	63.03	0.39
2020-21	211.50	99.62	0.47
2021-22	190.00	55.64	0.29
2022-23	211.98	50.00	0.24
Mean	184.53	72.49	0.41
SD	29.08	22.83	0.16
CV	15.76	31.49	38.70
R ²	0.74	0.50	0.85
Instability index	8.03	22.34	14.88
CAGR	9.20	-12.98	-20.31
Significance	10%	NS	5%

Table 3. Trends in area, production and productivity of black pepper in Kerala

Year	Area (‘000 ha)	Production (‘000 tons)	Productivity (tons/ha)
2018-19	82.76	36.78	0.44
2019-20	82.54	37.25	0.45
2020-21	82.12	33.59	0.41
2021-22	76.35	32.52	0.43
2022-23	76.16	33.29	0.44
Mean	79.99	34.69	0.43
SD	3.41	2.17	0.02
CV	4.27	6.25	3.83
R ²	0.80	0.73	0.14
Instability index	1.89	3.25	3.56
CAGR	-2.41	-3.30	-0.91
Significance	5%	10%	NS

Production levels also showed a significant increase during this period. In 2018-19, the production of black pepper was 1.25 thousand tonnes which increased to 1.64 thousand tonnes by 2022-23. However, the productivity of black pepper in Tamil Nadu did not show a significant difference over the study period. This stability in productivity suggests that the existing agricultural practices were sufficient to maintain consistent yields, but further advancements or innovations may be necessary to boost productivity levels.

Trends in export and import of black pepper

Export of black pepper (2018-19 to 2022-23)

The trend in export quantity was also estimated and tested for its significance (Table 5). The growth in the export of black pepper in terms of both export quantity and export value showed an increasing trend from 2018-19 (13,540 tonnes) to 2022-23 (21,863 tonnes). The export value consistently increased from 2018-19 to 2021-22, starting at Rs. 56,868 lakhs in 2018-19 and peaking at Rs. 75,331.23 lakhs in 2021-22. However, in 2022-23, there was a slight decline to Rs. 72,686.41 lakhs. The compound annual growth rate (CAGR) for the export value was 7.93 percent. The results were found to be different from the findings of Yogesh and Mokshapathy (2013) where the negative

annual growth rate was observed. Black pepper plays a significant role in India’s agricultural sector. The increasing trend in export quantity and value highlights its importance as a major export commodity. The consistent rise in export value until 2021-22 demonstrates its significant contribution to India’s foreign exchange earnings. Even with the slight dip in export value in 2022-23, the overall trend remains positive, underscoring black pepper’s resilience and economic significance.

Import of black pepper (2018-19 to 2022-23)

The trends in import of black pepper are illustrated in the table 6, highlighting the increasing trend over the years. From 2018-19 to 2021-22, the quantity of black pepper imports showed a notable positive growth. In 2018-19, the import quantity was 24,950 tonnes. This figure steadily increased, reaching 37,188 tonnes in 2021-22. However, in 2022-23, there was a slight decrease, with imports recorded at 35,905 tonnes. Similarly, the import value of black pepper also exhibited an upward trajectory over the same period. In 2018-19, the import value was Rs 77,991 lakhs. By 2022-23, this value had significantly increased to Rs 138,490 lakhs. However, the import value saw a minor decline in 2023-24, dropping to Rs 134,023.64 lakhs. The slight decline in 2023-24 indicates a potential stabilization or market

Table 6. Import of black pepper to India

Year	Qty (tonnes)	Value (lakh Rs.)
2018-19	24,950	77,991.40
2019-20	26,230	58,153.35
2020-21	29,415	78,134.81
2021-22	37,188	138,490.40
2022-23	35,905	134,023.64
MEAN	30737.60	97358.72
SD	5564.93	36461.78
CV	18.10	37.45
R ²	0.89	0.66
Instability index	5.97	21.72
CAGR	11.37	21.54
Significance	5%	10%

adjustment, warranting further analysis to understand the underlying factors. Similar results were observed by Sabu *et al.* (2024).

Instability analysis

Instability analysis is crucial for understanding the consistency of growth performance in black pepper cultivation. By evaluating fluctuations in key variables such as production, productivity, and export-import dynamics, instability analysis helps identify underlying risks and uncertainties. It enables policymakers, farmers, and industry stakeholders to anticipate challenges, optimize resource allocation, and implement measures to achieve sustainable growth and resilience in the black pepper industry.

There was a significant level of instability in the growth of black pepper production and productivity in Karnataka. Specifically, the instability index for pepper output in Karnataka was 22.34, indicating a high degree of variability in production levels. Similarly, the instability index for productivity was 14.88, also reflecting substantial fluctuations. The reasons for sharp productivity decline in Karnataka and high instability indices at the national level for production, export quantity and import value are discussed below.

Severe and recurrent disease pressure: In Karnataka, the increasing incidence of soil-

borne diseases (notably foot rot and slow decline) has caused large-scale vine mortality and progressive weakening of surviving plants. Once infected, yield losses persist for several years because black pepper is a perennial crop. This cumulative biological damage is a major structural reason behind the exceptionally high negative productivity growth in the state (-20.31% CAGR).

Ageing and senile plantations: A large proportion of pepper gardens in Karnataka consist of old and unproductive vines. Systematic replanting and rejuvenation programmes have been limited, mainly due to high establishment cost, delayed returns and lack of assured disease-free planting material. As a result, productivity continues to decline over time, unlike in states where gradual plantation renewal is more actively practiced.

High degree of climate sensitivity: Black pepper is extremely sensitive to rainfall distribution and soil moisture conditions. Irregular monsoon behaviour, short dry spells and occasional heavy rainfall events have increased stress on vines and favoured disease outbreaks. These climatic fluctuations directly explain the high instability indices in both production and productivity, since even a single unfavourable season can substantially reduce yield in perennial plantations.

Reduction in management intensity and input use:

Price volatility has significantly affected farmers' willingness to invest in labour-intensive and cost-intensive operations such as plant protection, mulching, nutrient management and vine training. During low-price years, growers often reduce field operations, which immediately lowers yield and accelerates plant health deterioration. This economic behaviour amplifies production instability and reinforces declining productivity trends.

Addressing each of these issues through improved management practices and climate adaptation strategies is essential for achieving more stable production outcomes. This instability in yield may be due to factors such as soil degradation, fluctuating input costs, or inefficient farming techniques also. To mitigate these issues, there is a need for interventions aimed at enhancing soil health, optimizing resource use, and implementing advanced agricultural technologies.

Contrasting trends among states arise mainly from differences in extension support, technology adoption and access to quality planting material. For instance, Kerala shows relatively better stability in some production pockets due to stronger extension outreach and wider adoption of integrated disease management practices, whereas Tamil Nadu and Karnataka face greater constraints related to old plantations, limited technological diffusion and weaker institutional support. These regional differences in production environment and support systems largely explain why some states perform better while others show sharp decline and high instability.

Moreover, the instability analysis highlights that the highest overall instability was observed in the total black pepper production for the entire country, with an index of 14.01. This high level of instability underscores the considerable fluctuations in national production levels, which can be attributed to factors such as climatic conditions, pest outbreaks, and market volatility. Addressing these challenges requires a comprehensive approach that includes national-level strategies for climate resilience,

market stabilization, and policy support for black pepper cultivation. The results are in line with the findings of Jacob and Job (2015).

There is considerable instability in export quantity and import value. The instability index for black pepper export quantity was 12.30, indicating notable variability in export volumes over the years. Similar findings were observed by Jacob and Job (2015). This instability may result from changing global demand, trade policies, or supply chain disruptions. Developing strategies to enhance market access, diversify export destinations, and stabilize trade relations are essential for managing export quantity fluctuations. The import value also exhibited high instability, with an index of 21.72, reflecting significant fluctuations in the financial value of black pepper imports. Factors contributing to this instability may include exchange rate volatility, changing import tariffs, and global market conditions. Effective strategies for managing import value fluctuations might involve hedging against currency risks, negotiating favorable trade agreements, and monitoring global market trends.

Conclusion

The present study provides a consolidated assessment of growth and instability in black pepper area, production, productivity and trade in India during the period 2018–19 to 2022–23 and clearly reveals strong regional disparities in performance. While a positive expansion in area under black pepper cultivation was observed in several states, particularly in Tamil Nadu, this expansion has not translated into commensurate productivity gains. On the contrary, the results demonstrate pronounced instability in production and productivity across major producing states, with an exceptionally sharp decline in productivity in Karnataka, indicating serious structural and management constraints. In contrast, relatively better stability in certain production pockets of Kerala highlights the importance of effective disease management, stronger extension support and better access to improved production technologies. Overall, the findings show that short-term expansion of

cultivated area alone is insufficient to ensure sustainable growth of the black pepper sector unless accompanied by improvements in plantation health, management intensity and economic viability.

From a policy perspective, the results emphasize the urgent need for state-specific intervention strategies rather than uniform national programmes. Policy makers should prioritise large-scale replacement of senile and disease-affected gardens with certified, disease-free planting material, particularly in high-decline and high-instability regions such as Karnataka. Strengthening institutional mechanisms for nursery regulation, quality planting material supply and region-specific integrated disease management programmes is essential for restoring productivity. Extension agencies should focus on improving farmers' adoption of canopy management, soil health management and timely plant protection practices through targeted capacity-building programmes in vulnerable production clusters.

For research and development organizations, greater emphasis is required on the development and dissemination of disease-tolerant and climate-resilient planting material and on refining location-specific production packages addressing dominant local constraints. Market and development agencies should promote price-stabilization and market-linked production strategies to reduce income uncertainty, which currently discourages adequate investment in crop management and plantation renewal. At the farm level, growers are advised to adopt systematic replanting of unproductive vines, strengthen integrated disease management practices and maintain recommended cultural operations to improve long-term productivity and resilience.

In conclusion, improving productivity and reducing instability rather than merely expanding cultivated area must become the central focus of future development strategies for the black pepper sector. Targeted technological, institutional and market-oriented interventions in high-risk states will be critical for enhancing the sustainability and global competitiveness of India's black pepper industry.

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