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Growth dynamics and decomposition analysis of major vegetables in Chhattisgarh

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Abstract

The present study was conducted to examine the trends in the area, production, and yield of key vegetables of Chhattisgarh including tomato, brinjal, okra, potato, and chilli—using secondary data from 2004–05 to 2023–24. The primary findings of the study revealed that the compound annual growth rate of all the major vegetables recorded positive growth over the last twenty years. Among them, brinjal exhibited the highest area growth rate at 4.81 percent, while the CAGRs for tomatoes, potatoes, okra, and chillies were 4.4 per cent, 4.29 percent, 3.98 percent, and 4.67 percent, respectively. When considering production, tomato recorded the fastest growth at 7.93 percent annually. Interestingly, between 2014 and 2024, negative area growth rate was experienced in case of chilli. Decomposition analysis highlighted yield as the main contributor to production growth, followed by interaction effects, while area effect contributed the least. The per cent contribution of yield towards production in tomato, brinjal, potato, okra and chilli were 49.97 per cent, 19 per cent, 64.25 per cent, 85.51 per cent and 75.82 per cent respectively. By implementing action plans into place and embracing contemporary technologies, the area hopes to boost vegetable output, guarantee sustainability, and enhance the standard of living of farmers of Chhattisgarh.

Keywords: Vegetables, compound growth rates, decomposition analysis, yield

Introduction

Recent developments in agricultural methods and cutting-edge technologies have also altered the landscape of India's horticultural sector. Based on data from 2022–2023, vegetables hold a significant position among the various horticulture crops, taking up 11.36 million hectares of land. 212.91 million tons of vegetables are produced annually, with an average output of 18.74 tons per hectare. According to the results, Indian vegetables are highly competitive in the global market because their nominal protection coefficient is less than one. This indicates that the vegetables have a significant potential for exportation. (Dastagiri *et al*, 2013) ^[3]. Located in the central India, Chhattisgarh holds a very important position in contributing to the vegetable production of the country. Moreover, the presence of three different agroclimatic regions makes it well fitted for the production of a wide variety of horticultural crops in which vegetables play a prominent role. In the case of vegetables, the total area covered is 491.393 thousand hectares with a production of 6789.14 thousand tons and a productivity of 13.81 metric tons per hectare, as per the statistics of 2023-2024. (Directorate of Horticulture, Chhattisgarh). For the majority of the vegetables, like cucurbits, solanaceous vegetables, cauliflower, cabbage and beans, the conditions are favorable for growth in the state. The crops that occupy the highest

area are tomato, brinjal, potato, chilli and okra. Studying the pattern of area, production, and yield of major vegetables shows up the potential and prospects of vegetable cultivation in Chhattisgarh, which helps to increase the crop yield and ensure sustainability. It is easier to execute alternative aims and strategic policies when production is projected by decomposing growth into its component parts.

Methodology

The study on growth and decomposition analysis of vegetables was performed in Chhattisgarh state based on area, production and yield of vegetables. This area was purposively selected for the study purpose. For the present study, major vegetable crops grown in the state were selected, which include tomato, brinjal, chilli, okra and potato. Major vegetables were selected based on the area being cultivated. The present study utilizes secondary data, and inferences are drawn based on the specific objectives. Secondary data required for the study purpose was collected from the website of the government of Chhattisgarh, the Directorate of Horticulture and Farm Forestry, Chhattisgarh, and the Agricultural Marketing Information Network. The data was obtained for the period of 20 years from 2004-05 to 2023-24, and for analytical convenience, this period is divided into two subgroups, viz., 2004-05 to 2014-15 (first subperiod) and 2015-16 to 2023-24 (second subperiod).

Analytical tools and techniques

Compound growth rate Analysis

Compound growth rate is an effective statistical tool that illustrates the overall growth performance and developmental patterns of a variable over a period of time. Examining the past trends helps to modify the existing situations and make strategic decisions in the future. To compute the growth rate of area, production and productivity of major vegetables of Chhattisgarh state, the following mathematical model was used:

$Y = aB^t$

$\log Y = \log a + t \log B$

Y = Area / Production / Productivity

a = Constant

B = Regression coefficient

t = time in year

Compound annual growth rate (%) = (Antilog B-1)100

Decomposition of Output Analysis

To find the relative contribution of area, production, and interaction between area and yield to the total vegetable production, Decomposition analysis model (Minhas and Vaidyanathan, 1965; Hemant *et al.*, 2017) was used. In this method, variables used are Ao, Po, and Yo indicate the respective area, production and productivity or yield in the base year, while another set of variables An, Pn and Yn indicate the respective variables in nth year.

Where, ΔA Y = Area effect ΔY A = Yield effect $\Delta A \Delta Y$ = Interaction effect A o = Triennium average of area in base year

A n = Triennium average of area in nth year

Y o = Triennium average of yield in base year

Y n =Triennium average of yield in nth year

P o = Triennium average of production in base year

P n = Triennium average of production in nth year

$P_o = A_o \times Y_o$ and $P_n = A_n \times Y_n$ (1)

Variation in production, area and yield are calculated using following functions:

$P_n - P_o = \Delta P$

$A_n - A_o = \Delta A$ and

$Y_n - Y_o = \Delta Y$ (2)

For equation (1) and (2) we can write

$P_o + \Delta P = (A_o + \Delta A) (Y_o + \Delta Y)$

Hence

$P = \frac{A_o \Delta Y}{\Delta P} \times 100 + \frac{Y_o \Delta A}{\Delta P} + \frac{\Delta Y \Delta A}{\Delta P} \times 100$

Production = yield effect + area effect + interaction effect

Results and Discussion

Growth rates of area, production and productivity of major vegetables of Chhattisgarh

Table 1: Compound Annual Growth Rate of major vegetables of Chhattisgarh during the period 2004-2024(in per-cent)

Crops	Period I 2004-2014			Period II 2014-2024			Overall period 2004-2024		
	A	P	Y	A	P	Y	A	P	Y
Tomato	7.21**	14.53*	6.83*	1.19***	1.61***	0.42***	4.40*	7.93*	3.38*
Brinjal	9.22*	14.81*	5.12*	1.40*	1.74*	0.34*	4.81*	7.27*	2.34*
Potato	11.97*	14.49*	2.25***	-0.55***	0.37***	0.13***	4.29*	5.49*	1.15*
Okra	8.19*	11.74*	3.29***	1.56*	2.22*	0.65***	3.98*	5.15*	1.12**
Chilli	18.47*	22.51*	3.41*	-1.21***	-1.48***	-0.31***	4.67*	6.32*	1.58*

***denotes significant at 10 percent * denotes significant at 1 percent

** denotes significant at 5 percent A-Area P-Production Y-Yield

Growth in area, production and yield of Tomato

The Compound Growth Rate analysis of tomato revealed that over the entire period, the highest growth rate was observed in production(7.93%) followed by the growth rate in area(4.40%). Taking into picture, the subperiod wise analysis of growth rate in area, production and productivity of tomato, all the parameters showed a significant and more

growth rate in first subperiod than the second subperiod where all the parameters dropped drastically. Production has shown the highest rate of increase among all the major vegetables in Chhattisgarh compared to area and productivity and this matches with the findings of Sahu *et al.* (2020)^[10] and Dhanush *et al.* (2024)^[6].

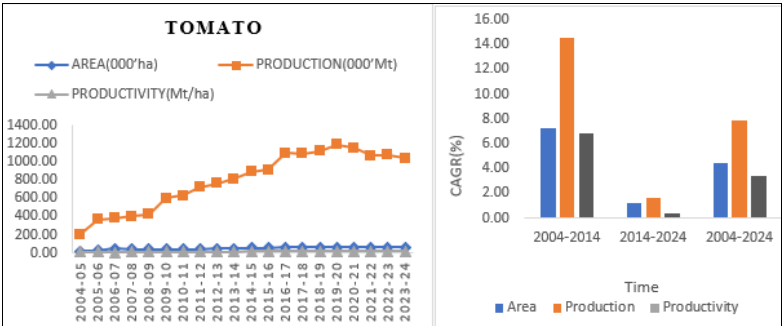


Fig 1: Trend and compound annual growth rate of tomato (2004-2024)

Growth in area, production and yield of brinjal

Examining the growth trends of brinjal, production showed the highest growth rate (7.27%) followed by area (4.81%). The first subperiod witnessed the increased growth rate in

all the variables as compared to the second subperiod. Declining growth rates across all the parameters were observed during the second subperiod, 2014-2024. The pace of agricultural expansion gave a slow pattern.

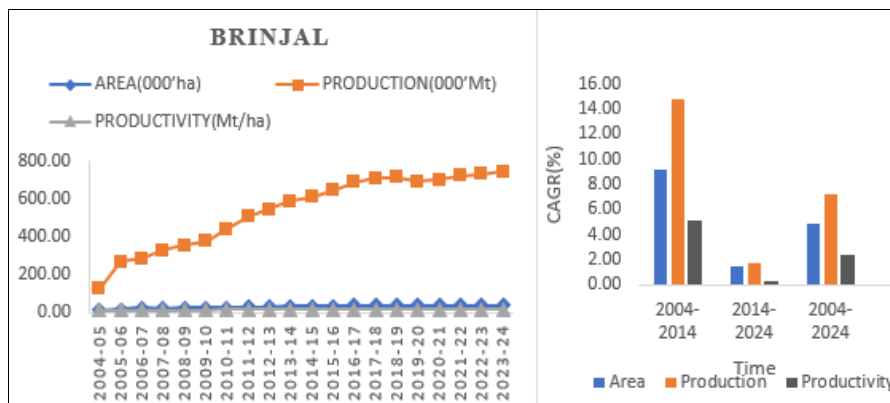


Fig 2: Trend and compound annual growth rate of brinjal (2004-2024)

Growth in area, production and yield of Potato

Results from the growth rate analysis of potato showed that the highest growth rate was found in production (5.49%). Area and productivity had growth rates of 4.29 and 1.15 respectively. The first subperiod showed significant growth

rates whereas the growth rate of area turned out to be negative in the second sub period. Stagnant behaviour of the parameters during the second subperiod resulted the overall averages to be low.

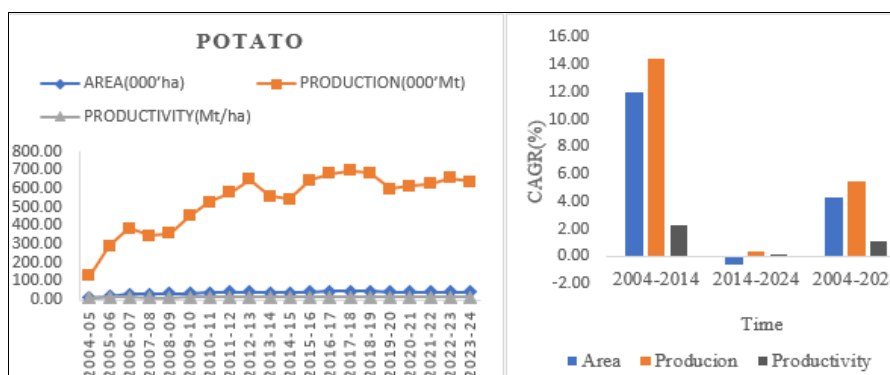


Fig 3: Trend and compound annual growth rate of potato (2004-2024)

Growth in area, production and yield of Okra

The growth analysis of area, production and productivity of okra recorded significant growth during the period 2004-2024. The area, production and productivity increased at the rate of 3.98, 5.15 and 1.12 per cent per annum respectively. Distinct slowdown of growth across each variables was

observed in the second decade. Area growth slowed to such an extent that it showed only 1.56 percent per annum. Production in combination with area increased only by 2.22 percent per annum. A very marginal improvement of 0.65 percent per annum was observed in the case of productivity

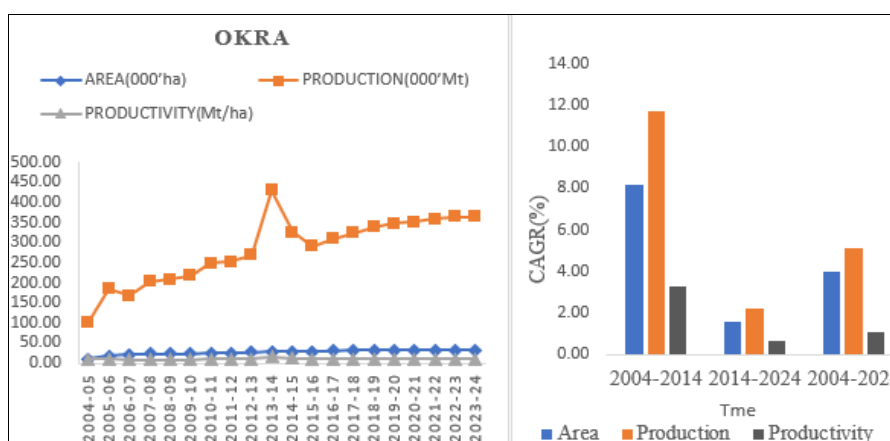


Fig 4: Trend and compound annual growth rate of okra (2004-2024)

Growth in area, production and yield of Chilli

The growth trend analysis of chilli revealed that a higher rate of expansion in area, production and productivity was observed during the first subperiod while each parameter showed negative growth rate during the second subperiod.

This was due to the outbreak of diseases in chilli. Over the entire study period, moderate growth rates of 4.67, 6.32 and 1.58 per cent per annum was found in the area, production and productivity of chilli.

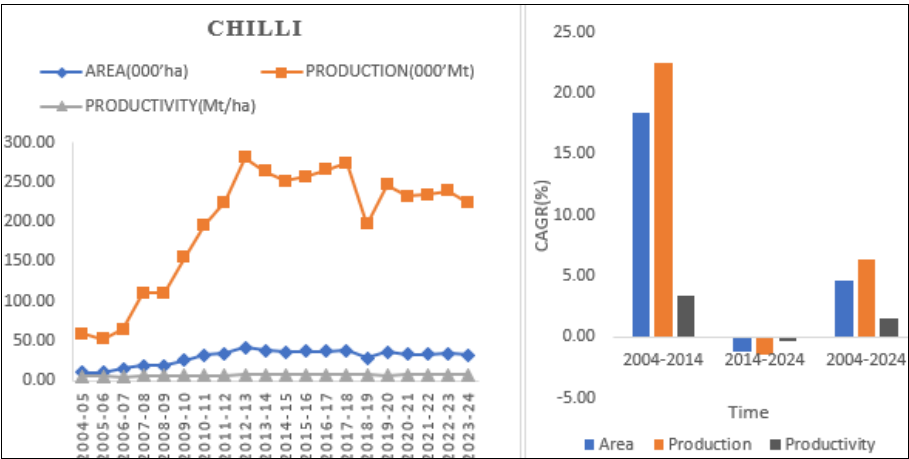


Fig 5: Trend and compound annual growth rate of chilli (2004-2024)

Decomposition Analysis

Table 2: Decomposition Analysis of major vegetables in Chhattisgarh during the period 2004-2024 (in percentage)

Period	Effect	Tomato	Brinjal	Potato	Okra	Chilli
2004-2014	Area effect	20.20	15.97	10.07	17.23	6.22
	Yield effect	50.07	52.60	67.37	53.19	77.18
	Interaction effect	29.73	31.44	22.55	29.59	16.60
2014-2024	Area effect	7.47	20.14	53.13	-13.75	11.32
	Yield effect	91.38	76.46	42.93	115.66	89.79
	Interaction effect	1.15	3.39	3.92	-1.91	-1.11
2004-2024	Area effect	16.66	14.21	10.12	4.52	7.77
	Yield effect	49.97	50.19	64.25	85.51	75.82
	Interaction effect	33.37	35.60	25.63	9.96	16.40

The study related to the relative contribution of area, yield and interaction effect in tomato showed that yield effect (49.97%) majorly impacted tomato production in the different subperiods as well as in the entire study period. The area effect contributed 20.20 percent towards production in the first subperiod and a relatively low 7.47 percent in the second subperiod. Interaction effect was responsible for a 29.73 percent increase in the first subperiod, while it contributed only 1.15 percent in the second subperiod. Over the years 2004-2024, the area effect showed a value of 16.66 percent, and the interaction effect was 33.37 percent.

The contribution of yield towards increase in the production of brinjal(50.19%) was found to be higher than the area as well as the interaction between area and yield effects. This result is supported from the studies of Sentilnathan *et al.*(2023) ^[11] During the first subperiod, the interaction effect, which accounted for 31.44 percent, was higher than the area effect, which was 15.97 percent. Area effect contributed to 20.14 percent in brinjal production while the interaction effect gave only 3.39 percent in the second subperiod.

Decomposition analysis of potato revealed that the yield effect(64.25%) contributed too increase in production of potato as compared to the area and interaction effect. During the first sub period, the interaction effect which accounted

to 22.55 per cent was higher than the area effect which was 10.07 per cent. The scenario in the second subperiod reversed such that the area effect of 53.13 per cent outweighed the interaction effect of 3.92 per cent than the first sub period.

The factor responsible for the increase in production of okra from 2004-2024 was observed to be the yield effect (85.51%). In the first subperiod each area, yield and interaction effect significantly affected production while in the second subperiod area and interaction effect turned out to be negative. This indicated that the cultivated land has decreased in the second decade. Interaction effect was responsible for a 29.59 percent increase in the first subperiod, while it also showed a negative value of -1.91 percent in the second subperiod.

Decomposition analysis of chilli revealed that the yield improvements (75.82%) contributed too increase in production of chilli as compared to the area and interaction effect. Area effect showed positive changes during the first and the second subperiod. It showed a value of 6.22 percent and 11.32 percent in the first and the second subperiods, respectively. The interaction effect depicted a positive change of 16.60 percent in the first subperiod, while it turned out to be negative at -1.11 percent in the second subperiod. This matches with the findings of Devegowda *et al.*, (2019)^[4].

Conclusion

Agriculture and allied activities constitute an increasingly important component of the Chhattisgarh economy. At current prices, the sector has contributed ₹10,703.83 billion to the state's income and has shown consistent growth over the last ten years. Additionally, the net value added nearly doubled to reach ₹4,758.04 billion between 2011–12 and 2024–2025 (Program Implementation and Statistics Ministry). Rising production levels and favorable market pricing have driven this upward trend.

Within this economic context, Chhattisgarh's horticultural sector plays a crucial role, contributing significantly to the state's Gross Domestic Product. Vegetable cultivation alone accounts for nearly 6.89 million tonnes of output, underscoring its central importance.

Greater efficiency in vegetable cultivation can be achieved by analyzing regional variations and formulating appropriate policies. A classification of districts in Chhattisgarh according to cropping efficiencies for major vegetables such as tomato, potato, chilli, brinjal, onion, cauliflower, cabbage, and okra shows that some districts fall into the Most Efficient Cropping Zone (MECZ), while others are categorized as Less Efficient Cropping Zone (LECZ) or Not Efficient Cropping Zone (NECZ) (Das *et al.*, 2022)^[2].

Expansion of the vegetable sector, leveraging regional advantages for each crop, can substantially increase the incomes of small and marginal farmers, particularly given the rising demand in both local and neighboring state markets. For long-term sustainability, adoption of water-saving irrigation techniques, climate-resilient crop varieties, integrated pest and disease management, and improved soil and water management practices will be essential.

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