Environment and Ecology 43 (1A) : 296—302, January—March 2025
Article DOI: https://doi.org/10.60151/envec/FRLF9317
ISSN 0970-0420

A Study on Growth and Decomposition Analysis of Area, Production and Yield of Mango in Uttar Pradesh, India

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Received 13 December 2024, Accepted 26 February 2025, Published on 17 March 2025

ABSTRACT

The research was carried out with the aim to know the growth performance, Instability and decomposition analysis of mango in Uttar Pradesh. The objectives of the study were to evaluate growth and instability as well as estimate the area, yield and there interaction on production of Mango in Uttar Pradesh. To fulfil these objectives, secondary data of 30 years (1994-2023) was utilized for analysis and using the statistical tools like CAGR (Compound Annual Growth Rates), CV (Coefficient of Variation), Cuddy Della Valle's Instability Index (CDVI) and decomposition analysis model. The study period was separate into four sub-times i.e. Period 1st from 1994 to 2003, Period 2nd from 2004 to 2013, Period 3rd from 2014 to 2023 and Period 4th from 2014 to 2023 for better understanding. The results depicted that area, production and yield of mango had a positive growth rate during all the study periods. Among the study periods, period 3rd had the highest and significant growth for area with 2.76% per annum of growth rate followed by period 2nd and period 1st. It is clear that mango production was the most instable, with a CVt of 12.52%, followed by yield (8.68%) and the cultivated area (4.53%). Decomposition analysis indicates that, during period 2nd, period 3rd and period 4th, the area impact was the most significant element driving the change in mango production in Uttar Pradesh.

Keywords Coefficient of variation, Cuddy Della Valle Index, Decomposition, Growth, Instability.

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INTRODUCTION

Horticulture accounting for 33% of agriculture's GVA i.e. (Gross Value Added), which is a key engine of the Indian economy, it has grown to play a significant part in Indian agriculture. Horticulture plays a vital role in rural development by increasing farmers' incomes and creating more jobs in rural areas (Balaganesh and Makarabbi 2023). The field of horticulture is arguably the most lucrative of all agricultural endeavours (Mahesh *et al*. 2000). It is difficult to over state the

value of horticulture in raising land productivity, creating jobs, boosting exports, improving the financial circumstances of farmers and business owners, and—above all—ensuring nutritional security for people living in desert regions (Mittal 2007). Due to the increased demand brought on by the population's rapid growth, as well as the rise in income levels and resulting shifts in consumption patterns, the production of vegetables and fruits has become increasingly important in recent years. In developing nations like India, fruits have a special role in enhancing income and nutritional status, especially for the rural masses, in both the social and economic spheres (Gowri *et al.* 2017).

The most significant tropical and subtropical fruits in the world is mango (*Mangifera indica* L.), which is a member of the Anacardiaceae family, is enjoyed both fresh and processed types. Its nutritional value, flavor, appealing scent, and health-promoting properties have earned it the title of "king of fruits." India is the world's greatest producer of mangoes, with hundreds of different types that vary in size, shape, and flavor. For the best growth and productivity, the majority of Indian mango varietals have particular eco-geographical needs. India's national fruit is the mango, which is grown primarily for its edible fruit (Murthy and Babu 2018).

The raw fruits of indigenous mango tree species are used to make a wide range of products, such as raw slices in brine, amchur, pickle, murabba, jam, jelly, chutney, panhe and more. In the coastal western zone, the fruits of the Alphonso type are used for squash, while the raw fruit of the local mango variety is utilized for commercial pickling and raw slices in brine. The dried twigs are utilized for religious purposes, while the wood is used as timber. 8–10% of mango kernels contain high-quality fat that may be saponified. Its starch is utilized in the confectionery sector. Mangoes can be used medicinally as well. The ripe fruit contains laxative, diuretic, and fattening effects. It facilitates the expansion of the digestive system (Priya and Singh 2020).

Among India's fruit harvests, mangoes hold a special and significant position. It is now playing vital role in the national economy of the country. Mangoes make up around half of all tropical fruits produced globally. India produces about half of the world's total, with 13.79 million tonnes, followed by China, Mexico and Thailand. Actually, around 80% of the world's mango production comes from the combined output of ten nations (Paulmurugan 2021).

As such with the above pretext it is proposed to undertake a study "Growth and Decomposition Analysis of Mango Production in Uttar Pradesh, India" with the following objectives.

1) To evaluate growth and instability in area, production and yield of mango in Uttar Pradesh.

2) To estimate the decomposition analysis of mango in Uttar Pradesh.

MATERIALS AND METHODS

Nature and source of data: India is the world's largest mango producer. Uttar Pradesh, Andhra Pradesh, Karnataka, Bihar, Gujarat, Maharashtra and other states are among the top producers of mangoes in India. The whole study, which covered the years 1994 to 2023, was derived from secondary sources i.e. 30 years for area ('000 Hectare), production ('000 MT) and yield (in kg/hectare) of mango in Uttar Pradesh. The obtained data were separated into four smaller times which are show in Table 1. The data were collect from official websites of Indiastat portal (www. indiastat. com 2024).

Analytical tools

***Descriptive statistics*:** To examine the nature of each

Table 1. Description of periods.

Sl. No.	Sub-periods	Description of periods
1	Period 1st (1994-2003)	Dominance of traditional farming practice
2	Period 2nd (2004-2013)	Expansion and challenges of high-yield variety adoption
3	Period 3rd (2014-2023)	Focused modernization, export boom and climate adaptation
4	Period 4th (2014-2023)	Consist whole period from 1994-2023

series, these have been subjected to get various statistics. Simple descriptive statistics like maximum, minimum, mean, median, standard deviation, skewness and kurtosis, are used for study. Descriptive statistics offer simple summaries about the data and the measures. Each descriptive statistics reduces a large amount of information into a small amount of text (Sathish *et al*. 2017).

These methods are used to compute descriptive statistics like mean and standard deviation as well as the compound annual growth rate (CAGR) is given here under:

a. Mean ($\bar{X}$)

$$(\bar{X}) = \frac{\sum X_i}{n}$$

Where, X_i is proportion of the year "i" and "n" is number of year.

b. Standard deviation (σ)

$$(\sigma) = \sqrt{\frac{\sum X_i}{n} - (\bar{X})^2}$$

Where, X_i is proportion of the year "i", "n" is number of year and $(\bar{X})^2$ is mean score.

c. Coefficient of Variation (CV)

$$CV = \left(\frac{\sigma}{\bar{X}}\right) \times 100$$

Compound annual growth rate:

The method of calculating the annual growth rate is CAGR, which is widely used. The compound annual growth rate is defined as the year-over-year growth rate over a specified period of time. The exponential function was fitted to determine the CAGR, as shown below (Gunadal *et al.* 2023).

Where,

$$Y = a\ bt\ ut \quad \text{.......................................} (1)$$

Y = Production, Area, yield and price of commodity consider in year t

a = Intercept

ut = Error term

b = Regression coefficient

t = Time variable

The equation obtained after transforming (1) is:

$$\text{Log } y = \log a + t \log b + \log ut \quad \text{..................} (2)$$

The percent CGR was calculated as:

$$G = ((\text{antilog of } b) - 1) \times 100$$

The significant CAGRs were classified in two groups i.e. negative and positive. The significance of growth rate was analyzed by conducting student's t- test at 1% and 5% level of significance.

Instability analysis

For assessing instability in production, area and yield, the index certain by Cuddy and Della (1978) and used by Srivastava *et al.* (2022), Supriya *et al.* (2023) and Gunadal *et al.* (2023).

$$\text{Instability index} = (CV) \times \sqrt{(1-)\ R^2}$$

Where,

CV = Coefficient of variation (%)

R^2 = Coefficient of determination of the variables linear trend model

Decomposition analysis

Using a decomposition analysis approach, the relative contributions of area and yield to the crop's overall production were calculated by Minhas and Vaidyanath (1964) which is given below.

Production= Yield effect+area effect+interaction effect

$$\text{Area effect} = \frac{Ao\ \Delta Y}{\Delta P} \times 100$$

$$\text{Yield effect} = \frac{\text{Yo}\,\Delta\,\text{A}}{\Delta\,\text{P}} \times 100$$

$$\text{Interaction effect} = \frac{\Delta\text{A}\ \Delta\text{Y}}{\Delta\,\text{P}} \times 100$$

Where,

Ao = Area in initial year
An = Area in final year
Yo = Yield in initial year
Yn = Yield in final year
Δ A = Change in area (An-Ao)
Δ P = Production change
Pn = Production in final year
Po = Production in initial year

The total production may thus be divided into three parts: The yield, area and interaction effect brought on by variations in both yield and area (Gaware *et al.* 2022).

RESULTS AND DISCUSSION

Growth rates

Growth rates of any element offer the concept of change in them, they either rise or decrease with time. Likewise, here the growth rates were computed to study the changes in production, area and yield of mango over time by using exponential function.

Table 2. Growth rate in area, production and yield of mango in Uttar Pradesh.

Compound annual growth rate %	Period 1st	Period 2nd	Period 3rd	Period 4th
Area (000 hectors)	2.70	2.72	2.76	2.73
Production (000 MT)	2.78	2.89	2.78	2.82
Yield (kg/ hectors)	2.96	2.87	2.74	2.80

The results obtained through analysis are presented in Table 2.

Table 2 depicted that among the study periods, period 3rd had the highest and significant growth for area with 2.76% annually of growth rate followed by period 2nd (2.72% annually) and period 1st (2.70% annually). In production, period 2nd experienced the largest and most significant annual growth rate of 2.89%, followed by period 3rd (2.78%) and period 1st (2.78% annually). The yield of mango had a positive and significant annual growth rate of 2.96% in period 1st followed by period 2nd (2.87% annually) and period 3rd (2.74% annually).

Fig. 1 showed that area, production and yield all increased significantly and positively during overall period i.e., period 4th with 2.73, 2.82 and 2.80% an-

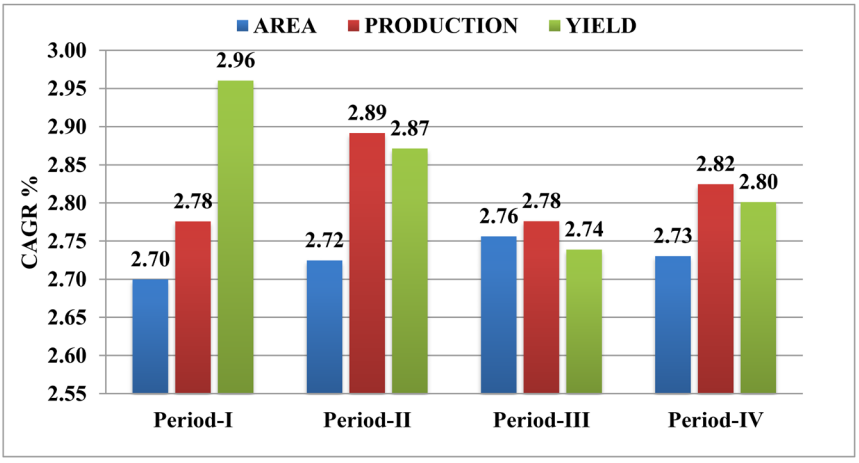

Fig. 1. Compound annual growth rate of mango in Uttar Pradesh 1994–2023.

Table 3. Instability of area, production and yield of mango in Uttar Pradesh.

Statistics	Period 1st	Period 2nd	Period 3rd	Period 4th
		Area ('000 hectare)		
R^2	0.41	0.03	0.48	0.44
CV	3.28	3.82	6.25	6.04
CVt	2.51	3.76	4.50	4.53
Mean	252.80	260.81	277.33	263.65
Standard deviation	8.30	9.96	17.32	15.91
		Production ('000 MT)		
R^2	0.09	0.95	0.54	0.86
CV	29.73	18.24	9.04	33.47
CVt	28.43	4.05	6.16	12.52
Mean	2256.1	3462.4	4703.2	3473.9
Standard deviation	670.8	631.6	425.1	1162.8
		Yield (kg/hectare)		
R^2	0.15	0.96	0.35	0.91
CV	14.70	16.39	3.81	29.42
CVt	13.55	3.36	3.08	8.68
Mean	8.5	13.1	16.9	12.9
Standard deviation	1.3	2.2	0.6	3.8

nually growth, respectively.

Instability index

The instability index indicates the degree of volatility. To analyze the degree of volatility in area, production and yield of mango, instability analysis was performed using the CV (coefficient of variation) and CDVI (Cuddy Della Valle's Instability Index).

Table 3 Provide the estimated coefficients of variation and the Cuddy-Della Valley Index for the period between 1994 and 2023. Looking at the data, it is clear that mango production was the most instable, with a CVt of 12.52%, followed by yield (8.68%) and the cultivated area (4.53%). This suggests that while there is some volatility, the overall prospects for mango crop growth remain relatively stable. In general, the area, production, and yield of mangoes in India have shown consistent and steady growth over the years. Despite the occasional fluctuations, the trends indicate that mango production in the country is relatively reliable, making India a stable supplier for importing countries.

Fig. 2 showed that area under mango cultivation showed low instability during periods 1st and 2nd while mango production had low instability in periods 2nd and 3rd. Similarly, mango yield remained more stable in periods 2nd and 3rd. However, the highest instability was observed in different periods for each factor: Area showed the most variability in periods 3rd and 4th, production was most instable in periods 1st and 4th, and yield was most unpredictable in periods 1st and 4th.

Various factors can contribute to the instability of

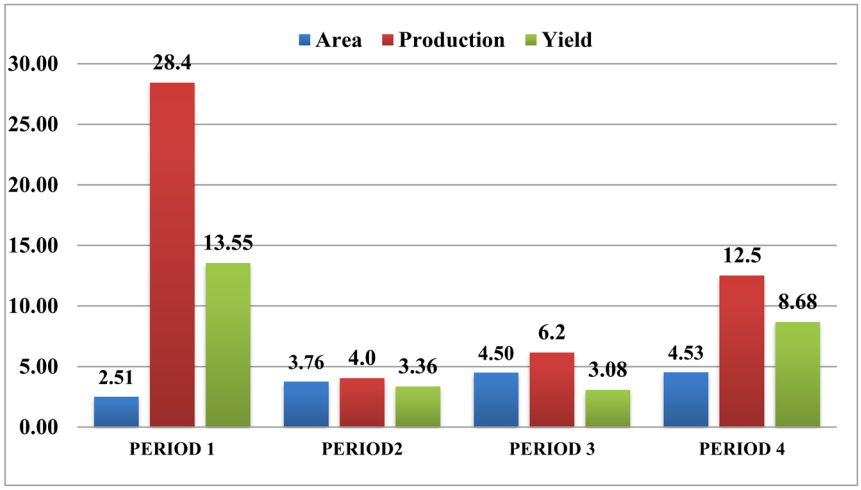

Fig. 2. Instability of area, production and yield of mango in Uttar Pradesh

Table 4. Decomposition analysis of area, yield and their interaction towards increasing production of mango (1994-2023). (Note: Sum of all three effects =100).

Sl.No.	Periods	Area	Yield	Interaction
1	Period 1st	-101.99	194.22	8.02
2	Period 2nd	85.10	9.28	5.22
3	Period 3rd	45.70	46.20	7.76
4	Period 4th (overall period)	54.97	29.80	14.95

mango production. Pests or diseases, such as mango hoppers, fruit flies, powdery mildew, anthracnose, and bacterial infections, can severely reduce yield if not controlled. In addition, improper agricultural practices—like inadequate pruning, poor fertilization, and suboptimal irrigation-can harm mango yield. Moreover, mango trees require specific climatic conditions, and any unfavorable shifts in the weather can impede their growth and affect the overall yield.

Decomposition analysis

Decomposition analysis was used to assess how yield, area and their interaction contributed to growth of mango production in Uttar Pradesh from 1994 to 2023. Three factors i.e. yield effect, area effect and interaction effect were identified as contributing to the growth in mango output. The research period was split into four sub periods the importance of each sub period as mentioned in the materials and methods.

Table 4 Indicates that, during Period 2nd Period 3rd and Period 4th, area effect was the most responsible factor for shift in production of mango in Uttar Pradesh. While during period 1st yield impact was found to be most responsible for change in production of mango in India. The highest yield effect was observed during period 1st i.e., 194.22% with negative area effect i.e. -101.99% and interaction effect i.e. 8.02%. While during period 2nd and period 3rd the yield effects were (9.28 and 46.20%, respectively with area effect (85.10 and 45.70%, respectively) and interaction effect (5.22 and 7.76%, respectively). During period 4th (overall period) area effect, yield and interaction effect were recorded 54.97, 29.80 and 14.95%, respectively. Thus, overall area effect had played a driving force in the differential production of mangoes in India during period 2nd, period 3rd and period 4th.

CONCLUSION

Uttar Pradesh is among the most important states of mango production in India. It is renowned for its diverse range of mango varieties and favorable agro-climatic conditions that support mango cultivation. Uttar Pradesh is known for its premium mango varieties such as Langra, Chausa and Dashehari. These varieties are sought after in both the domestic and global markets. The state has witnessed an overall increase in mango production and yield. This can be attributable to the adoption of improved farming techniques, research and development efforts, access to better inputs and government support. These factors have helped Uttar Pradesh's mango farmers enhance their production and achieve higher yield levels. From above discussion, highlight the decomposition analysis, growth and instability of mango production in Uttar Pradesh for the last 30 years from 1994 to 2023. The study concludes that, the mango area had increasing growth in a decreasing rate during the study periods. The growth rates of production and yield of mango in Uttar Pradesh had a fluctuating trend during the study periods. Also, the area, production and yield of mango in Uttar Pradesh had stability during all the study periods. In instability analysis indicates substantial volatility in mango production, followed by yield and area. The decline in yield might be caused to climatic factors or might be caused to poor cultivation practices like poor plant population, growing of traditional low yielding varieties, poor nutrient and water management are the key factors of low yield. Production also showed the highest instability followed by yield and area. According to the decomposition Analysis, area under mango was the primary contributing factor to the production change (excluding period 1st). As a result, yield can be boosted by establishing true-to-type nurseries for high producing fruit varieties, managing fruit orchards using scientific principles, and improving farmers' abilities to reduce fruit production losses both before and after harvest. As a result, stronger pricing rules and cold storage facilities should be implemented in the state.

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