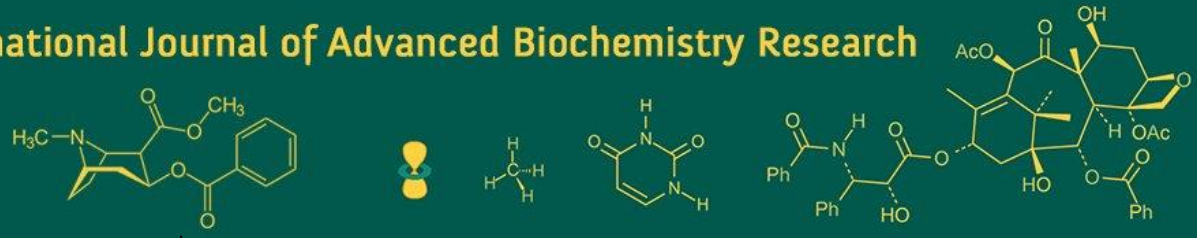
International Journal of Advanced Biochemistry Research



**ISSN Print:** 2617-4693
**ISSN Online:** 2617-4707
IJABR 2025; 9(2): 738-742
www.biochemjournal.com
Received: 22-11-2024
Accepted: 25-12-2024

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# Absolute change, relative change and variabilities in the area of papaya in the Chhattisgarh plain agroclimatic zone of Chhattisgarh state

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**DOI:** https://www.doi.org/10.33545/26174693.2025.v9.i2j.4150

**Abstract**
The study focused on the Chhattisgarh plains agroclimatic zone, covering 11 districts selected purposefully. It analyzed papaya area, production, and productivity data from 2009-10 to 2020-21. Absolute change, Relative change and variabilities were examined using official data from Chhattisgarh's agriculture department. In the Chhattisgarh plain zone, papaya cultivation expanded considerably during the study period. Districts such as Raigarh, Bilaspur, Kabirdham, Janjgir, Mahasamund, Rajnandgaon, Durg, Dhamtari, and Kanker showed positive growth in area, with Kabirdham and Mahasamund recording the highest increases of 195.70% and 126.19%, respectively. However, Korba and Raipur experienced declines. Overall, the area under papaya rose by 1,753.13 ha, from 7,929.20 ha to 9,682.33 ha, with a growth rate of 22.11% and annual variation of 12.38%. Papaya production surged by 86,472.47 metric tonnes (45.13% growth), led by Mahasamund, Durg, Raipur, and Raigarh, while Korba and Dhamtari saw declines. Productivity also improved, increasing by 4,639.98 kg/ha (19.26% growth) with annual variation of 9.22%. Significant productivity gains were observed in Raigarh, Raipur, Janjgir, and Mahasamund, while Kabirdham, Durg, and Dhamtari recorded decreases. Overall, the zone demonstrated a strong and positive trend in area, production, and productivity of papaya.

**Keywords:** Papaya, Chhattisgarh plains, trend, growth and area

## 1. Introduction
Papaya (*Carica papaya*), a tropical fruit crop, thrives in warm climates and requires high temperatures to produce high-quality fruits throughout the year. Believed to have originated in South Mexico, papaya was introduced to India in the 16th century by the Portuguese (Agriculture Info at a Glance, agristudent.com, 2022). Over the years, it has gained immense popularity due to its nutritional, medicinal, and industrial values. Papaya serves a variety of culinary purposes. Ripe fruits are consumed fresh, used in fruit salads, juices, jams, jellies, and candies, while the green, immature fruits are cooked as vegetables or processed into products like tutti-frutti. Papaya is highly nutritious—rich in proteins, carbohydrates, calcium, minerals, and energy—and contains strong antioxidant properties. Medicinally, it is highly valued for its latex, which contains two key enzymes: papain and chymopapain. Of these, papain is particularly significant due to its wide industrial applications in pharmaceuticals, food processing, and leather industries (Biology of *Carica papaya*, Ministry of Environment, Forest and Climate Change, 2017).

A well-managed papaya tree can produce 25 to 40 fruits per season, with total fruit weight ranging from 40 to 60 kilograms per tree. The fruits typically mature in 5 to 9 months, and harvesting begins once the skin starts turning yellow. However, papaya has a short shelf life of only 3 to 8 days at room temperature, which limits its marketability. To extend shelf life and reduce post-harvest losses, chemicals such as silver nitrate and cobalt chloride are often used (Agriculture Info at a Glance, agristudent.com, 2022). Globally, India ranks first in papaya production, followed by Brazil and Mexico (FAOSTAT, 2020). In 2020, papaya was cultivated across 142 thousand hectares in India, yielding approximately 6.011 million tonnes. The major papaya-producing states in India include Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, and Chhattisgarh. Some of the popular papaya varieties grown in India are Pusa Nanha, Pusa Giant, Pusa Majesty, Honey Dew, and Pusa

Delicious (Agriculture Info at a Glance, agristudent.com, 2022). Chhattisgarh plays a crucial role in India's papaya cultivation. The state ranks third in fruit production overall and, based on 2017-18 data, stands sixth in papaya production, contributing 381.42 thousand metric tonnes—about 6.36% of India's total papaya output (National Horticultural Board, 2020). Papaya is cultivated across nearly all districts in Chhattisgarh, with major growing areas including Bilaspur, Raipur, Durg, and Mahasamund.

During 2020-21, the Chhattisgarh plain zone had 13.987 thousand hectares under papaya cultivation, yielding 377.383 thousand metric tonnes (National Horticultural Board, 2020). This demonstrates the state's growing significance in the country's papaya sector, both in terms of area and production. With favorable climatic conditions and increasing farmer interest, papaya cultivation in Chhattisgarh holds considerable potential for further expansion, value addition, and improved economic returns for the agricultural community.

## 2. Materials and Methods

The state of Chhattisgarh comprises of three agroclimatic zones namely Chhattisgarh plain Northern hills zone, Bastar plateau, the present study was confined to the Chhattisgarh plains agroclimatic zone of Chhattisgarh. There are 11 districts in the selected region namely Raipur, Bilaspur, Janjgir, Korba, Raigarh Mahasamund, Durg, Kanker Dhamtari Kabir Dham, and Rajnandgaon. These districts were chosen purposefully for the study. The analysis covered a period of 12 years. This research had Considered data for the period 2009-10 to 2020-21. Analysis has been done to find out the Growth rate, Relative change, absolute change, yield effect, area effect, and interaction effect and policy related to papaya production for the whole period. The study was conducted mainly in 11 district of Chhattisgarh plain zone of Chhattisgarh state. The state divided into 3 agroclimatic zone namely the Chhattisgarh plains, the Baster plateau, and the northern hills zone, including 28 Chhattisgarh district out of the three agroclimatic zones, Chhattisgarh plain zone was selected purposely for the study. The data pertaining to area, production and productivity of papaya was obtained from the official website of the Chhattisgarh agricultural development and farmer welfare and biotechnology department Chhattisgarh.

**Period (2009-10 to 2020-21)**

Base year (Triennium ending)-2009-10 to 2011-12
Current year (Triennium ending)-2018-19 to 2020-21

### 3.1 Analytical tools

The analytical tools used in this study are mentioned below:

#### 3.5.1 Absolute Change

Absolute change is the total change in the considered quantity in a fixed amount of time. It is a simple difference between initial and final amount over a period of time. It was worked out to analyse the cropping pattern change by using the following formula:

Absolute change = Yn-Yo
Where,
$Y_n$ = Current Year
$Y_0$ = Base Year

### 3.2 Relative Change

Relative change is the indicator of difference between two similar quantities. it is use to express absolute change as percentage with respect to the initial point. Relative change in area of selected districts were estimated by using the following formula

$$\text{Relative change (\%)} = \frac{Yn-Yo}{Yo} \times 100$$

$$\text{Relative change (\%)} = \frac{\text{Current year} - \text{Base year}}{\text{Base year}} \times 100$$

Where

- Base year (Yo) = Triennium average (ending 2011-12) of Area, Production, Productivity of selected Papaya crop.
- Current year (Yn) = Triennium average (ending 2020-21) of Area, Production, Productivity of selected Papaya crop.

#### 3.5.3 Student t-test

$$t = \frac{b}{SE(b)}$$

## 3. Results

### 3.1 Absolute change, Relative change, and Variabilities in Area of papaya in the Chhattisgarh plain Agroclimatic zone

This section has attempted to measure the magnitude of change in area, production and productivity of papaya crop in all the selected districts of the selected zone of the state by using statistical tools such as absolute change, relative change and coefficient of variation. District by district changes under different crop variables (area, production and productivity) presented:

#### 3.1.1 Area

Among all the papaya grown districts in Chhattisgarh plain zone, the area in Raigarh district has increased by 176.33 ha, at the rate of 77.23 percent, from 228.33 ha (base year) to 404.67 ha (current year), with an annual variation of 20.92 percent. Area under papaya in Bilaspur district has increased from 1831.67 ha (base year) to 2270.67 ha (current year) by 439 ha at the rate of 23.97 percent, with a fluctuation of 15.09 percent per year.

During the study it was observed that area of papaya in Kabir Dham district has gained by 227.67 ha at the rate of 195.70 percent, from 116.33 ha (base year) to 344 ha (current year), at an annual variation of 41.02 percent. Janjgir district has also marked the increase in area under papaya at the rate of 16.93 percent by the magnitude of 111.33 ha, from 657.67 ha (base year) to 769 ha (current year) during the study period, with a variation of 8.05 percent.

Area under papaya in Mahasamund district has increased from 485 ha (base year) to 1097 ha (current year) by 612 ha at the rate of 126.19 percent, with a fluctuation of 40.86 percent per year. Rajnandagaon district has also marked the increase in area under papaya at the rate of 62.19 percent by the magnitude of 148.67 ha, from 236.33 ha (base year) to 385 ha (current year) during the study period, with a variation of 31.22 percent.

Similar pattern was observed in Durg district, papaya area was increased from 1380.67 ha (base year) to 2179.33 ha (current year), at the rate of 57.85 percent by the magnitude of 798.67 ha, facing a variation of 18.87 percent over the study period. Further it was observed that in Dhamtari district, papaya has gained with respect to area by the magnitude of 194 ha at the rate of 75.68 percent, from 256.33 ha in base year to 450.33 ha in current year, with a annual fluctuation of 24.72 percent.

Area under papaya in Kanker district has increased from 251.67 ha (base year) to 346.67 ha (current year) by 95 ha at the rate of 37.75 percent, with a fluctuation of 43.31 percent per year. It was observed that, among all the selected districts of the Chhattisgarh plain zone of the state, there was increase in area of papaya except in Korba and Raipur district. Area under papaya in Korba district has decreased from 676.67 ha (base year) to 155.67 ha (current year) by 521 ha at the rate of 77 percent, with a maximum fluctuation of 90.26 percent per year.

Similar pattern was observed in Raipur district, papaya area was decreased from 1808.53 ha (base year) to 1280 ha (current year), at the rate of 29.22 percent by the magnitude of 528.53 ha, facing a variation of 19.36 percent over the study period. Papaya has gained in Chhattisgarh plain zone in terms of area by 1753.13 ha, from 7929.20 ha in base year to 9682.33 ha in current year at the rate of 22.11 percent, with an annual variation of 12.38 percent. Table 1 has clearly indicated that papaya area has increased in Chhattisgarh state from 10327.03 ha in base year to 14108.33 ha in current year, at the rate of 36.62 percent by the magnitude of 3781.30 ha, with a 14.33 percent variation during the period of study annually.

**Table 1:** Absolute change, Relative change, and Variabilities in Area of papaya in Chhattisgarh plain Agroclimatic zone

| S. No. | District | Base year (ha) | Current year (ha) | Absolute change (ha) | Relative Change (%) | CV (%) |
|---|---|---|---|---|---|---|
| 1 | Korba | 676.67 | 155.67 | -521.00 | -77.00 | 90.26 |
| 2 | Raigarh | 228.33 | 404.67 | 176.33 | 77.23 | 24.92 |
| 3 | Bilaspur | 1831.67 | 2270.67 | 439.00 | 23.97 | 15.09 |
| 4 | Kabir Dham | 116.33 | 344.00 | 227.67 | 195.70 | 41.02 |
| 5 | Janjgir | 657.67 | 769.00 | 111.33 | 16.93 | 8.05 |
| 6 | Mahasamund | 485.00 | 1097.00 | 612.00 | 126.19 | 40.86 |
| 7 | Rajnandgaon | 236.33 | 385.00 | 148.67 | 62.91 | 31.22 |
| 8 | Durg | 1380.67 | 2179.33 | 798.67 | 57.85 | 18.87 |
| 9 | Raipur | 1808.53 | 1280.00 | -528.53 | -29.22 | 19.36 |
| 10 | Dhamtari | 256.33 | 450.33 | 194.00 | 75.68 | 24.72 |
| 11 | Kanker | 251.67 | 346.67 | 95.00 | 37.75 | 43.31 |
| A | Chhattisgarh plain zone | 7929.20 | 9682.33 | 1753.13 | 22.11 | 12.38 |
| B | Chhattisgarh state | 10327.03 | 14108.33 | 3781.30 | 36.62 | 14.33 |

### 3.1.2 Production

Among all the papaya grown districts in Chhattisgarh plain zone, the production in Raigarh district has increased by 9300 mt, at the rate of 77.23 percent, from 4639.33 mt (base year) to 13939.33 mt (current year), with an annual variation of 39.78 percent. Production under papaya in Bilaspur district has increased from 41869.98 mt (base year) to 53490 mt (current year) by 11620.02 mt at the rate of 27.75 percent, with a fluctuation of 32.03 percent per year. During the study it was observed that production of papaya in Kabir Dham district has gained by 2371.67 mt at the rate of 133.46 percent, from 1777 mt (base year) to 4148.67 mt (current year), at an annual variation of 33.20 percent.

Janjgir district had also shown the increase in production under papaya at the rate of 46.25 percent by the magnitude of 5587.66 mt, from 12081.34 mt (base year) to 17669 mt (current year) during the study period, with a variation of 16.46 percent. Production under papaya in Mahasamund district has increased from 9173 mt (base year) to 25976 mt (current year) by 16803 mt at the rate of 183.18 percent, with a fluctuation of 53.38 percent per year.

Rajnandagaon district has also marked the increase in production under papaya at the rate of 82.76 percent by the magnitude of 3618.5 mt, from 4372.17 mt (base year) to 7990.67mt (current year) during the study period, with a variation of 34.45 percent. Similar pattern was observed in Durg district, papaya production was increased from 55326.33 mt (base year) to 86837 mt (current year), at the rate of 56.95 percent by the magnitude of 31510.67 mt, facing a variation of 18.60 percent over the study period. Production under papaya in Kanker district has increased from 4041.17 mt (base year) to 5601 mt (current year) by 1559.83 mt at the rate of 38.60 percent, with a fluctuation of 43.30 percent per year. Production under papaya in Raipur district has increased from 40415.88 mt (base year) to 53337.33 mt (current year) by 12921.45 mt at the rate of 31.97 percent, with a fluctuation of 22.23 percent per year.

It was observed that, among all the selected districts of the Chhattisgarh plain zone of the state, there was increase in production of papaya except in Korba and Dhamtari district. Production under papaya in Korba district has decreased from 13533.33 mt (base year) to 5323.67 mt (current year) by 8209.67 mt at the rate of 60.66 percent, with a maximum fluctuation of 63.88 percent per year. Similar pattern was observed in Dhamtari district, papaya production was decreased from 4373.33 mt (base year) to 3762.67 mt (current year), at the rate of 13.96 percent by the magnitude of 610.67 mt, facing a variation of 19.53 percent over the study period. Papaya has gained in Chhattisgarh plain zone in terms of production by 86472.47 mt, from 191602.87 mt in base year to 278075.33 mt in current year at the rate of 45.13 percent, with an annual variation of 19.06 percent.

Table 2 has clearly indicated that papaya production has increased in Chhattisgarh state from 24364.46 mt in base year to 372565.33 mt in current year, at the rate of 53.72 percent by the magnitude of 130200.87 mt, with a 19.07 percent variation during the period of study annually.

**Table 2:** Absolute change, Relative change, and Variabilities in Production of papaya in Chhattisgarh plain Agroclimatic zone

| S. No. | District | Base year (mt) | Current year (mt) | Absolute change (mt) | Relative Change (%) | CV (%) |
|---|---|---|---|---|---|---|
| 1 | Korba | 13533.33 | 5323.67 | -8209.67 | -60.66 | 63.88 |
| 2 | Raigarh | 4639.33 | 13939.33 | 9300.00 | 77.23 | 39.78 |
| 3 | Bilaspur | 41869.98 | 53490.00 | 11620.02 | 27.75 | 32.03 |
| 4 | Kabir Dham | 1777.00 | 4148.67 | 2371.67 | 133.46 | 33.20 |
| 5 | Janjgir | 12081.34 | 17669.00 | 5587.66 | 46.25 | 16.46 |
| 6 | Mahasamund | 9173.00 | 25976.00 | 16803.00 | 183.18 | 53.38 |
| 7 | Rajnandgaon | 4372.17 | 7990.67 | 3618.50 | 82.76 | 34.45 |
| 8 | Durg | 55326.33 | 86837.00 | 31510.67 | 56.95 | 18.60 |
| 9 | Raipur | 40415.88 | 53337.33 | 12921.45 | 31.97 | 22.23 |
| 10 | Dhamtari | 4373.33 | 3762.67 | -610.67 | -13.96 | 19.53 |
| 11 | Kanker | 4041.17 | 5601.00 | 1559.83 | 38.60 | 43.30 |
| A | Chhattisgarh plain zone | 191602.87 | 278075.33 | 86472.47 | 45.13 | 19.06 |
| B | Chhattisgarh state | 242364.46 | 372565.33 | 130200.87 | 53.72 | 19.07 |

### 3.1.2 Productivity

It was observed that in Korba district productivity of papaya has increased by 2984.96 kg/ha, at the rate of 12.74 percent, from 23425.65 kg/ha (base year) to 26410.61 kg/ha (current year), with an annual variation of 6.51 percent. The productivity in Raigarh district has increased by 14365.33 kg/ha, at the rate of 77.23 percent, from 20081.17 kg/ha (base year) to 34446.50 kg/ha (current year), with an annual variation of 25.03 percent. Productivity under papaya in Bilaspur district has increased from 22736.43 kg/ha (base year) to 22861.67 kg/ha (current year) by 125.24 kg/ha at the rate of 0.55 percent, with a fluctuation of 24.88 percent per year.

Janjgir district had also marked the increase in productivity under papaya at the rate of 25.08 percent by the magnitude of 4606.52 kg/ha, from 18370 kg/ha (base year) to 22976.52 kg/ha (current year) during the study period, with a variation of 10.48 percent. Productivity under papaya in Mahasamund district has increased from 18790kg/ha (base year) to 23666.67 kg/ha (current year) by 4876.67kg/ha at the rate of 25.95 percent, with a fluctuation of 22.72 percent per year.

Rajnandagaon district has also marked the increase in productivity under papaya at the rate of 12.17 percent by the magnitude of 2250.66 kg/ha, from 18500 kg/ha (base year) to 20750.66 kg/ha (current year) during the study period, with a variation of 5.64 percent. Productivity under papaya in Kanker district has increased from 16066.67 kg/ha (base year) to 16157.52 kg/ha (current year) by 90.85 kg/ha at the rate of 0.57 percent, with a fluctuation of 0.35 percent per year. Productivity under papaya in Raipur district has increased from 22335.38 kg/ha (base year) to 41824.82 kg/ha (current year) by 19489.44 kg/ha at the rate of 87.26 percent, with a fluctuation of 25.51 percent per year.

It was observed that, among all the papaya grown selected districts of the Chhattisgarh plain zone of the state, there was increase in productivity of papaya crop except in three districts such i.e., Kabir Dham, Durg and Dhamtari district. During the study it was observed that productivity of papaya in Kabir Dham district has reduced by 3939.91 kg/ha at the rate of 24.62 percent, from 16000 kg/ha (base year) to 12060.09 kg/ha (current year), at an annual variation of 14.33 percent. Similar pattern was observed in Durg district, papaya productivity was decreased from 40066.67 kg/ha (base year) to 39845.70 kg/ha (current year), at the rate of 0.55 percent by the magnitude of 220.97 kg/ha, facing a variation of 0.45 percent over the study period.

In case of Dhamtari district, papaya productivity was decreased from 17080.81 kg/ha (base year) to 8355.29 kg/ha (current year), at the rate of 51.08 percent by the magnitude of 8725.52 kg/ha, facing a variation of 39.68 percent over the study period. Papaya has gained in Chhattisgarh plain zone in terms of productivity by 4639.98 kg/ha, from 24094.16 kg/ha in base year to 28734.14 kg/ha in current year at the rate of 19.26 percent, with an annual variation of 9.22 percent.

Table 3 has clearly indicated that papaya productivity has increased in Chhattisgarh state from 23425.65 kg/ha in the base year to 26410.61 kg/ha in current year, at the rate of 12.74 percent by the magnitude of 2984.96 kg/ha, with a 6.51 percent variation during the period of study annually.

**Table 3:** Absolute change, Relative change, and Variabilities in Productivity of papaya in the Chhattisgarh Plain Agroclimatic zone

| S. No. | District | Base year (kg/ha) | Current year (kg/ha) | Absolute change (kg/ha) | Relative Change (%) | CV (%) |
|---|---|---|---|---|---|---|
| 1 | Korba | 23425.65 | 26410.61 | 2984.96 | 12.74 | 6.51 |
| 2 | Raigarh | 20081.17 | 34446.50 | 14365.33 | 71.54 | 25.03 |
| 3 | Bilaspur | 22736.43 | 22861.67 | 125.24 | 0.55 | 24.88 |
| 4 | Kabir Dham | 16000.00 | 12060.09 | -3939.91 | -24.62 | 14.33 |
| 5 | Janjgir | 18370.00 | 22976.52 | 4606.52 | 25.08 | 10.48 |
| 6 | Mahasamund | 18790.00 | 23666.67 | 4876.67 | 25.95 | 22.72 |
| 7 | Rajnandgaon | 18500.00 | 20750.66 | 2250.66 | 12.17 | 5.64 |
| 8 | Durg | 40066.67 | 39845.70 | -220.97 | -0.55 | 0.45 |
| 9 | Raipur | 22335.38 | 41824.82 | 19489.44 | 87.26 | 25.51 |
| 10 | Dhamtari | 17080.81 | 8355.29 | -8725.52 | -51.08 | 39.68 |
| 11 | Kanker | 16066.67 | 16157.52 | 90.85 | 0.57 | 0.35 |
| A | Chhattisgarh plain zone | 24094.16 | 28734.14 | 4639.98 | 19.26 | 9.22 |
| B | Chhattisgarh state | 23425.65 | 26410.61 | 2984.96 | 12.74 | 6.51 |

## 4. Conclusion

In the Chhattisgarh plain zone, the Papaya area increased significantly across most districts. Raigarh, Bilaspur, Kabirdham, Janjgir, Mahasamund, Rajnandgaon, Durg, Dhamtari, and Kanker showed notable growth, with Kabirdham and Mahasamund recording increases of 195.70% and 126.19%, respectively. However, Korba and Raipur districts saw a decline of 77% and 29.22%. Overall, the region witnessed a gain of 1,753.13 ha, rising from 7,929.20 ha to 9,682.33 ha at a rate of 22.11%, with 12.38% annual variation, reflecting a strong expansion in papaya cultivation. Papaya production in the Chhattisgarh plain zone increased by 86,472.47 metric tonnes, rising from 191,602.87 mt to 278,075.33 mt at a growth rate of 45.13%, with 19.06% annual variation. Districts like Mahasamund, Durg, Raipur, and Raigarh showed significant gains, while Bilaspur, Janjgir, Kabirdham, Kanker, and Rajnandgaon recorded moderate increases. However, Korba and Dhamtari districts witnessed a decline. Overall, the region experienced a strong and positive growth trend in papaya production during the study period. Papaya productivity in the Chhattisgarh plain zone showed an overall increase of 4,639.98 kg/ha, rising from 24,094.16 kg/ha to 28,734.14 kg/ha at a growth rate of 19.26%, with 9.22% annual variation. Districts like Raigarh, Raipur, Janjgir, and Mahasamund showed notable gains, while Bilaspur, Korba, Rajnandgaon, and Kanker recorded modest increases. However, Kabirdham, Durg, and Dhamtari experienced declines. Despite these, the overall trend suggests significant improvement in papaya productivity across the region during the study period.

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