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The effect of area, yield and their interaction on the change in total production of the papaya crop in the Chhattisgarh plain zone

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Abstract

Papaya (*Carica papaya*), a widely cultivated horticultural fruit crop in India, is grown both in household kitchen gardens and on a commercial scale. Belonging to Caricaceae, papaya plants are sparsely branched, mostly dioecious, and produce berry-like fruits. The Caricaceae family includes six small genera and 48 species globally. This study focused on the Chhattisgarh Plains agroclimatic zone, one of the three agroclimatic zones in Chhattisgarh, encompassing 11 purposefully selected districts: Raipur, Bilaspur, Janjgir, Korba, Raigarh, Mahasamund, Durg, Kanker, Dhamtari, Kabirdham, and Rajnandgaon. The objective was to analyze the influence of area, yield, and their interaction on papaya production. Findings revealed that area expansion was the dominant factor influencing production increases in most districts. In Kabirdham and Durg, strong area effects (159.25% and 101.53%) offset negative yield impacts. Conversely, Raipur and Dhamtari showed significant yield effects (268.21% and 363.26%), which compensated for negative area influences. Raigarh displayed a balanced contribution from all three factors. Across the Chhattisgarh Plains zone, area, yield, and interaction effects contributed 48.46%, 42.21%, and 9.33%, respectively. At the state level, area effect was the most significant contributor (67.78%), followed by yield (23.58%) and interaction (8.64%). Overall, area expansion was the primary driver of increased papaya production.

Keywords: Papaya, Chhattisgarh plains, area, yield and effect

1. Introduction

Papaya (*Carica papaya*), a widely cultivated horticultural fruit crop in India, is grown both in household kitchen gardens and on a commercial scale. Belonging to the family Caricaceae, papaya plants are sparsely branched, mostly dioecious, and produce berry-like fruits. The Caricaceae family includes six small genera and 48 species globally. Ripe papaya is consumed in various forms like salads, juices, jellies, and candies, while unripe fruits are used as vegetables and in making tutti-frutti. It is rich in proteins, carbohydrates, calcium, antioxidants, and has medicinal value. Papaya latex contains enzymes papain and chymopapain, with industrial applications. A healthy tree yields 25-40 fruits, weighing 40-60 kg, with fruits maturing in 5-9 months. India ranks first globally in papaya production, with major producing states including Andhra Pradesh, Gujarat, and Chhattisgarh. In 2020-21, Chhattisgarh's plains had 13.987 thousand hectares under papaya cultivation, producing 377.383 thousand metric tonnes.

2. Materials and Methods

The present study was conducted in the Chhattisgarh Plains agroclimatic zone, one of the three agroclimatic zones in the state, the others being the Northern Hills Zone and the Bastar Plateau. Eleven districts—Raipur, Bilaspur, Janjgir, Korba, Raigarh, Mahasamund, Durg, Kanker, Dhamtari, Kabirdham, and Rajnandgaon—were purposefully selected

for analysis. The study covered 12 years from 2009-10 to 2020-21, with the triennium ending 2009-10 to 2011-12 used as the base year and 2018-19 to 2020-21 as the current year. The analysis focused on calculating growth rate, absolute and relative change, and the decomposition of changes in production into area effect, yield effect, and interaction effect. The study also considered relevant policy aspects related to papaya cultivation in the region. Data on papaya area, production, and productivity were sourced from the official records of the Chhattisgarh Agricultural Development and Farmer Welfare and Biotechnology Department. The Chhattisgarh Plains zone was selected due to its substantial share in the state's overall papaya production, making it a critical region for understanding production dynamics and formulating development strategies in horticultural crops.

2.1 Analytical tools

The analytical tools used in this study are mentioned below

2.1.1 Decomposition Analysis (Vidyasagar Model)

This model is used to estimate the contribution of area, yield and their interaction towards change (increase/decrease) in production over the period.

$$\Delta y_t = \Delta A_t Y_0 + Y_t A_0 + \Delta A_t \Delta Y_t$$

1. Percentage share of average yield in total production

$$\text{Yield effect (\%)} = \frac{(Y_n - Y_o)A_o}{P_n - P_o} \times 100$$

2. Percentage share of area in total production

$$\text{Area effect} = \frac{(A_n - A_o)Y_o}{P_n - P_o} \times 100$$

3. Percentage share of interaction between area and yield towards total production

$$\text{Interaction effect} = \frac{(Y_n - Y_o)(A_n - A_o)}{P_n - P_o} \times 100$$

3. Results

3.1 Effect of area, yield and their interaction on the change in total production of papaya crop

It is a well-known fact that production is influenced by the area, yield and their interaction effect. This section has an attempt to discuss the area, yield and their interaction effect on the total production of the papaya crop in different districts of the Chhattisgarh Plain zone of the state. The results of the analysis are presented in Table 4.3. It was observed that in the Korba district, area effect (126.92%) was the principal factor for the change in the total production of the papaya crop in the district, followed by 90.11 percent of the interaction effect, whereas the yield effect shared (-)117.03 percent in a change in total production. For the Raigarh district similar pattern was observed, area effect (37.85%) contributed relatively more than the yield effect (35.07%) and their interaction effect (27.08%) towards the increase in the total production of papaya crop. Regarding, Bilaspur district area effect (97.23%) contributed fairly more as compared to yield (2.23%) and their interaction effect of 0.54 percent, for the increase in total papaya production in the district.

In Kabirdham district the area effect (159.25%) was able to nullify the negative effect of yield (20.04%) and their interaction effect (39.22%) over the change in total papaya crop production. It was observed that in the Janjgir district,

the yield effect (126.92%) was the powerful factor for the change in the total production of the papaya crop in the district, followed by the 36.60 percent of the area effect and their interaction effect (9.18%) towards change in total production. For the Mahasamund district, it was observed that area effect (68.25%) contributed relatively more than their interaction effect (17.71%) and yield effect (14.04%) towards the increase in the total production of papaya crop. Regarding, the Rajnandagaon district area effect (76.04%) contributed fairly more as compared to yield (14.71%) and their interaction effect of 9.25 percent, for the increase in total papaya production in the district. In Durg district, the area effect (101.53%) was able to nullify the negative effect of yield (0.97%) and their interaction effect (0.56%) over the change in total papaya crop production.

It was observed that in the Raipur district, the yield effect (268.21%) was the powerful factor for the change in the total production of the papaya crop in the district, and was able to nullify the negative effect of the area effect (89.83%) and their interaction effect (78.38%) towards change in total production. In the Dhamtari district, yield (363.26%) and their interaction effect (274.92%) have contributed better towards change in total production as compared to the negative area effect of 538.18%, in the district. It was observed that in the Kanker district, the area effect (97.98%) was the powerful factor for the change in the total production of the papaya crop in the district, followed by the 1.47 percent of the yield effect and their interaction effect (0.55%) towards change in total production. In general, for the Chhattisgarh plain zone, area effect (48.46%) has proved to be the most promising factor than yield (42.21%) and their interaction effect (9.33%) towards the total change in papaya crop production.

Thus, it could be concluded from Table 1 that, the area effect (67.78%) was the strongest factor among all the three effects analyzed for increasing the production of papaya as compared to the yield effect (23.58%) and their interaction effect (8.64%) in Chhattisgarh state.

Table 1: Area, yield, and their interaction effect on the change in total production of papaya crop in the Chhattisgarh plain zone

S. No.	District	Area effect (%)	Yield effect (%)	Interaction effect (%)	Absolute change in production (mt)
1	Korba	126.92	-117.03	90.11	-8209.67
2	Raigarh	37.85	35.07	27.08	9300.00
3	Bilaspur	97.23	2.23	0.54	11620.02
4	Kabir Dham	159.25	-20.04	-39.22	2371.67
5	Janjgir	36.60	54.22	9.18	5587.66
6	Mahasamund	68.25	14.04	17.71	16803.00
7	Rajnandgoan	76.04	14.71	9.25	3618.50
8	Durg	101.53	-0.97	-0.56	31510.67
9	Raipur	-89.83	268.21	-78.38	12921.45
10	Dhamtari	-538.18	363.26	274.92	-610.678
11	Kanker	97.98	1.47	0.55	1559.83
A	C.G Plain Zone	48.46	42.21	9.33	86472.47
B	Total C. G. State	67.78	23.58	8.64	130200.87

4. Conclusion

The analysis highlights the influence of area, yield, and their interaction effects on papaya production across various districts in the Chhattisgarh Plain zone. The area effect emerged as the dominant contributor in most districts.

Notably, in Korba, Bilaspur, Kabirdham, Mahasamund, Rajnandgaon, Durg, and Kanker, area expansion significantly influenced production increases, often offsetting negative yield effects. For instance, Kabirdham and Durg districts showed strong area effects of 159.25%

and 101.53%, respectively, which compensated for negative yield impacts. In contrast, Raipur and Dhamtari districts were exceptions, where yield effects (268.21% and 363.26%) played a greater role, surpassing negative area influences. Raigarh district showed a balanced contribution of area, yield, and interaction effects. Overall, the Chhattisgarh Plain zone data revealed area effect as the most significant factor (48.46%), followed by yield (42.21%) and interaction (9.33%). At the state level, area effect contributed 67.78% to the increase in total papaya production, while yield and interaction effects contributed 23.58% and 8.64%, respectively. The findings suggest that expansion in cultivation area was the primary driver of increased papaya production, although improvements in yield also played a crucial role in certain districts.

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