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Sources of growth to seed spices in India: A decomposition analysis

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Abstract

The present study analyzes the sources of growth in the Value of Produce (VOP) of major seed spices in India, including coriander, cumin, fennel, and fenugreek, over the period 2004–05 to 2023–24, using decomposition analysis. The results indicate that the combined influence of changes in area, yield, and real prices played over 90% role in enhancing the total VOP value change, as the interaction effect overwhelmingly dominated growth across all crops. Coriander and cumin showed the highest growth in VOP, driven mainly by area expansion and favourable price interactions. At the same time, fennel and fenugreek showed moderate growth, primarily influenced by interaction and diversification effects. The area effect contributed modestly to growth, indicating limited land expansion. In contrast, the price effect showed mixed trends, positive for coriander and cumin but negative for fennel and fenugreek, highlighting the impact of market volatility and price instability in seed spices. Overall, the study concludes that the growth in spice value during the two decades was primarily driven by multi-factor interactions rather than isolated productivity gains or area expansion. This emphasizes the need for integrated policy interventions focusing on yield enhancement, price stabilization, and market diversification to sustain value growth in India's seed spice sector.

Keywords: Seed spices, Value of produce, Decomposition analysis, Area effect, Price effect, Interaction effect, India.

Introduction

India is the world leader in spice production, consumption and export. It accounts for 65% and 69% of the world's spice area and output, respectively, and for 40% and 12% of spice trade volumes and value, respectively (Spices Board India & FAOSTAT, 2024). Spices play a crucial role in the Indian agricultural economy, accounting for 1.96% and 15.26% of the gross cropped area and horticulture area, respectively. Spices contribute 5.45% share in India's agricultural value of produce, 9% of India's total agricultural exports and more

than 40% of horticultural exports during 2023-24. During 2023-24, India produced a total of 11.80 million MT of spices from an area of 4.76 million hectare and exported 1.54 million MT of spices as 225 distinct products to over 180 countries. Seed spices accounts for 43.61% of the total spice area (2.07 million hectares) and 18.46% of the total spice production in the country (2.17 million ton; Spice Board India, 2024). They also account for 25% (0.39 million tonnes) of India's total spice exports, valued at ₹8,140 crore.

During 2004-05 to 2023-24, spice acreage almost doubled from 24.4 lakh ha to 50.06 lakh ha, and yield increased from 1553 to 2469 kg ha^{-1} at CAGRs of 4.15% and 1.27% per annum, respectively. The combined effect of area and yield results in a fourfold increase in all-spice production, rising from 37.9 lakh ton in 2004-05 to 124.8 lakh ton in 2024-25, at a CAGR of 5.47 per cent. Production increase coupled with price enhancement resulted in the Value of Spice Produce (VOP) increasing from 31704 crore rupees in 2004-05 to 94756 crore rupees in 2023-24 (Base year: 2011-12), at an annual rate of 8.05%. In this period, seed spice acreage in the country tripled (from 8.66 lakh ha to 23.20 lakh ha), indicating their growing contribution to the spice economy. The value of major seed spices, namely, cumin (2004 to 23734 crore rupee), coriander (1076 to 3928), fennel (304 to 1834) and fenugreek (148 to 307), also increased from 2004-05 to 2023-24. The change in VOP of an agricultural commodity reflects the combined effects of area expansion, yield improvement, and price increases. It can be decomposed into changes in sown area, yield, and price, and a residual that captures the interaction among these three sources of growth. Changes in the gross income of total spice production can be similarly decomposed, except that there is a fourth source of growth: changes in the crop mix toward higher-value crops (Joshi *et al*., 2006). A study by Bairwa *et al*. (2022) analysed the sources of growth of seed spice in Rajasthan, focusing on production volume rather than the value of the produce, which does not provide a complete analysis. Therefore, the present study analyses all spices, including major seed spices, at the all-India level, considering the Value of Produce in value terms, highlighting the price effect along with area, yield, diversification and interaction effect from 2004-05 to 2023-24.

Material and Methods

This study is purely based on secondary data collected from various sources. The information on area, production, and yield of all spices, including major seed spices, namely coriander, cumin, fennel, and fenugreek, was compiled from the Spice Board of India. The Value of Produce (VOP) information was compiled from the Ministry of Statistics and Program Implementation (MOSPI), Government of India, for the period 2004-05 to 2023-24. To make the study more comparative, the study period was divided into two equal sub-periods, viz., Period I (2004-05 to 2013-14) and Period II (2014-15 to 2023-24), along with the overall period (2004-05 to 2023-24). The VOPs to different base years were adjusted to the same base year (2004-05 to 2011-12) using the appropriate linking factor set by the Reserve Bank of India, i.e., 2.003. The real price was calculated by dividing the VOP for a particular crop by its production in that year.

Further, decomposition analysis was used to decompose growth in VOP and identify the sources of growth in major seed species at the country level. The growth accounting approach developed by Minot, *et. al.* (2003) was employed here. Under this approach, the change in gross revenue from production of a crop can be decomposed into change in cropped area, change in yield, change in real price and a residual represents the interaction among area, yield and price factors except above three there is one more source of change is diversification i.e. reallocation of area from one to other crops. The contribution of area, yield, price and diversification was captured using the equation given below:

$$R = \sum_{i=1}^{n} AiYiPi \quad \ldots\ldots(1)$$

Where,

R = Gross revenue from a crop, i.e. VOP here

Ai = Area under crop

Yi = Yield, and

Pi = Real price per unit.

Ai can be further expressed as the share of crop i in the total cropped area, $ai = \frac{Ai}{\sum_{i=1}^{n} Ai}$ and substituting this in above equation (1), we get

$$dR \cong (\sum_{i=1}^{n} a_i Y_i P_i) d(\sum_{i=1}^{n} A_i) + \sum_{i=1}^{n} A_i \sum_{i=1}^{n} (a_i Y_i dP_i) + \sum_{i=1}^{n} A_i \sum_{i=1}^{n} (a_i dY_i P_i) + \sum_{i=1}^{n} A_i \sum_{i=1}^{n} (Y_i P_i da_i)$$

The first term on the right-hand side of this equation represents the change in gross revenue due to a change in total cropped area. The second term on the right-hand side captures the change in gross revenue resulting from changes in the real prices of commodities. The third term measures the change in gross revenue resulting from changes in crop yield or technology. The fourth term represents the change in gross revenue associated with changes in crop composition. Dividing both sides of the final equation by the overall change in gross revenue of a crop gives us the proportionate share of each source in the overall change in gross revenue or agricultural growth (For detailed derivation, Meena *et al.*, 2018, may be referred to).

Results and Discussion

Table 1 depicts the performance of all spices in India, including major seed spices namely, coriander, cumin, fennel, and fenugreek, in terms of their area, production, productivity, area share to GCA, and real prices, at the all-India level. The data are presented as triennial ending (TE) averages for the period 2004-05 to 2023-24, along with the annual compound growth rates (CAGR). This analysis provides insight into the structural and temporal changes in the performance of India's spice sector. Production in volume and VOP in value terms have increased over the period 2004–05 to 2023–24, with varying rates across crops and periods. Cumin showed the highest growth in both production quantity (9.09%) and value of produce (15.86%), driven by a significant expansion in area (6.46%) and a sharp rise in real price (6.20%). Its strong export demand and high market price volatility contributed to this remarkable value growth. Coriander also recorded substantial production growth (8.20%), mainly supported by yield improvement (4.57%) and moderate area expansion (3.47%). However, the real price declined slightly (-0.12%), which restrained the overall increase in its VOP (8.02%). Fennel experienced moderate growth in production (5.47%) and value (8.05%). Although area expanded (4.14%), yield improvement remained modest (1.26%). A slight rise in the real price (2.44%) helped boost overall value, reflecting steady domestic and export demand. In Fenugreek, despite robust increases in area (7.95%) and production (9.56%), value growth was modest (4.36%) due to a sharp decline in its real price (-4.75%). The price decline offset gains from higher production.

Table 2 presents the decomposition of growth in the VOP of all spices in India, into different contributing factors, namely, area, yield, price, diversification, and interaction effects during two sub-periods (2004–05 to 2013–14 and 2014–15 to 2023–24) as well in the overall period (2004–05 to 2023–24). The analysis reveals an almost threefold increase in the value of all spices, rising from ₹ 3170493 lakh during 2004-05 to ₹ 9475626 lakh during 2023-24, indicating significant structural and economic growth in the spice sector. The interaction effect found as the most dominant source of growth throughout all periods, contributing over 90% to the total change in VOP, indicates the combined influence of multiple factors of development, i.e. area expansion, yield enhancement, and price changes, working synergistically. Similar results were reported by Chand and Raju (2009) and Kumar *et al.* (2016), who found that interaction effects were the major drivers of agricultural value growth in several crop groups, particularly in high-value and export-oriented commodities.

The yield contributed positively, accounting for 3.93% of total growth in period I and 3.22% in period II, indicating consistent improvements in productivity of all spices in the country. It highlights the roles of technological advancement, improved crop varieties, and the adoption of better management practices in spice cultivation. These findings are consistent with those of Birthal *et al.* (2015) and Narayan and Suresh (2017), who emphasised the importance of yield enhancement as a critical factor in increasing the value of output from horticultural and spice crops. The diversification effect also played a significant role, contributing a 5.30% share to this increase in VOP (4.35% during 2004-05 to 2013-14 and 5.69% during 2014-15 to 2023-24), reflecting a growing shift toward high-value spices and increased diversification within the cropping system. This aligns with the findings of Joshi *et al.* (2004) and Kannan and Sundaram (2011), who highlighted that diversification toward high-value

crops, including spices, was a key pathway to agricultural income growth in India. The area effect showed a relatively small and positive contribution, rising over the period from 1.27 to 1.41%, highlighting moderate expansion in the cultivated area of spices during study period. On the contrary, the price effect made a negative contribution throughout, declining from -0.53% in the first period to -1.90% in the second, indicating that real price instability and deflationary trends in spice real prices constrained overall value growth (Figure 3). These results are in line with Raju and Chand (2008), who reported that price variability often limited the contribution of price effects in the growth of agricultural value output.

Table 1: Area, production, productivity, real price and value of produce with CAGR of major seed spices, 2004-05 to 2023-24

Crop	Particulars	Period	Area (Million ha)	Production (Million ton)	Productivity (kg/ha)	Area share (%)	Real price (₹/ton)	VOP (Lakhs ₹)
Coriander	Average	TE-2004-05	0.34	0.23	698.02	0.0018	44695.31	104927.82
		TE-2023-24	0.62	0.85	1361.60	0.0028	47818.25	406059.07
	CGR	2004-05 to 23-24	3.47	8.20	4.57	2.72	-0.12	8.02
Cumin	Average	TE-2004-05	0.40	0.19	481.95	0.0021	100728.31	193067.17
		TE-2023-24	1.04	0.68	647.34	0.0047	263030.79	1780130.45
	CGR	2004-05 to 23-24	6.46	9.09	2.46	5.69	6.20	15.86
Fennel	Average	TE-2004-05	0.05	0.07	1395.46	0.00024	60646.92	30243.30
		TE-2023-24	0.12	0.21	1744.14	0.00056	48423.72	104071.94
	CGR	2004-05 to 23-24	4.14	5.47	1.26	3.39	2.44	8.05
Fenugreek	Average	TE-2004-05	0.04	0.05	1193.06	0.0002	26603.05	13597.03
		TE-2023-24	0.16	0.24	1550.79	0.0007	12723.73	31078.51
	CGR	2004-05 to 23-24	7.952	9.56	1.49	7.17	-4.75	4.36
All spices	Average	TE-2004-05	2.39	3.85	1607.71	0.01	85158.79	3276590.49
		TE-2023-24	4.66	11.82	2537.30	0.02	75363.53	8906915.05
	CGR	2004-05 to 23-24	4.19	7.35	3.03	3.44	-1.11	6.16

Table 2: Sources of growth to all spices Value of Produce at the all-India level

Particulars	2004-05 to 2013-14		2014-15 to 2023-24		2004-05 to 2023-24	
	Value change (₹ Lakhs)	% share	Value change (₹ Lakhs)	% share	Value change (₹ Lakhs)	% share
Area effect	23253.58	1.27	63132.01	1.41	86385.59	1.37
Yield effect	71855.33	3.93	143987.55	3.22	215842.87	3.42
Price effect	-9753.78	-0.53	-85083.12	-1.90	-94836.90	-1.50
Diversification	79423.99	4.35	254941.99	5.69	334365.97	5.30
Interaction	1662765.38	90.98	4100609.71	91.58	5763375.08	91.41
Total Change	1827544.49	100.00	4477588.13	100.00	6305132.62	100.00

Source: Authors' Calculations based on data on Value of Output from MoSPI

Figure 1 shows the remarkable rise in the value of production of all spices in India from 2004-05 to 2023-24, with increasing trends in all spice areas and yield. This increase in VOP is driven by interaction and yield effects, supported by diversification towards high-value crops. At the same time, area expansion played a minor role, and price volatility acted as a limiting factor. The dominance of interaction and yield effects highlights the significance of technological progress in the development and adoption of GAP and HYV technologies, efficient resource use, and integrated growth dynamics for sustaining the performance of the spice sector.

Table 3 illustrates the decomposition of growth in the VOP of coriander, highlighting the relative contributions of area, yield, price, diversification, and interaction effects to the total change in value at the national level. Over the entire study period (2004-05 to 2023-24), the coriander VOP increased from 107603 lakh rupees (base year 2011-12) to 392806 lakh rupees, with an all-time high of ₹472687 lakh in 2022-23. The decomposition of this increase shows that the interaction effect consistently remained the leading growth driver (88.22%), followed by a moderate contribution from yield (2.57%) and price (8.81%). In contrast, the area effect (-1.02%) was adverse. During the period-I, a higher positive yield effect (4.22%) was measured with a price effect (15.95%), and a more negative area effect (-2.46%). The diversification effect was negative (-4.30%), implying a shift of area away from coriander to other competing crops. In contrast, the second period (2014–2024) witnessed a remarkable expansion in coriander VOP (Figure 2). The interaction effect (88.57%) continued to be the leading driver of growth, supported by positive contributions from area (1.13%), yield (5.18%), and price (5.00%) effects. The diversification effect (0.11%) declined considerably, suggesting reduced inter-crop movement from coriander cultivation. Singh *et al.* (2020) emphasized that the recent increase in coriander value is largely attributed to yield stabilization and price realization, driven by growing domestic and export demand.

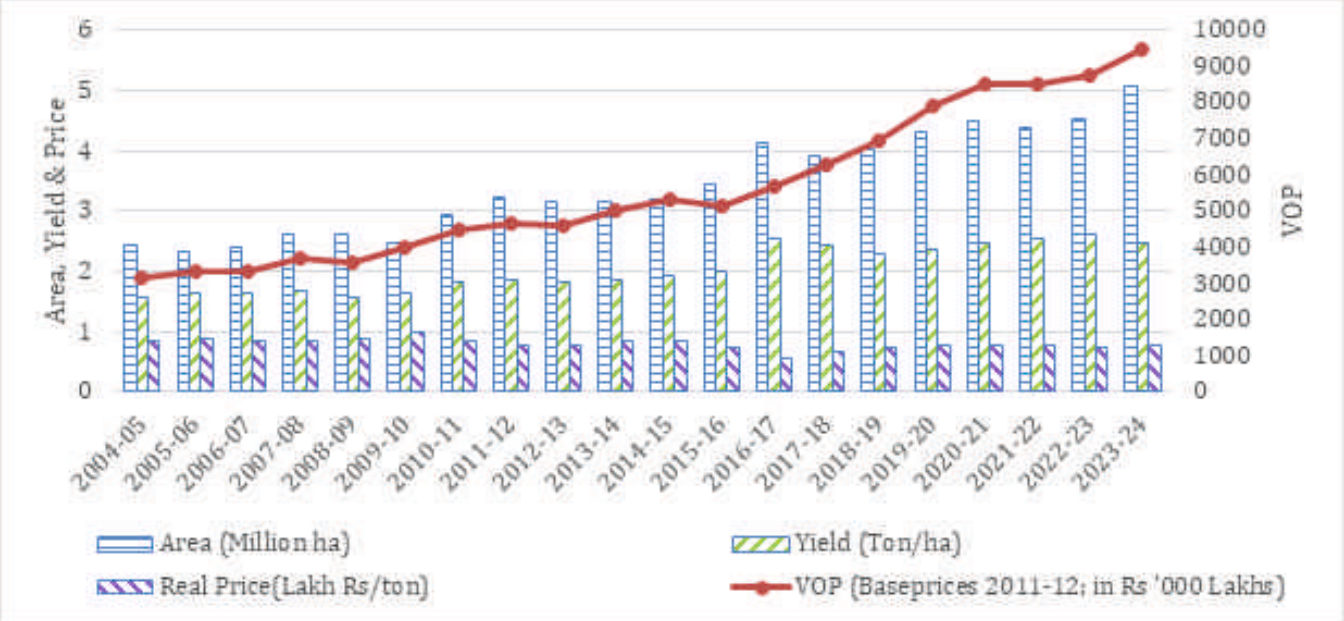

Fig 1: Area, yield, real price and VOP of all seed spices in India during 2004-05 to 2023-24

Table 3: Sources of growth coriander value of produce at all India level

Particulars	2004-2013		2014-2024		2004-2024	
	Value change (₹ Lakhs)	% share	Value change (₹ Lakhs)	% share	Value change (₹ Lakhs)	% share
Change in VOP	17771.34	100.00	267431.64	100.00	285202.98	100.00
Area effect	474.69	2.67	3034.25	1.13	3508.94	1.23
Yield effect	2451.00	13.79	13865.13	5.18	16316.14	5.72
Price effect	-17794.19	-100.13	13373.31	5.00	-4420.88	-1.55
Diversification effect	4695.39	26.42	290.52	0.11	4985.90	1.75
Interaction effect	27944.45	157.24	236868.43	88.57	264812.88	92.85

Source: Authors' calculations based on data on coriander Value of Output from MoSPI.

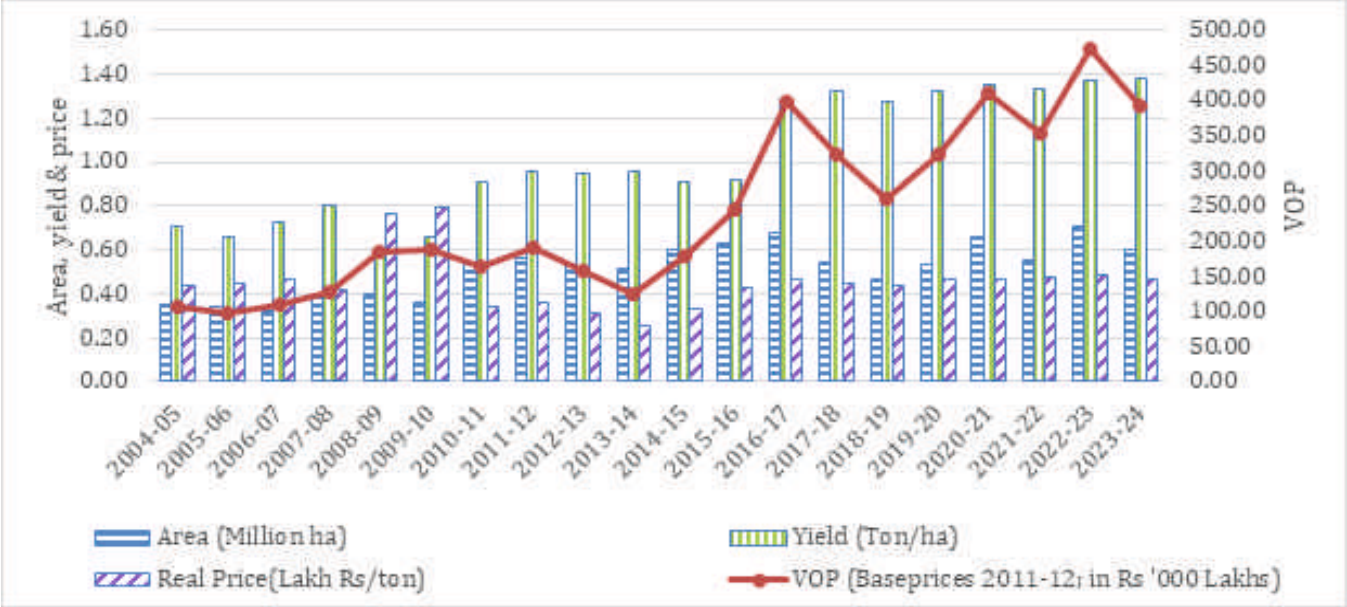

Fig 2: Area, yield, real price and VOP of coriander produce in India from 2004-05 to 2023-24

Table 4 presents a decomposition of the growth in cumin VOP at the all-India level. Its cultivation in India increased more than three folds, from 0.43 MHa in 2004-05 to 1.30 MHa in 2023-24 at CGR 6.46% per annum. Its yield and prices also increase resulting its VOP increased (Figure 3). During 2004-05 to 2013-14, the total change in cumin VOP was ₹11,52,993.65 lakhs. The price (6.74%), diversification (1.66%), yield (0.49%), and area (0.32%) effects, all contributed positively to above increase. The dominance of the interaction effect (90.79%) indicates that cumulative and simultaneous changes in area, yield, and price largely drove the growth in cumin VOP during period I. In next period, the diversification effect became increasingly important, contributing 9.27% share, reflecting crop diversification towards cumin cultivation in the country. The adverse price effect (-2.20%), due to declining real prices partially offset growth in cumin value during this period. Area and yield effects contributed 1.62 and 1.83%, respectively, indicating modest expansion in cumin area with productivity improvements. During overall period 2004–2024, the cumulative change in cumin VOP was mainly due to interaction effect with positive contribution from all the factors. This highlights that while individual factors like area expansion, yield improvement, and price fluctuations contributed to value growth, the synergistic interaction among these factors was the dominant driver over the two decades. These findings are consistent with studies by Kumar and Shekhar (2017)

and Lathika et al. (2017) on increased cumin production. Singh *et al.*, (2015) noted that the interaction effect often plays a major role in value growth of spices, while diversification gains are increasingly significant in recent years due to adoption of high-yielding varieties and integrated farming systems.

Cumin cultivation in India has increased from 0.43 MHa in 2004-05 to 1.30MHa in 2023-24 at compound growth (CGR) 6.46 per cent per annum. The real value of cumin spice in India increased by 8.44% at compound growth (CGR) 15.86% per annum which increase from 200404.156 to 2373412.387 in lakh rupees from 2004-05 to 2023-24. Production of cumin seed spice increase by 22.47% at compound growth (CGR) 9.09% per annum increase from 0.20 in 2004-05 to 0.89 MT in 2023-24 (Figure 3).

Table 5 presents a decomposition of the growth in fennel VOP in India during 2004-05 to 2023-24. The fennel cultivation in the country expanded from 0.22 lakh ha in 2004-05 to 2.16 lakh ha in 2023-24. Yield increased by more than 500 $kgha^{-1}$ but real prices decreased in above period (Figure 4). From 2004-05 to 2023-24, real value of fennel in India increased more than six folds, at CGR of 8.05% annum, from 30391.51 to 183418.63 in lakh rupees. The VOP remains relatively low and stable for during period I, showing upward trend in later period. The decomposition of VOP increase highlighted that interaction effect contributed the largest share (134.98%), due to simultaneous changes in area, yield, and prices. The diversification effect also had a significant contribution (99.22%), suggesting increased area under fennel cultivation. In contrast, the price effect was strongly negative (-138.85%), due to stiff decline in real prices offset the gains from other factors. The contributions of area (3.43%) and yield (1.22%) were relatively small, indicating minor expansion in cultivation area and modest productivity gains. Area and yield effect decreased during period II whereas the price effect turned slightly positive (1.56%), suggesting a period of relative price stability or mild increase. Over the overall period 2004-05 to 2023-24, the cumulative change in fennel VOP (₹1,53,027.11 lakhs) was primarily contributed by interaction effect (91.78%). The diversification effect accounted for 9.85%, while the contributions from area (0.42%), yield (0.59%), and price (-2.65%) remained minor. These results suggest that the growth in fennel's value at the national level was primarily driven by the combined effect of multiple factors and strategic diversification, rather than large-scale area expansion or yield improvements. A study by Lathika, *et al.*, (2017), also found similar results.

Table 4: Sources of growth cumin value of produce at all–India level

Particulars	2004-2013		2014-2024		2004-2024	
	Value (₹ Lakhs)	Percent	Value (₹ Lakhs)	Percent	Value (₹ Lakhs)	Percent
Average Change in VOP	1152993.65	100.00	1020014.58	100.00	2173008.23	100.00
Area effect	3729.74	0.32	16573.18	1.62	20302.91	0.93
Yield effect	5677.71	0.49	18661.70	1.83	24339.41	1.12
Price effect	77678.78	6.74	-22428.03	-2.20	55250.75	2.54
Diversification effect	19160.51	1.66	94512.15	9.27	113672.66	5.23
Interaction effect	1046746.92	90.79	912695.59	89.48	1959442.51	90.17

Source: Authors' calculations based on data on Value of Output of Crop Sector from MoSPI.

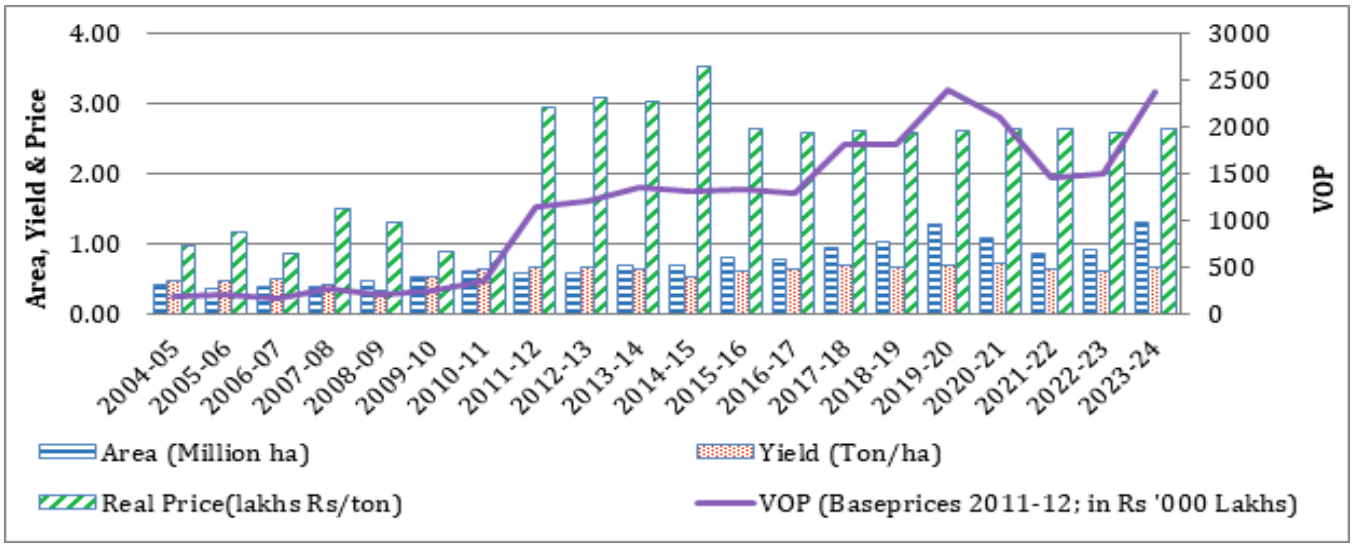

Fig 3: Area, yield, real price and VOP of cumin in India from 2004-05 to 2023-24.

Table 5: Sources of growth in fennel value of produce at all–India level

Particulars	2004-2013		2014-2024		2004-2024	
	Value (₹ Lakhs)	Percent	Value (₹ Lakhs)	Percent	Value (₹ Lakhs)	Percent
Average Change in VOP	4581.82	100.00	148445.30	100.00	153027.11	100.00
Area effect	157.27	3.43	492.34	0.33	649.61	0.42
Yield effect	55.94	1.22	846.66	0.57	902.60	0.59
Price effect	-6361.80	-138.85	2312.90	1.56	-4048.90	-2.65
Diversification effect	4545.89	99.22	10522.48	7.09	15068.37	9.85
Interaction effect	6184.52	134.98	134270.91	90.45	140455.43	91.78

Source: Authors' calculations based on data on Value of Produce from MoSPI.

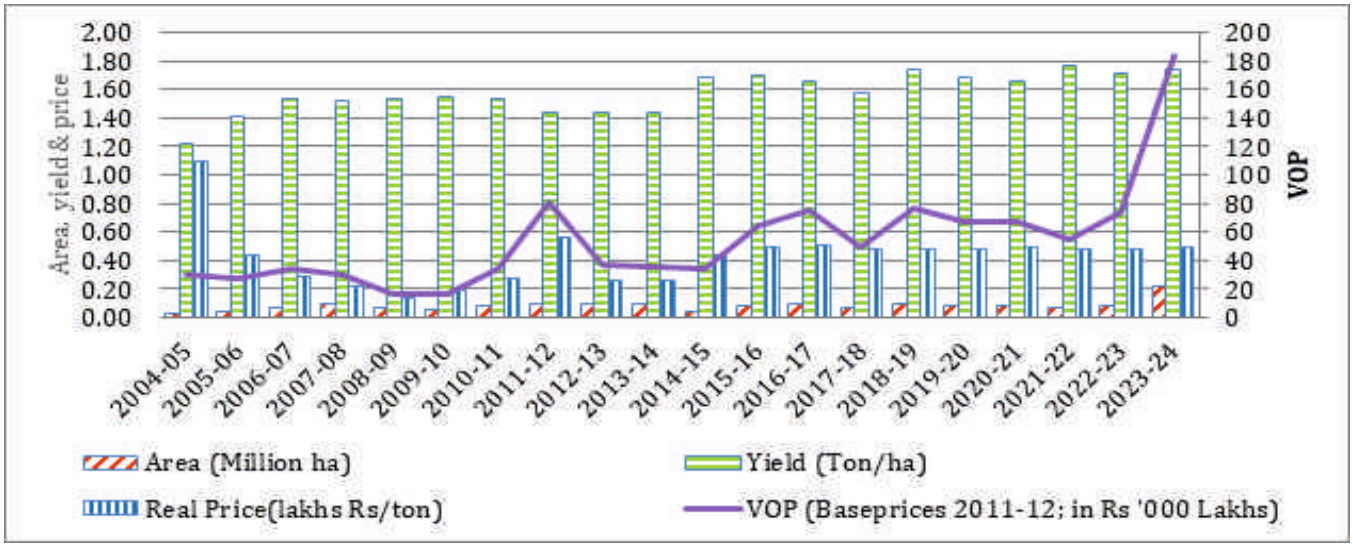

Fig 4: Area, yield, real price and VOP of fennel in India from 2004-05 to 2023-24.

Table 6 presents the decomposition of growth in fenugreek VOP in India. The analysis breaks down the total change in VOP into five contributing components, area effect, yield effect, price effect, diversification effect, and interaction effect, to identify the major drivers of VOP growth in fenugreek production. During period I, the total change in VOP was ₹798.37 lakhs. The interaction effect accounted for the largest share (88%), indicating that combined changes in area, yield, and price influencing value growth. The diversification effect contributed 18%, highlighting a shift towards fenugreek cultivation resulting its increasing area share. The area and yield effect was positive (1.58% and 0.14%) and price effect was negative (-29.45%), due to declining real prices constrained value growth during first period. During 2014-15 to 2023-24, the price effect turned more negative (-24.54%) due to continues decline in real prices during this period. However, the yield effect improved further to 11.57% reflecting persistent improvement in productivity due to technological advancements in term of more availability of HYV's and adoption of improved GAP. For the overall period, the cumulative change in fenugreek VOP was ₹15,962.89 lakhs. The interaction effect remained the predominant factor with 89.61% contribution, followed by diversification (19.03%), yield (6.43%), and area (2.20%). The price effect, however, continued to exert a negative impact (-17.27%), indicating that despite gains from diversification and yield improvements, declining real prices moderated the overall increase in value. These results clearly highlight that fenugreek's VOP growth at the national level has been driven mainly by interaction and diversification effects, rather than direct expansion in area or steady improvement in prices. The rising contribution of yield in the later period reflects gradual technological progress and adoption of improved production practices. The persistent negative price effect, however, suggests that market interventions and price policy support to sustaining value growth.

The area under fenugreek cultivation shows increasing but fluctuating trend over time. After a slight decline around 2005–06**,** the area gradually increases, reaching a major expansion peak in 2016–17, decline further. The yield increases from 1250 to 1580 kgha^{-1} during the study period with fluctuating trend. As coupled effect of area expansion and yield improvement, fenugreek production in the country increased from 0.6 lakh ton in 2004-05 to 2.5 lakh ton in 2023-24. The multiplicative effect of production with price, resulting increasing followed by decreasing trend in fenugreek VOP (Figure 5). Similar results were also highlighted by Lathika, *et al.*, (2017) and Bairwa *et al.,* (2022).

Table 6: Sources of growth Fenugreek value of produce at all India level.

Particulars	2004-2013		2014-2024		2004-2024	
	Value (₹ Lakhs)	Percent	Value (₹ Lakhs)	Percent	Value (₹ Lakhs)	Percent
Average Change in VOP	7185.33	100.00	8777.56	100.00	15962.89	100.00
Area effect	113.74	1.58	237.15	2.70	350.89	2.20
Yield effect	10.41	0.14	1015.80	11.57	1026.21	6.43
Price effect	-602.46	-8.38	-2154.42	-24.54	-2756.88	-17.27
Diversification effect	1340.60	18.66	1697.79	19.34	3038.39	19.03
Interaction effect	6323.03	88.00	7981.25	90.93	14304.27	89.61

Source: Authors' calculations based on data on Value of Produce from MoSPI.

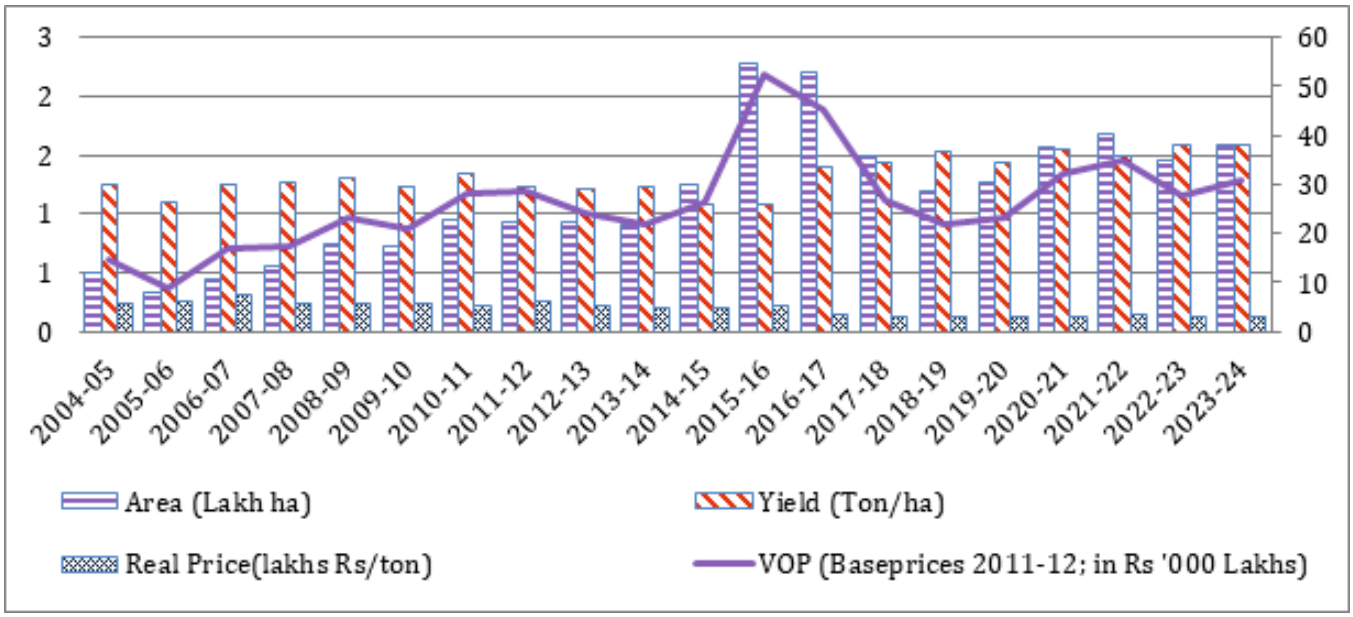

Fig 5: Area, Yield and real price of fenugreek produce in India.

Conclusion

The study highlights the remarkable and sustained growth of India's seed spice sector over the past two decades. Expansion in area and yield gains supported production increase and favorable market dynamics, has positioned India as a global leader in the seed spice economy. The decomposition analysis of the sources of growth in the VOP for major seed spices during 2004-05 to 2023-24 reveals that interaction effects were the most dominant contributors across all spices as well as major seed spices at the all-India level. Overall, the interaction effect accounted for more than 90% of the total change in VOP for all spices, indicating that simultaneous changes in area, yield, and price collectively drove most of the growth rather than any single factor.

Among major seed spices, coriander and cumin recorded the highest total change in VOP, largely influenced by the combined effect of area expansion, favourable price and productivity interactions. In coriander, both area effect and price effect played significant roles, while in cumin, the area and diversification effects contributed notably to its sustained growth in value. Fennel and fenugreek, although having smaller overall shares in the total VOP, showed similar dominance of interaction effects, indicating that integrated improvements in area, yield, and price collectively enhanced their value. Interestingly, the area effect showed a positive but modest contribution across all crops, reflecting the limited scope of area expansion. Conversely, the price effect exhibited mixed trends positive for coriander and cumin, but negative for fennel and fenugreek, suggesting price volatility and market fluctuations influenced their VOP performance. The diversification effect, though small in percentage, remained an essential driver for certain crops, indicating the gradual shift in cropping patterns toward these high-value spices during study period.

Conflict of Interest

The authors declare that they have no conflict of interest.

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