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Research Paper

Growth and Variability Analysis of Seed Spices in Rajasthan

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ABSTRACT

The purpose of this study was to investigate the growth and instability in area, production, and productivity of major seed spices in Rajasthan. This study was entirely based on secondary data. The study period was separated into three sub-periods: pre-Agri Export Zone Period (1991-92 to 2004-05), post-Agri Export Zone Period (2005-06 to 2019-20), and overall period (1991-92 to 2019-20). The data was analyzed using the compound annual growth rate, Cuddy-Della Valle instability index to accomplish the study's objectives. The results of the study indicated that highest growth rates were observed in the production of fenugreek (7.53%), cumin (18.66%), and fennel (11.15%) during the pre-AEZ, post-AEZ, and overall periods. The highest instability was found in fennel production in Rajasthan, with 49.73, 65.51, and 73.76 percent, respectively. Based on findings, researchers should give more emphasis to increasing the area under cultivation and improving spice productivity. The state government should establish Agri-Export Zones for fenugreek and fennel crops like cumin and coriander.

HIGHLIGHTS

- The maximum growth rate reported in cumin production in Rajasthan.
- The highest variability in area and production of fennel were found in the overall period.
- Area and production of coriander augmented negatively after the establishment of AEZ.

Keywords: Growth rate, Variability, Seed spices, Cuddy-Della Valle, Rajasthan

Indian spices are known for their flavor and smell all over the world. India is renowned as the "Home of Spices," as it is the world's greatest producer, consumer, and exporter of spices. There is no other country in the world that produces such a diverse range of spices as India. Almost all of the country's states produce one or more spices. In India, 75 species of the 109 spices are grown. Only 16 are essential, including black pepper, cardamom, ginger, turmeric, clove, chili, garlic, saffron, celery, cumin, coriander, fennel, fenugreek, ajwain, dill, and nigella (RSAMB, 2010). Seed spices are a group of crops that include coriander, cumin, fennel, fenugreek aniseed, dill, celery, nigella, and caraway. Seed spices are annual herbs that are used as spices in the form of dried seeds or fruits. They are a gift from nature to humans since they add flavor to our food and make it delicious. Seed spices are utilized in a variety of indigenous remedies, nutraceuticals, pharmaceuticals, aromatherapy, natural colors, drinks, preservatives, botanicals, and insecticides, in addition to flavor and scent. Spices have a wide range of chemical properties according

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to the substances they produce. On the basis of nutritional and medicinal characteristics, seed spice crops are categorized into major and minor groups. Coriander, cumin, fennel, and fenugreek belong to the major group, whereas ajwain, dill, celery, nigella, and caraway belong to the minor group. Seed spices are frequently used in crushed form for flavoring and garnishing meals and beverages.

Indian spices are finding international markets and bringing the foreign exchange to the exchequer due to the benefits to human health and varied tastes. Seed spice demand is on the rise, and importing countries are looking to India as a reliable supply. The arid and semi-arid states of Rajasthan, Gujarat, Madhya Pradesh, Uttar Pradesh, and Andhra Pradesh form India's main belt of these seed spice crops. Orissa, Tamil Nadu, Karnataka, Bihar, Punjab, and West Bengal are also important seed spice growing states. Coriander was cultivated on 5.29 lakh hectares, cumin on 12.76 lakh hectares, fenugreek on 1.26 lakh hectares, and fennel on 0.82 lakh hectares, with the production of 7.01, 9.12, 1.82, and 1.40 lakh tonnes, respectively, in 2019-20. Cumin, coriander, fenugreek, and fennel contributed 29.55, 12.25, 2.91, and 1.70 percent, respectively, in the area and 9.01, 6.92, 1.79, and 1.38 percent, in production (Spice Board of India, 2019-20).

Rajasthan and Gujarat states collectively contributed approximately 70 percent of total seed spice production in the country, winning them the term "Bowl of Seed Spices" (Spice Board of India, 2019-20). Rajasthan has the highest area and production of spices and seed spices in India. In Rajasthan, seed spices are mostly grown in arid and semi-arid conditions, where most other crops fail to grow, and these crops provide a living and employment to a large portion of the population. The area under total spice cultivation in Rajasthan in 2019-20 was 10.20 lakh hectares, with a production of 10.59 lakh tonnes, while the area and production under seed spices were 9.19 lakh hectares and 6.09 lakh tonnes, respectively (Spice Board of India, 2019-20). During 2019-20, the state of Rajasthan produced 0.89, 42.81, 0.67, and 0.25 lakh tonnes of coriander, cumin, fenugreek, and fennel from 0.60, 7.79, 0.53, and 0.26 lakh hectares, respectively. Despite having a scattered cultivable area across the country, more than 70 percent of seed coriander comes from Rajasthan's *Hadoti* region, which includes the districts of Kota, Baran, Bundi, and Jhalawar; similarly, more than 90 percent of cumin and 50 percent fenugreek are only produced in Rajasthan's dry western stretch, which includes the districts of Jodhpur, Barmer, Jaisalmer, Bikaner, Churu, Jalore and Nagaur.

The concept of an Agri-Export Zone (AEZ) was introduced in 2001 as part of the Export Import (EXIM) Policy 1997-2001. In total, 60 AEZs were established in 20 states in India for specific commodities to reap the full benefits of exports, including developing and sourcing raw materials, processing, packaging, and so on. In the year 2005, Rajasthan established the Agri-Export Zone for the development and expansion of seed spice exports. Agri-Export Zones for coriander crops have been established in Kota, Baran, Bundi, Jhalawar, and Chittorgarh districts. Simultaneously, AEZs for cumin were implemented in the Rajasthan districts of Jodhpur, Barmer, Nagaur, Pali, and Jalore to increase production and export value in international markets.

Seed spices play an essential role in our country's annual spice export basket. With this excellent commercial opportunity for the country, we must remember that there are significant competitors in the wings. Egypt, Iran, Pakistan, Turkey, Iraq, Morocco, and Italy are among them. It is thus critical that, to meet global challenges, India's seed spice production and productivity increase by a great margin. The existence of a sound market structure is also a sine qua non for providing growers with incentive prices for seed spices in order to boost production. However, future seed spice production planning is hampered by crop production and income uncertainties. Growth patterns in the area, production, and yield of seed spices are also crucial for understanding changes in a country or state over time. Identifying trends in individual seed spice crops is a very informative work because it will provide us with a chronological background of how the cultivation of seed spices influences the lives of farmers, either positively or negatively. The study has attempted to determine the peak or trough in the cultivation of seed spice crops in the past. As we all know, Indian farmers are in a bad way these days, so this information useful to policymakers in developing new measures to increase the area, production, and yield of seed spices in the state of

Rajasthan. With the aforementioned facts in mind, a study on the growth and instability in the area, production, and productivity of major seed spices in Rajasthan.

MATERIALS AND METHODS

The principal crops grown in an arid and dry part of Rajasthan are Cluster bean, Pearl Millet, Sorghum, Mungbean, Cumin, Fennel, and Fenugreek. The Rajasthan state is leading in the country's production of spices and seed spices. However, the present study is based on tope four seed spice crops *viz.*, coriander, cumin, fennel, and fenugreek. Based on triennium ending average (2016 to 2018), these four seed spice crops together accounted for about 98 percent of the total seed spice area and production of Rajasthan. Simultaneously, the arid and semi-arid climatic conditions of Rajasthan are found suitable for spice production. The study period from the year 1991-92 to 2019-20 was selected for growth and instability analysis. Further, for drawing meaningful conclusions in growth and instability, the study period was analyzed as a whole as well as by dividing it into two subperiods *viz.*, period-I: Pre-Agri Export Zone (1991-92 to 2004-05) and period-II: Post-Agri Export Zone (2005-06 to 2019-20). The information in respect of the area, production, and productivity of coriander, cumin, fennel, and fenugreek was collected from published Government sources as the Directorate of Economics and Statistics, Government of Rajasthan, Spice Board of India, National Research Centre on Seed Spices-Ajmer and Rajasthan Agricultural Statistics at a Glance.

Analytical framework: The collected data on the area, production, and yield of coriander, cumin, fennel, and fenugreek and their competitive crops were compiled and analyzed logically. For the present investigation, the following analytical techniques were used to compute the compound annual growth rate and instability in the area, production, and productivity of selected spice crops. The growth rate was estimated in relative terms by this method, which is commonly used as a measure of growth rate in chronological data (Bairwa *et al.* 2020; Bairwa *et al.* 2021; Balai *et al.* 2021). The detailed explanations of these techniques are given as follows:

Compound annual growth rate (CAGR): The compound annual growth rate in the area, production, and yield of major seed spices, *viz.*, cumin, fenugreek, coriander, and fennel in the Rajasthan state as a whole, were computed by following the exponential equation.

$$Y_t = A\,(1 + r)^t \qquad \ldots(1)$$

After taking log on both sides of equation (1),

$$\ln Y_t = \ln A + t \ln (1 + r) \qquad \ldots(2)$$

Where,

Y_t is the variable (area/production/productivity) for which growth calculated for t^{th} period

t is period-I (1991-92 to 2004-05)/II (2005-06 to 2019-20)/III (1991-92 to 2019-20)

r is the compound annual growth rate, and

ln is the natural logarithm.

CAGR was computed using this formula:

$$r = (Antilog\ of\ b - 1) \times 100$$

Student '*t*' test was used to test the significance level of growth in the area, production, and productivity of seed spice crop.

Instability Analysis: The Cuddy-Della Valle instability index was utilized in this study, which was developed by John Cuddy and Della Valle in 1978 to measure instability over the period. Firstly, the compiled time series data on each seed spice's area, production, and productivity were de-trended to overcome the systematic trend from selected data series, which may be due to inflationary forces. The de-trended value was used to eliminate the long-term trends in variables by using a displaced moving average. This index is better than CV and index of dynamic instability because simple CV overestimate the extent of variability in secular data series characterized by long-term trend. This method removes this distortion in the coefficient of variation. The variability was estimated in relative terms by this index, which is commonly used as a measure of instability in chronological data (Singh and Byerlee, 1990 and Deb *et al.* 1999; Bairwa *et al.* 2020; Bairwa *et al.* 2021; Balai *et al.* 2021). The

algebraic form of this index is given as follows:

$$I = CV \times \sqrt{\left(1 - Adj\ R^2\right)}$$

Where,

I is the instability index (%),

CV is the coefficient of variation (%), $CV = \frac{SD}{AM} \times 100$

SD is standard deviation

AM is Arithmetic mean

Adj R^2 is the adjusted *R* square = coefficient of determination from a time trend regression adjusted by the number of degrees of freedom.

The range of CDVI is categorized into three sub-groups (Balai *et al*, 2022) as given below:

CDVI category	Range in (%)
Low instability	0-15
Medium instability	15< to 30
High instability	30<

RESULTS AND DISCUSSION

Growth and instability in area, production and productivity of major seed spices

Coriander: It is a winter season crop cultivated mostly in the Rajasthan southern part than. The compound annual growth rate and instability in the area, production, and yield of coriander in Rajasthan are depicted in Table 1. During Pre-AEZ (Agri Export Zone) period, the production and productivity of coriander increased significantly at 6.94 and 4.80 percent per annum, respectively. At the same time, the area under coriander also increased non-significantly at 2.14 percent. In this period, production might be increased due to expansion in area and improved crop productivity. Boyal and Mehra (2016) also reported a similar growth rate in the area, production, and productivity of coriander in Rajasthan during the 1991-92 to 2013-14 period. During the post-AEZ (Agri Export Zone) period, the growth rate in area and production of coriander was -5.32 and -3.99 percent per annum, respectively. The productivity was found to be increased non-significantly at 1.33 percent. During this period, the negative growth rate in area and production might be due to increased diseases, insects attack, and attractive changes in the minimum support price, especially for wheat. During this period, the minimum support price for wheat increased more than three folds from ₹ 650/quintal in 2005-06 to ₹ 1840/quintal in 2019-20. Therefore, the cultivated area under coriander was replaced by the competitive crop wheat in the Kota, Baran, and Jhalawar districts of Rajasthan.

During the overall period (1991-92 to 2019-20), production increased at an annual rate of 1.31 percent. In the case of area, coriander reported a negative and non-significant growth rate of -0.27 percent. Kumawat and Meena (2005) recorded a significant growth rate in the coriander area, production, and productivity in Rajasthan and India from 1967-68 to 2000-01.

It could be observed from the table that the CDVI for the area during pre-AEZ period (26.34%) was smaller than the post-AEZ period (33.16%)and overall period (33.54%). The higher instability was recorded in the overall period as compared to pre-AEZ and post-AEZ. A similar pattern of

Table 1: Growth rate and instability analysis of coriander in Rajasthan (In Per cent)

Particulars	Pre-AEZ (1991-92 to 2004-05)		Post-AEZ (2005-06 to 2019-20)		Overall Period (1991-92 to 2019-20)	
	CAGR	CDVI	CAGR	CDVI	CAGR	CDVI
Area	2.14^{NS} (0.251)	26.34	-5.32^{NS} (0.412)	33.16	-0.27^{NS} (0.378)	33.54
Production	6.94^{*} (0.276)	28.36	-3.99^{NS} (0.4)	35.22	1.31^{NS} (0.408)	39.36
Productivity	4.80^{*} (0.071)	6.82	1.33^{NS} (0.239)	20.06	1.58^{**} (0.199)	18.91

Source: *Author's own computation from compiled time series data.*

Note: *Figures in parentheses are standard errors of exponential model.*

CAGR—Compound Annual Growth Rate and CDVI—Cuddy Della Valle Instability Index.

*Significant at 1 percent level of significance, **significant at 5 per cent level of significance and ^{NS}Non-significant.

instability index for production of coriander crop was also smaller in the pre-Agri Export Zone period (28.36%) than both the post-Agri Export Zone period (35.22%) and overall period (39.26%). The instability index for the productivity of coriander in the post-Agri Export Zone period (20.06%) was higher than the pre-Agri Export Zone period (6.82) and overall period (18.91%). This indicated that the coriander growers pointed out higher profitability of coriander production since they were appreciated by the seed spices producing giants like MDH and large size exporters of coriander. This could be due to higher flexibility in productivity during the post-Agri Export Zone period. In their study, Naik and Hosamani (2016) also depicted that the degree of instability in the production of turmeric was higher than the area and productivity in the Karnataka state as a whole.

Cumin: The cumin crop in Rajasthan is mostly grown in Jodhpur, Barmer, and Nagaur districts. In the state, the cultivated area under the cumin crop depicted affirmative growth rates in all three periods (Table 2). The growth of area under cumin was 4.39, 12.13, and 5.62 percent in pre-AEZ, post-AEZ and overall period, respectively. After the introduction of a new concept of Agri-Export Zones for cumin in the Rajasthan, the area under cumin crop was mounted up significantly. The production and productivity of cumin had also increased significantly from the pre-Agri Export Zone period to the post-Agri Export Zone period in the state. However, the overall period reported positively significant growth rates in area (5.62%) and production (6.79%) in the state. The analysis revealed that there has been extensive growth in the area, production, and productivity of cumin, especially after the introduction of Agri-Export Zones for seed spices in Rajasthan. Boyal *et al.* (2015) reported similar results of the growth pattern in the area, yield, and production of cumin in Rajasthan during the 1991-92 to 2010-11 period.

The instability index was measured for the area, production, and productivity of cumin in Rajasthan for all three periods and depicted in Table 2. It was revealed from the table that the CDVI for an area during the pre-Agri Export Zone period (37.52%) was smaller than the post-Agri Export Zone period (47.18%). Similarly, the extent of instability index for production of cumin in the pre-Agri Export Zone period (43.50%) was lower than both the pre-Agri Export Zone period (54.33%) and overall period (62.16%). In the case of productivity, the instability index increased from 22.60 percent in pre-AEZ to 30.41 percent in the post-AEZ period and 30.13 percent in the overall period. The CDVI in area production and productivity varied from medium (22.60%) to high (62.16%). These fluctuations in the productivity of cumin were principally affected by the variation in average annual rainfall and other climatic reasons. It could be seen from the discussion that instability in the area, production, and productivity of cumin was spread out after the implementation of the Agri Export Zone for cumin in Rajasthan. Further, National Research Centre and SAUs have developed various new varieties and a modern package of practices in recent years was keynote accountable for instability in productivity which is directly associated with the level of production in the last years. Dhakre and Sharma (2009), in their study, have reported the highest instability in the area (204.20%) followed by yield (29.43%) and production (10.46%) in the North-East region of India.

Table 2: Growth rate and instability analysis ofcumin in Rajasthan (In per cent)

Particulars	Pre-AEZ (1991-92 to 2004-05)		Post- AEZ (2005-06 to 2019-20)		Overall Period (1991-92 to 2019-20)	
	CAGR	CDVI	CAGR	CDVI	CAGR	CDVI
Area	4.39^{NS} (0.355)	37.52	12.13* (0.202)	47.18	5.62* (0.356)	36.50
Production	3.77^{NS} (0.424)	43.50	18.66* (0.339)	54.33	6.79* (0.553)	62.16
Productivity	-0.62^{NS} (0.243)	22.60	6.53* (0.271)	30.41	1.17^{NS} (0.311)	30.13

Source: *Author's own computation from compiled time series data.*

Note: *Figures in parentheses are standard errors of an exponential model.*

**Significant at 1 percent level of significance,* ***significant at 5 percent level of significance and* ^{NS}*Non-significant.*

Fennel: It is grown principally in Nagaur district, followed by Jodhpur, Sirohi, and Pali districts in Rajasthan. The area, production, and productivity of this crop did not report a significant growth in the pre-Agri Export Zone period. It could be seen from the table-3 that the area and production of this crop were non-significantly increased at the rate of 4.70 and 4.21 percent per annum, respectively, during pre-AEZ. During post-AEZ, the area and production of fennel were augmented significantly at 10.96 and 13.14 percent per annum, respectively, in the state. This crop's area and production was increased due to financial assistance, fiscal incentives, market-oriented benefits, etc., under the Agri-Export Zone Scheme of seed spices. The growth rates of area, production, and yield were positive and significant in post-AEZ and overall period except for productivity in post-AEZ. During the overall period (1991-92 to 2019-20), positive growth was observed for all three aspects, *viz.*, area, production, and yield in the state. The production, area, and yield increased significantly at a compound annual growth rate of 11.15, 9.05, and 2.10 percent in the state. Singh and Singh (2020) showed an affirmative growth rate in the production and productivity of spices and the area under garlic, ginger, and coriander crops in India during the 1997-98 to 2017-18 period.

The extent of the instability index for the area, production, and productivity of the fennel were estimated and presented in Table 3. It was observed from the table that the Cuddy Della Valle instability index for an area during the pre-Agri Export Zone period (37.68%) was relatively smaller than post-Agri Export Zone period (47.67%)and overall period (53.41%) as a whole Rajasthan. In the state, the maximum instability index for production of fennel was found in the overall period (73.76%) followed by the post-Agri Export Zone period (65.51%) and pre-Agri Export Zone period (49.73%). The instability index computed between pre and post-Agri Export Zone periods showed that CDVI for fennel has considerably mounted up during the post-Agri Export Zone period, the augmentation ranging from 49.73 percent in the pre-Agri Export Zone period to 65.51 percent in post-Agri Export Zone period. Similar to the cumin crop, the variability in area, production, and productivity of fennel also ranged from medium (20.58%) to high (73.76%). The instability of productivity for the fennel crop, on the contrary, has declined from 18.41 percent in the post-Agri Export Zone to 20.58 percent in the pre-Agri Export Zone. Ganesana (2015) reported in his study that instability in the area, production, and productivity of turmeric were reduced in Andhra Pradesh, Tamil Nadu, and Karnataka state, respectively, during 1979-80 to 2010-11 period.

Fenugreek: Fenugreek is mostly cultivated during the winter season under irrigated and semi-irrigated conditions. It has an important place in the cropping pattern of the Bikaner, Jhunjhunu, Jodhpur, Kota, Nagaur, and Sikar districts of Rajasthan. The performance of area, production & productivity, and associated compound annual growth rates during all three periods are presented in Table 4. It is revealed from the table that there was positive and significant augmentation in all three periods (except non-significant growth rate in production and productivity of pre-AEZand area of post-AEZ.

During the pre-Agri Export Zone period, the area, production, and productivity of fenugreek were augmented at 6.23, 7.53, and 1.30 percent

Table 3: Growth rate and instability analysis of fennel in Rajasthan (In per cent)

Particulars	Pre- AEZ (1991-92 to 2004-05)		Post- AEZ (2005-06 to 2019-20)		Overall Period (1991-92 to 2019-20)	
	CAGR	CDVI	CAGR	CDVI	CAGR	CDVI
Area	4.70 ^{NS} (0.379)	37.68	10.96* (0.548)	47.67	9.05* (0.478)	53.41
Production	4.21 ^{NS} (0.510)	49.73	13.14* (0.675)	65.51	11.15* (0.618)	73.76
Productivity	-0.50 ^{NS} (0.213)	20.58	2.18 ^{NS} (0.189)	18.41	2.10* (0.209)	20.86

Source: *Author's own computation from compiled time series data.*

Note: *Figures in parentheses are standard errors of exponential model.*

**Significant at 1 percent level of significance,* ***significant at 5 per cent level of significance and* ^{NS}*Non-significant.*

Table 4: Growth rate and instability analysis of fenugreek in Rajasthan (In per cent)

Particulars	Pre-AEZ (1991-92 to 2004-05)		Post-AEZ (2005-06 to 2019-20)		Overall Period (1991-92 to 2019-20)	
	CAGR	CDVI	CAGR	CDVI	CAGR	CDVI
Area	6.23* (0.307)	41.85	4.39 NS (0.400)	43.12	4.22* (0.351)	40.38
Production	7.53 NS (0.332)	41.65	6.31** (0.386)	44.77	4.83* (0.363)	40.91
Productivity	1.30 NS (0.133)	13.69	1.92* (0.091)	11.23	0.60** (0.122)	12.36

Source: *Author's own computation from compiled time series data.*

Note: *Figures in parentheses are standard errors of exponential model.*

**Significant at 1 percent level of significance, **significant at 5 per cent level of significance and NSNon-significant.*

Table 5: Growth rate and instability analysis of all seed spices in Rajasthan (In per cent)

Particulars	Pre-AEZ (1991-92 to 2004-05)		Post-AEZ (2005-06 to 2019-20)		Overall Period (1991-92 to 2019-20)	
	CAGR	CDVI	CAGR	CDVI	CAGR	CDVI
Area	3.56** (0.241)	25.15	6.83* (0.178)	30.86	3.90* (0.227)	22.12
Production	5.89* (0.264)	28.50	6.98* (0.218)	35.08	4.56* (0.252)	24.78
Productivity	2.32** (0.129)	13.27	0.15 NS (0.154)	13.51	0.65 NS (0.147)	14.66

Source: *Author's own computation from compiled time series data.*

Note: *Figures in parentheses are standard errors of exponential model.*

**Significant at 1 percent level of significance, **significant at 5 per cent level of significance and NSNon-significant.*

per annum, respectively in the state. During post-AEZ, the area, production, and productivity of fenugreek increased at 4.39, 6.31, and 1.92 percent per annum, respectively. In the case of productivity, the growth rate has slightly accelerated from 1.30 percent in pre-AEZ to 1.92 percent in post-AEZ. The accelerated growth rate in productivity and decelerated growth in the area of fenugreek over the period suggested that the improved technology had helped to growers for enhancing production. Since fenugreek is a *rabi* season irrigated crop. Therefore, timely irrigation is an essential requirement for better performance in production and productivity. In the overall period, the positive and significant growth rate in all three aspects, *viz.*, area (4.22%), production (4.83%), and productivity (0.60%) of fenugreek have registered. Kumawat and Meena (2005), in their study, also found a positive and significant growth rate in the area and production of fenugreek during the 1970-71 to 2000-01 period.

The instability index for the area, production, and productivity of fenugreek in Rajasthan during pre-AEZ, post-AEZ, and overall period are depicted in Table 4. It was revealed from the table that the instability indices of area, production, and yield for fenugreek for pre-AEZ, post-AEZ, and overall period were (41.85, 41.65, 13.69); (43.12, 44.77, 11.23) and (40.38, 40.91, 12.36), respectively. During all three periods, the CDVI of fenugreek varied from low (12.36%) in productivity to high (44.77%) in production. These figures depicted that during the pre-AEZ period, the instability pattern for all three aspects was just about similar to the overall period. However, after the establishment of AEZ there was a slight increase in instability for area and production but not in the case of productivity. It means the instability effect on production was higher than the area and yield of fenugreek. Boyal *et al.* (2015) reported in their study that instability in production of fenugreek was superior to area and yield at district as well as state as whole except Jhunjhunu district during 1991-92 to 2000-01.

Total Seed spices: Seed spices is a group of coriander, cumin, fennel, fenugreek, carom seeds, dil, celery, nigella, and caraway. As a group, the compound annual growth rates in the area, production, and productivity of seed spices were analyzed and presented in Table 5. It was revealed from the analysis that in the pre-Agri Export Zone, the growth rate of area, production, and yield of

seed spices in Rajasthan were reported to be positive and significantly increased at 3.56 5.89, and 2.32 percent/annum, respectively.

The increasing trend in the growth of area and production under seed spices were also continued in the post-Agri Export Zone period at 6.83 and 6.98 percent per annum, respectively. The production of total seed spices increased steadily over the years, and it was registered very high in the post-Agri Export Zone.

Similar a positive and significant growth rate was also reported in the overall period for area and production of seed spices in the state. During this period, a significant growth rate under seed spices was registered in production (4.56%) and area (3.90%). Meena *et al.* (2018) accounted for positive and significant growth rates in all three aspects, viz., area, production, and productivity of total seed spices in 1985-2015.

The instability indices for all three aspects, area, production, and yield of whole seed spices in Rajasthan, were depicted in Table-5. During pre-AEZ period, the instability in terms of CDVI for the area, production, and yield were 25.15, 28.50, and 13.27 percent, respectively. During this period, the major cause of lower instability could be the moderately fluctuation of the area under these crops. During the Post-AEZ period (2005-06 to 2019-20), the computed CDVI was 30.86 percent, showing higher instability in the case of the area under composite seed spices. At the same time, CDVI was 35.08 percent for production and 13.51 percent for the productivity of total seed spices, depicting more instability in case of production and area in the study period i.e., 2005-06 to 2019-20. Further, it might be due to anomalous weather and climatic condition along with intensive attack of insects and pests on these seed spices.

During the overall period (1991-92 to 2019-20), the extent of instability for area and production of seed spices except productivity was lower than both pre-AEZ period and post-AEZ period. During this period, the calculated CDV indices for the area, production, and productivity were 22.12, 24.78, and 14.66 percent, respectively. Rajasthan state has to steady its march up in seed spices production, as the state is a major contributor towards achieving national food and nutritional security. Similarly, Soumya *et al.* (2014) pointed out in their study that pepper and cumin's area, production, and productivity were stable at the state and national levels during the 2001-2010 period.

CONCLUSION AND POLICY IMPLICATIONS

It could be summarized from the findings that during the pre-AEZ period, the area, production, and productivity of coriander grew at a higher rate than the post-AEZ period and entire study period. However, higher instability in area and production of coriander was notified in the overall period than pre-AEZ and post-AEZ periods. After the establishment of AEZ in the state, an appreciable and significant growth rate was recorded in area, production, and productivity of cumin than pre-AEZ and overall study period. In the meantime, the instability in area and productivity of cumin was also higher than pre-AEZ and the entire study period. In case of production, higher instability was recorded in the entire study period. A positive and significant growth rates were notified for the area and production of fennel in post-AEZ and overall study periods. During overall study period, the variability in all aspects *viz.*, area, production, and productivity of fennel were higher than pre-AEZ and post-AEZ periods. During post-AEZ period, the production and productivity of fenugreek increased significantly at a higher rate than pre-AEZ and overall study period. The extent of instability in area and production of fenugreek were greater in post-AEZ period. In case of productivity, the variability declined from pre-AEZ period to post-AEZ period. During all three periods, the area and production of total seed spices increased significantly at a positive rate. In the case of productivity, a positive and significant growth rate was observed in the pre-AEZ period. The area and production of total seed spices were more unstable in the post-AEZ period as compared to pre-AEZ period.

Based on findings, researchers should emphasis on strengthen package of practices and region-based varietal assistance through the National Research Centre on Seed Spices in Ajmer, SAUs, and the Rajasthan Agriculture Department for coriander crop. After establishment of AEZ, yield and area effect were the primary contributors to the state's spice output growth. Therefore, researchers should

place a greater emphasis on increasing area under cultivation and improving spice productivity, as Rajasthan lags behind neighbouring states like Gujarat and Madhya Pradesh in spice productivity. Just like cumin and coriander, the state government should establish an Agri-Export Zone for fenugreek and fennel crops in Rajasthan so that farmers can access better world-class facilities to produce high-quality spices that can be exported to other countries.

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