

## Growth and instability in area, production and yield of major spice crops in Rajasthan vis-à-vis India

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### Abstract

A study on growth and instability in area, production and yield of spice crops such as coriander (*Coriandrum sativum*), cumin (*Cuminum cyminum*), fenugreek (*Trigonella foenum-graecum*), fennel (*Foeniculum vulgare*), garlic (*Allium sativum*) and chilli (*Capsicum annum*) in Rajasthan vis-à-vis India indicated that almost all the spices registered significant growth rates in their production in Rajasthan as well as in India during the entire study period mainly due to significant increases in the same during post-Technology Mission on Oilseeds (TMO) period (1986–87 to 2000–01). The significant increase in production in coriander was mainly due to significant increase in yield whereas in cumin and fennel, it was due to significant increase in area. In fenugreek, the increase in production was the result of increase in both area and yield. In case of chilli and garlic, both area and yield at the national level and only area at the state level played significant role in increasing the production. In majority of the spice crops the instability in production increased during the post-TMO period over the pre-TMO period (1967–68 to 1985–86) in Rajasthan and India as well. However, the magnitudes of coefficients of variations were more pronounced at the state level than at the national level. The instability in area in the state was higher in the post-TMO period than in the pre-TMO period. The same was true of India except that the magnitudes of coefficients of variations were less at the national level. In general, yield instability, on the other hand, decreased during the post-TMO period over the pre-TMO period in both Rajasthan and India. As regards sources of variance of production, area variance played a dominant role in case of coriander, cumin, fennel and garlic. Yield variance predominantly destabilised the production of chilli in Rajasthan and of fenugreek in India. In majority of spices, area-yield covariance helped stabilize the production in Rajasthan as well as in India.

**Key words:** area, growth rate, instability, production, Rajasthan, spices, yield.

### Introduction

Although many spice crops are grown in Rajasthan in India, only coriander (*Coriandrum sativum* L.), cumin (*Cuminum cyminum* L.), fenugreek (*Trigonella foenum-graecum* L.), fennel (*Foeniculum vulgare* Miller), garlic (*Allium sativum* L.) and chilli (*Capsicum*

*annuum* L.) are widely grown in different agroclimatic zones of the state. In 2000–01 the state contributed nearly 41% of national area and 71% of national production of coriander. Cumin accounted for nearly 63% and 55% of national area and production, respectively. Other crops like fenugreek, fennel, garlic and chilli contributed 84%, 24%, 15% and 4% of

the respective areas and 88%, 10%, 10% and 3% of the production in the country. The state has a large potential for earning income by exporting spices to other parts of India and abroad. However, due to large domestic market, severe competition from food and cash crops and relatively low yield, not enough marketable surpluses are available for export.

In order to increase the production of various crops, the Government of India initiated various production-oriented programmes from time to time which have affected the production of spices in one way or the other. The green revolution which was mainly confined to cereals especially, wheat and rice, neglected the production of other crops like pulses, oilseeds, spices, etc. As a consequence the country heavily depended on imports, mainly of oilseeds. In order to reduce the import of oilseeds and increase their domestic production, the Government of India established the Technology Mission on Oilseeds (TMO) in May 1986 to accelerate self reliance in oilseed production. The present investigation was undertaken to answer some of the questions such as: What has been the nature and extent of growth and instability in area, production and yield of spice crops in Rajasthan and India? Has the TMO adversely affected the production of spices in the state and the country? What are the sources of instability in production of spices in the state and the country? Such information will equip decision-makers and planners with first-hand knowledge in formulating suitable plans for manipulating the area, production and yield of these crops in Rajasthan in future.

Though a number of attempts were made earlier by Peter (1982), Ray (1977; 1983), Mahendradev (1987), Dhawan (1987), Rao *et al.* (1988), Pal & Sirohi (1989) and Mitra (1990) to measure the extent of instability in area, production and yield of different crops, most of these studies are mainly related to food grains. The measure of instability used in this study was coefficient of variation and standard deviation expressed as a percentage of

mean, in year to year changes in area, production and yield of spices.

### Materials and methods

The investigation was based on yearly time series secondary data on area, production and yield of major spices grown in Rajasthan. The secondary data were collected from published records and reports of the Directorate of Economics and Statistics, Government of Rajasthan, Jaipur and the Revenue Board, Ajmer. The period of study pertained to 1967–68 to 2000–01 for chilli and coriander, 1973–74 to 2000–01 for cumin, fenugreek and fennel and 1986–87 to 2000–01 for garlic, the periods corresponding to the availability of time series data on area and production of these crops. For drawing meaningful conclusions, the study period was analysed as a whole as well as by dividing it into pre-TMO period (1967–68 to 1985–86) and post-TMO period (1986–87 to 2000–01). Information in respect of area, production and yield of these crops for all India level were also collected to compare the state results with that of India. This data was collected from Spices Statistics (Abstract) (4th edition) and the records of the Directorate of Agriculture, Government of Rajasthan. The time series data pertained to 1970–71 to 2000–01 for chilli and coriander and 1975–76 to 2000–01 for cumin, fennel, fenugreek and garlic. Instead of using raw data, their index numbers were used for analysis. Index numbers for area, production and yield of different spice crops were calculated by taking average of the initial three years of the time series as base which was dictated by the availability of the data. Triennium averages were taken as base periods to mitigate the effect of abnormal years. Compound growth rates of area, production and yield of spice crops were worked out by using the exponential function of the form  $Y_t = ab^t U_t$ , where  $Y_t$  = index number of area / production / yield of a spice crop in year 't', t = time element,  $U_t$  = the disturbance term with usual Ordinary Least Squares (OLS) assumptions, 'a' and 'b' are constants or parameters to be estimated by OLS technique after converting it into log linear form. The

compound growth rates were worked out as  $\hat{g} = (\hat{b} - 1) 100$ , where  $\hat{b}$  = antilog of  $\log \hat{b}$ ,  $\log \hat{b}$  = estimated value of  $\log b$  and  $\hat{g}$  = compound growth rate in percentage annum<sup>-1</sup>. The standard errors of the compound growth rates were worked out by using the formula

$$Se(\hat{g}) = \frac{100 \hat{b}}{\log_{10} e} \sqrt{\frac{[\Sigma (\log Y)^2 - (\Sigma \log Y)^2 / N] - [\Sigma t^2 - (\Sigma t)^2 / N] (\log \hat{b})^2}{(N-2) [\Sigma t^2 - (\Sigma t)^2 / N]}}$$

where  $Se(\hat{g})$  = standard error of compound growth rate,  $\log_{10} e = 0.4343$ ,  $N$  = number of observations and other terms have the meanings as defined earlier (Acharya 1985). Student's 't' test was used to test the significance of the estimated compound growth rate as follows  $t_{n-2} = \hat{g} / Se(\hat{g})$ ; where suffix  $n-2$  connotes the degree of freedom of 't'.

The area and yield data for each crop was detrended using linear relations of the form:  $Z_t = a + bt + e_t$ , where  $Z_t$  = dependent variable (area/yield index),  $t$  = time,  $e_t$  = random residual with zero mean and variance  $\sigma^2$  (Peter 1982). In this analysis, yields were estimated for each crop and year by dividing the relevant production figures by the area sown. Separate regressions were run for each period. After detrending, the residuals ( $e_t$ ) were centered on the mean areas and mean yields for each crop and for each period,  $\bar{Z}$ , resulting in detrended time series data of the form  $Z = e_t + \bar{Z}$ . Time series detrended production indices for each crop were then calculated as the product of detrended area and yield indices divided by 100, i.e.,  $(AY) 100^{-1}$ . To investigate further into the variables explaining the changes in relative production instability, sources of variance of production in major spice crops were estimated. The variance of production was decomposed into its constituent sources, namely, area variance, yield variance and area-yield covariance and higher order interaction between area and yield. Let  $P$ ,  $A$  and  $Y$  denote production, area and yield indices. Then for each crop  $P = (AY) 100^{-1}$ . The variance of production  $V(P)$  can

be expressed as :

$V(P) = \bar{A}^2 V(Y) 100^{-2} + \bar{Y}^2 V(A) 100^{-2} + 2 \bar{A} \bar{Y} \text{cov}(AY) 100^{-2} - \text{cov}(A, Y)^2 100^{-2} + R$ , where  $A$  and  $Y$  denote the means of area and yield indices of each spice crop and  $R$  is a residual term which is expected to be small and hence ignored in the analysis. It is clear from this expression that  $V(P)$  is not only a function of the variances in yields and areas sown, but also of the mean area and yield and of the covariance between areas and yields.

Clearly a change in any one of these components would lead to a change in  $V(P)$  between two periods of time.

## Results and discussion

### Growth rate

The production of cumin, the main spice crop of the state, significantly increased at a compound growth rate of 4.16% per annum during the overall period (Table 1a). A comparison of growth rates during different sub-periods show that cumin production was stagnant during the pre-TMO period, and grew at 5.57% per annum which was significant during the post-TMO period. The achievement of an overall growth rate of slightly above 4% per annum was possible mainly because of 5.57% annual growth rate in the same during the post-TMO period. The trend of growth in production of the crop for India was similar to that for the state and registered a significantly positive growth of 3.20% per annum during the overall period mainly due to significant growth of 5.72% during the post-TMO period. In the pre-TMO period, the production rate declined to 4.71% per annum which was not significant. Coriander registered a significant growth rate of 6.13% per annum in the state during the overall period due to significant growth of 3.14% and 3.67% per annum during pre-TMO and post-TMO periods, respectively. At the national level, the production of coriander increased at a non-significant growth rate of 2.43% per annum during the pre-TMO period, at a significant rate of

**Table 1a.** Annual compound growth rates (per cent) in production of spice crops in Rajasthan and India

Crop	Location	Pre-TMO period			Post-TMO period			Overall period		
		R <sup>2</sup>	Growth rate	St. error	R <sup>2</sup>	Growth rate	St. error	R <sup>2</sup>	Growth rate	St. error
Chilli	Rajasthan	0.1649	2.35 *	1.38	0.1039	2.31	1.90	0.6424	4.32 ***	0.60
	India	0.5078	3.05 ***	0.88	0.8078	3.97 ***	0.55	0.8444	3.01 ***	0.25
Coriander	Rajasthan	0.1219	3.14 *	2.21	0.2465	3.67 **	1.81	0.6788	6.13 ***	0.79
	India	0.1316	2.43	1.82	0.2189	2.46 **	1.30	0.6053	3.44 ***	0.54
Cumin	Rajasthan	0.0002	-0.26	5.43	0.2483	5.57 **	2.76	0.3001	4.16 ***	1.32
	India	0.165	-4.71	3.91	0.3255	5.72 **	2.35	0.2728	3.20 ***	1.13
Fennel	Rajasthan	0.0007	0.27	3.39	0.1490	4.78 *	3.24	0.3145	3.95 ***	1.21
	India	0.0661	-2.96	4.14	0.4557	7.43 ***	2.33	0.1183	2.05 *	1.21
Fenugreek	Rajasthan	0.3246	3.95 **	1.94	0.3196	3.36 **	1.38	0.0832	0.92 *	0.62
	India	0.2836	-4.10 *	2.41	0.4395	4.40 ***	1.41	0.0264	-0.66	0.85
Garlic	Rajasthan	-	-	-	0.5336	8.57 ***	2.52	0.5336	8.57 ***	2.52
	India	0.4635	6.47 **	2.71	0.4222	4.04 ***	1.34	0.7269	4.67 ***	0.62

\* Significant at 10% level; \*\* Significant at 5% level; \*\*\*Significant at 1% level

Pre-TMO period=1967-68 to 1985-86 for chilli and coriander; 1973-74 to 1985-86 for cumin, fennel and fenugreek in case of Rajasthan. For India, 1970-71 to 1985-86 for chilli and coriander and 1975-76 to 1985-86 for cumin, fennel, fenugreek and garlic; Post-TMO period=1986-87 to 2000-01; St. error=standard error of growth rate

2.46% during the post-TMO period and at an overall significant annual rate of 3.44% during the entire period. In case of chilli, the significant growth of 4.32% per annum in the state was due to significant growth of 2.35% per annum during the pre-TMO period and non-significant growth of 2.31% during the post-TMO period. In the country as a whole, the significant annual growth of 3.05% and 3.97% during the pre- and post-TMO periods, respectively, led to a significant annual growth rate of 3.01% during the entire study period. In case of fennel also the significant increase in its production in the state and the country as well during the overall period was due to significant increases during the post-TMO period. As regards fenugreek, the significant increase of 0.92% during the overall period was due to the combined effect of significant increases during both pre-TMO (3.95%) and post-TMO periods (3.36%). At all India level, the significant growth of 4.40% of fenugreek production during the post-TMO period was nullified by the significant negative growth of 4.10% during the pre-TMO period causing the production to be stagnant during the overall period. Garlic recorded significant growth in its production during all the three periods.

The area under cumin in the state increased at a significant rate of 5.76% per annum, which was due to significant annual growth of 9.47% during the post-TMO period only. Contrary to this, the significant growth of 3.34% per annum in area of coriander during the overall study period was caused by a significant growth of 3.41% during the pre-TMO period. In spite of significant annual growth of 1.65% per annum during pre-TMO period, the area under chilli could not record significant growth in the overall period due to stagnation in area during the post-TMO period. Fennel recorded a significant annual growth of 3.94% in its area as a result of 4.68% annual growth during post-TMO period and of non-significant growth of 4.37% during the pre-TMO period. Though the area in fenugreek witnessed a significant growth of 1.53% during the post-TMO period, the same stagnated at 0% level in the overall period due to its stagnation in the pre-TMO period. The area under garlic recorded significant growth of 7.08% during the post-TMO period (Table 1 b).

At the national level the significant annual growth of 0.73% in area under chilli could be possible due to significant growth of 1.29%



**Table 1b.** Annual compound growth rates (per cent) in area of spice crops in Rajasthan and India

Crop	Location	Pre-TMO period			Post-TMO period			Overall period		
		R <sup>2</sup>	Growth rate	St. error	R <sup>2</sup>	Growth rate	St. error	R <sup>2</sup>	Growth rate	St. error
Chilli	Rajasthan	0.2891	1.65 **	0.67	0.0073	0.44	1.42	0.0443	0.43	0.36
	India	0.586	1.29 ***	0.31	0.3884	1.00 ***	0.35	0.5710	0.73 ***	0.12
Coriander	Rajasthan	0.1863	3.41 **	1.87	0.0496	1.21	1.48	0.5031	3.34 ***	0.62
	India	0.3477	3.45 **	1.39	0.0311	0.75	1.16	0.3840	1.82 ***	0.45
Cumin	Rajasthan	0.0447	-2.82	4.29	0.5273	9.47 ***	2.60	0.4731	5.76 ***	1.28
	India	0.3522	-6.80 **	3.36	0.5289	7.75 ***	2.10	0.4520	4.73 ***	1.14
Fennel	Rajasthan	0.0768	4.37	5.16	0.2976	4.68 **	2.04	0.3637	3.94 ***	1.08
	India	0.011	-1.16	4.14	0.4915	6.51 ***	1.89	0.1161	1.76 *	1.05
Fenugreek	Rajasthan	0.1317	1.88	1.62	0.1474	1.53 *	1.03	0.0000	0.00	0.47
	India	0.002	-0.23	1.96	0.3086	2.69 **	1.13	0.0082	0.24	0.57
Garlic	Rajasthan	-	-	-	0.5422	7.08 ***	2.03	0.5422	7.08 ***	2.03
	India	0.5489	5.84 **	2.06	0.3092	2.50 **	1.05	0.7037	3.59 ***	0.51

\* Significant at 10% level ; \*\* Significant at 5% level; \*\*\*Significant at 1% level

Pre-TMO period= 1967-68 to 1985-86 for chilli and coriander; 1973-74 to 1985-86 for cumin, fennel and fenugreek in case of Rajasthan. For India, 1970-71 to 1985-86 for chilli and coriander and 1975-76 to 1985-86 for cumin, fennel, fenugreek and garlic; Post-TMO period=1986-87 to 2000-01; St. error=standard error of growth rate

and 1.00% during the pre- and post- TMO periods, respectively. Despite significantly negative growth of 6.80% per annum during the pre-TMO period, the area under cumin significantly increased at an overall rate of 4.73% per annum due to significant growth of 7.75% during the post-TMO period. The area under coriander at national level remained stagnant during the post-TMO period. The overall growth of 1.82% per annum in the area was due to significant growth of 3.45% per annum during the pre-TMO pe-

riod only. Fennel and fenugreek recorded significant increase in area under them during the post-TMO period after having stagnated during the pre-TMO period. Garlic registered significant increase of 5.84%, 2.50% and 3.59% in its area in the country during the pre-TMO, post-TMO and overall periods, respectively.

Regarding yield, no spice crop in the state recorded significantly positive growth during the pre-TMO period (Table 1c). Fennel was the only crop to record significantly

**Table 1 c.** Annual compound growth rates (per cent) in yield of spice crops in Rajasthan and India

Crop	Location	Pre-TMO period			Post-TMO period			Overall period		
		R <sup>2</sup>	Growth rate	St. error	R <sup>2</sup>	Growth rate	St. error	R <sup>2</sup>	Growth rate	St. error
Chilli	Rajasthan	0.0137	0.68	1.49	0.2069	1.87 **	1.02	0.6240	3.88 ***	0.56
	India	0.2717	1.73 **	0.83	0.7564	2.93 ***	0.47	0.7876	2.86 ***	0.23
Coriander	Rajasthan	0.0088	-0.56	1.52	0.3632	2.41 ***	0.89	0.4507	2.61 ***	0.53
	India	0.1078	-0.99	0.82	0.3636	1.70 ***	0.63	0.5034	1.59 ***	0.31
Cumin	Rajasthan	0.1343	2.67	2.29	0.4419	-3.56 ***	1.09	0.2065	-1.49 ***	0.59
	India	0.3562	2.51 **	1.29	0.2237	-1.88 **	0.96	0.3087	-1.41 ***	0.45
Fennel	Rajasthan	0.2159	-3.46 *	2.16	0.0002	0.10	2.07	0.0060	0.09	0.79
	India	0.3676	-1.96 **	0.96	0.0844	0.88	0.81	0.0271	0.28	0.35
Fenugreek	Rajasthan	0.0814	2.06	2.33	0.2767	1.78 **	0.80	0.1316	0.91 **	0.48
	India	0.2617	-4.13 *	2.56	0.3097	1.71 **	0.72	0.1171	-0.94 **	0.55
Garlic	Rajasthan	-	-	-	0.0503	1.53	2.03	0.0503	1.53	2.03
	India	0.0688	0.58	0.81	0.4795	1.49 ***	0.44	0.5461	1.04 ***	0.20

\* Significant at 10% level; \*\* Significant at 5% level; \*\*\*Significant at 1% level

Pre-TMO period= 1967-68 to 1985-86 for chilli and coriander; 1973-74 to 1985-86 for cumin, fennel and fenugreek in case of Rajasthan. For India, 1970-71 to 1985-86 for chilli and coriander and 1975-76 to 1985-86 for cumin, fennel, fenugreek and garlic; Post-TMO period=1986-87 to 2000-01; St. error=standard error of growth rate

negative growth of 3.46% per annum during the period. During the post-TMO period, the yield of cumin significantly declined at 3.56% per annum, whereas that of chilli (1.87%), coriander (2.41%) and fenugreek (1.78%) significantly increased and of fennel and garlic remained stagnant. In overall period, the trend of growth in yield of all the spices under study in the state was similar to that in post-TMO period indicating that the growth in yield of spices was governed by the growth in the post-TMO period.

The results of yield growth rates of different spices for India revealed that only chilli and cumin recorded significant increases in their yields being 1.73% and 2.51%, respectively during the pre-TMO period (Table 1c). Fennel and fenugreek witnessed significant decline of 1.96% and 4.13% per annum in that order during the period. The yields of coriander and garlic were estimated to have been stagnated during the same period. The pattern of growth for all the spices except garlic in India was almost similar to that in the state during the post-TMO period. In overall period, chilli recorded significant increase of 2.86% per annum in its yield due to significant growth of 1.73% per annum during the pre-TMO period and of 2.93% during the post-TMO period. Yield of coriander significantly increased at 1.59% per annum during the overall period solely due to significant increase of 1.70% in the same during the post-TMO period. The yield of cumin, on the other hand, declined at 1.41% per annum due to significant decline (1.88%) in it during the post-TMO period in spite of significantly positive growth rate of 2.51% during the pre-TMO period. In fenugreek, in spite of significantly positive growth rate of 1.71% per annum during the post-TMO period, the overall yield declined at 0.94% per annum due to high negative growth (4.13%) during the pre-TMO period.

To sum up, the overall rate of growth of around 4% per annum in the production of cumin in the state was brought about by the growth rate in area only. Its yield negatively affected its production during both post-TMO

and overall periods. In case of coriander, both area and yield helped increase the production of the crop during the overall period. Among other spices, the area of garlic and fennel and yield of chilli and fenugreek were the parameters leading to increase in their production. During post-TMO period, chilli, coriander and fenugreek gained considerable increase in their yield in the state. Growth results for the selected spices for India were almost the same as that for the state except chilli and garlic. In case of chilli and garlic, the significant increases in production were brought about by both area and yield of the crops.

#### *Instability*

The results of instability in spices production as measured in terms of coefficients of variation (CV) show that the CV of production of fennel (54.03%) and chilli (34.15%) in Rajasthan were considerably higher during the post-TMO period. Cumin and fenugreek also recorded increase in CV during post-TMO period over the pre-TMO period. Coriander observed decrease in CV over the period in the state. During the pre-TMO period, the range of CV in the state varied from as low as 20.81% in chilli to as high as 42.63% in cumin. In post-TMO period, CV of production ranged from as low as 24.45% in fenugreek to as high as 54.03% in fennel. The percentage change in CV computed between pre-TMO and post-TMO periods clearly brings out that CV for fennel, chilli, cumin and fenugreek has considerably increased during the post-TMO period, the increase ranging from 10.09% in fenugreek to 92.41% in fennel. The CV of production of coriander, on the contrary, decreased by 14.06% over the period (Table 2a).

As regards India, CV of production of all the spices except fenugreek were lower than that in the state during both pre-TMO and post-TMO periods. The range of CV of production varied from as low as 11.55% in chilli to as high as 30.55% in fenugreek during pre-TMO period as against as low as 11.22% in chilli to as high as 39.51% in fennel during the post-

**Table 2a.** Coefficients of variation (per cent) for detrended production of spice crops in Rajasthan and India

Crop	Rajasthan			India		
	Pre-TMO period	Post-TMO period	% change between periods	Pre-TMO period	Post-TMO period	% change between periods
Chilli	20.81	34.15	64.10	11.55	11.22	-2.86
Coriander	41.40	35.58	-14.06	14.20	21.08	48.45
Cumin	42.63	52.89	24.07	26.17	24.96	-4.62
Fennel	28.08	54.03	92.41	25.92	39.51	52.43
Fenugreek	22.21	24.45	10.09	30.55	38.02	24.45
Garlic	-	32.07	-	20.43	29.27	43.27

Pre-TMO period=1967-68 to 1985-86 for chilli and coriander; 1973-74 to 1985-86 for cumin, fennel and fenugreek in case of Rajasthan. For India, 1970-71 to 1985-86 for chilli and coriander and 1975-76 to 1985-86 for cumin, fennel, fenugreek and garlic; Post-TMO period=1986-87 to 2000-01

TMO period. Fennel recorded the highest percentage change in CV (52.43%) between pre-TMO and post-TMO periods followed by coriander (48.45%), garlic (43.27%) and fenugreek (24.45%). CV of production decreased in case of chilli and cumin by 2.86% and 4.62%, respectively, over the period.

The results of instability in area of major spices in the state and the country show that CV of area of different spices in the state varied from as low as 13.91% in chilli to as high as 41.65% in fennel during the pre-TMO period. Chilli registered considerable increase of 62.04% in its area instability in the post-TMO period. In case of cumin and coriander, the respective increases were 53.35% and 8.41%, respectively. As regards fennel and fenugreek, their area instability decreased by 3% to 4% over the period in the state. At all India level, amongst all the selected spices

which recorded positive changes in CV between pre-TMO and post-TMO periods, coriander with 75.74% change was the most unstable crop in terms of area instability. In rest of the crops the increase varied from 9.29% in fenugreek to 37.65% in garlic. Further, the magnitude of CV for area under different crops in the country was lower than that in the state during both the periods except fenugreek (Table 2b).

CV in respect of yield of each spice crop and period for the state of Rajasthan and India were also computed from the detrended series of yield. The per cent changes in CV between pre-TMO and post-TMO periods were also calculated. The magnitude of CV for yield of different spices at the state level varied from as low as 21.26% in fenugreek to as high as 26.19% in cumin during the pre-TMO period. The corresponding figures for the

**Table 2 b.** Coefficients of variation (per cent) for detrended area of spice crops in Rajasthan and India

Crop	Rajasthan			India		
	Pre-TMO period	Post-TMO period	% change between periods	Pre-TMO period	Post-TMO period	% change between periods
Chilli	13.91	22.54	62.04	4.64	6.01	29.53
Coriander	30.32	32.57	8.41	10.43	18.33	75.74
Cumin	33.29	51.05	53.35	18.50	23.31	26.00
Fennel	41.65	39.99	-3.99	28.62	37.68	31.66
Fenugreek	17.53	16.98	-3.14	30.77	33.63	9.29
Garlic	-	26.31	-	13.97	19.23	37.65

Pre-TMO period=1967-68 to 1985-86 for chilli and coriander; 1973-74 to 1985-86 for cumin, fennel and fenugreek in case of Rajasthan. For India, 1970-71 to 1985-86 for chilli and coriander and 1975-76 to 1985-86 for cumin, fennel, fenugreek and garlic; Post-TMO period=1986-87 to 2000-01

post-TMO period ranged from as low as 15.20% in case of fenugreek to as high as 28.52% in fennel. Except fennel, all other spices recorded decline in yield instability during the post-TMO period, the level of decline ranging from 14.37% to 30.00%.

At all India level the results were more or less similar to that of the state. However, the magnitude of instability in yield were considerably lower at the national level than that at the state level. The magnitude of CV for yield of different crops varied from as low as 5.55% in coriander to as high as 23.22% in garlic during pre-TMO period and from 7.54% to 16.93% during the post-TMO period with the crops remaining unchanged. Except coriander and fenugreek, all other spice crops witnessed decline in their yield instability during the post-TMO period over the pre-TMO period. The percentage of decline varied from 3.94% in fennel to 27.09% in garlic. Yield instability in case of coriander and fenugreek, on the other hand, increased by 35.86% and 39.00%, respectively (Table 2c).

#### *Sources of variance of production*

The results of sources of variance of production in major spices in Rajasthan and India indicated that area variances accounted for above 60% or more (up to 87.26 %) of total variance in production in respect of coriander, cumin and fennel in Rajasthan during the pre-TMO period. Further area-yield covariance was of smaller magnitude compared to yield variance. It is only in case of chilli and

fenugreek that yield variances (102.15% and 69.12%, respectively) dominated the area variances (29.01% and 47.01%, respectively) during the pre-TMO period. The area-yield covariances for these two crops turned out to be sizeably negative during the pre-TMO period indicating a stabilizing effect on fluctuation in their production brought about mainly by yield instability. In case of fennel also the area-yield covariance was of the order of -20.72% leading to stabilizing effect on fluctuation in its production caused mainly by area variance. So far as changes between the two periods are concerned there was considerable increase in the area variance of chilli, coriander and cumin and some increase in case of fenugreek during the post-TMO period over the pre-TMO period. As regards yield variance, chilli observed a sharp decrease from 102.15% during pre-TMO period to 46.44% during post-TMO period. Rest of the crops also witnessed severe to low fall in their yield variances during the post-TMO period (Table 3).

At the national level the yield variance accounted for 88.05% and 80.97% of total production variance in respect of chilli and garlic, respectively, during the pre-TMO period. Area-yield covariance turned out to be negative with 4.22% and 10.28% indicating low stabilising effect on fluctuation in their production brought about mainly by yield instability. In case of coriander, cumin, fennel and fenugreek, area variance dominated the yield variance. The magnitude of area vari-

**Table 2c.** Coefficients of variation (per cent) for detrended yield of spice crops in Rajasthan and India

Crop	Rajasthan			India		
	Pre-TMO period	Post-TMO period	% change between periods	Pre-TMO period	Post-TMO period	% change between periods
Chilli	26.09	22.34	-14.37	10.82	9.70	-10.35
Coriander	25.03	17.52	-30.00	5.55	7.54	35.86
Cumin	26.19	18.81	-28.18	14.59	11.60	-20.49
Fennel	25.79	28.52	10.59	14.98	14.39	-3.94
Fenugreek	21.26	15.20	-28.50	9.23	12.83	39.00
Garlic	-	18.99	-	23.22	16.93	-27.09

Pre-TMO period=1967-68 to 1985-86 for chilli and coriander; 1973-74 to 1985-86 for cumin, fennel and fenugreek in case of Rajasthan. For India, 1970-71 to 1985-86 for chilli and coriander and 1975-76 to 1985-86 for cumin, fennel, fenugreek and garlic; Post-TMO period=1986-87 to 2000-01



**Table 3.** Sources of variance (per cent) of production in spice crops in Rajasthan and India

Crops		Rajasthan			India		
		Area variance	Yield variance	Area-yield covariance	Area variance	Yield variance	Area-yield covariance
Chilli	Pre-TMO	29.01	102.15	-31.16	16.18	88.05	-4.22
	Post-TMO	47.27	46.44	6.29	28.00	72.78	-0.77
Coriander	Pre-TMO	59.69	40.69	-0.38	68.68	19.47	11.84
	Post-TMO	78.70	22.35	-1.05	75.34	12.75	11.91
Cumin	Pre-TMO	64.59	39.96	-4.56	59.90	37.27	2.83
	Post-TMO	91.98	12.48	-4.46	84.09	20.84	-4.93
Fennel	Pre-TMO	87.26	33.46	-20.72	87.51	23.98	-11.49
	Post-TMO	61.43	31.24	7.33	86.16	12.71	0.13
Fenugreek	Pre-TMO	47.01	69.12	-16.13	91.24	8.21	0.54
	Post-TMO	51.67	41.43	6.90	80.52	11.71	7.77
Garlic	Pre-TMO	-	-	-	29.32	80.97	-10.28
	Post-TMO	69.47	36.18	-5.64	47.54	36.83	15.63

Pre-TMO period=1967-68 to 1985-86 for chilli and coriander; 1973-74 to 1985-86 for cumin, fennel and fenugreek in case of Rajasthan. For India, 1970-71 to 1985-86 for chilli and coriander and 1975-76 to 1985-86 for cumin, fennel, fenugreek and garlic; Post-TMO period=1986-87 to 2000-01

ance for these crops varied from as low as 59.90% in cumin to as high as 91.24% in fenugreek. Area-yield covariance in case of coriander helped destabilize the production by 11.84% during the pre-TMO period. On the contrary, in case of fennel it helped stabilize production by 11.49% during the period. As regards changes between the two periods, area variance recorded considerable increase in case of chilli, coriander, cumin and garlic during post-TMO period over the pre-TMO period. In case of fenugreek, the area variance decreased over time whereas in fennel it was almost the same. So far as yield variance is concerned, except fenugreek, which recorded a marginal increase, all other spices recorded decrease in their yield variances during the post-TMO period over the pre-TMO period. In chilli, the yield variance decreased from 88.05% to 72.78% and in garlic from 80.97% to 36.83% over the period. In case of coriander, cumin, fennel and fenugreek, the yield variance accounted for 12.75%, 20.84%, 12.71% and 11.71%, respectively, of the total variance in production.

### Conclusions

Significant increase in production of coriander, cumin, chilli, fennel, fenugreek and garlic during the entire study period was due

to significant increase in the same during post-TMO period (1986-87 to 2000-01) indicating that TMO did not adversely affect the production of selected spices in Rajasthan and in India. The effect of area and yield in significantly increasing the production of the spices was not same in all the spices. In cumin and fennel, mainly area, whereas, in coriander, yield played a dominant role in increasing their production. In fenugreek, the increase in production was the result of increase in both area and yield. In chilli and garlic, both area and yield at the national level and only area at the state level played a significant role in increasing the production. Production instability and area instability increased during the post-TMO period over the pre-TMO period both at the state and national levels. However, a reverse trend was seen in the case of yield instability. This indicated that high growth rates in area and production of spices led to high instability in their area and production. Yield growth rates were negatively associated with yield instability. The contribution of area variance to total variance of production was high in case of coriander, cumin, fennel and garlic. Yield variance had a dominant role in destabilizing the production of chilli in the state and of fenugreek in India. Area-yield covariance helped stabilize the production in majority of the spice crops.

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