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Production Analysis: A Non-Parametric Time Series Application for Pulses in Rajasthan

Shirish Sharma and Swatantra Pratap Singh*

ICAR- National Institute of Agricultural Economics and Policy Research, New Delhi - 110 012, India

**Corresponding author*

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A B S T R A C T

In view of the importance of pulses in Indian dietary system and agriculture sector in state economy several attempts have been made to study the trends in area and production of pulses crops which reveal the growth performance. The secondary data were collected for area and production of pulses for the period of 1979–80 to 2011-12. The study period was classified as Pre WTO (World Trade Organization) era and Post WTO era. For the estimation of the trends in area and production and to measure the association in productivity we use Mann-Kendall test. In the present study correspondence analysis was applied to contingency table on different level of productivity with districts. It is evident from the findings that during first and second period of the study Nagaur, Swai Madhopur, Alwar, Banswara, Bharatpur, Chittoegarh, Jhalawar, Kota, sirohi and Udaipur districts were show negative trend in area for pulses. However for the first and second period Bundi, Chittorgarh, Dungarpur, Jhunjhunu, Bikaner, Jaisalmer and Nagaur districts found positive trend in production for pulses.

Introduction

Since the onset of the Green Revolution in the late 1960s, India has been treading on a path towards self-sufficiency in food. The achievements have remained highly skewed towards wheat and rice on account of technological as well as policy support towards these two crops. With high and assured prices paid through public procurement encouraging farmers to increase output, the production of cereals in India has generally been greater than the domestic demand since the mid-1990s. The per capita production of cereals has steadily increased in each decade from 145 kg during the 1970s to 158 kg during the 2000s. Meanwhile, Per capita production of pulses in India has declined from 18.5 kg during 1965-1970 to about 15 kg during 2011-2014. It touched the lowest level of 10.5 kg in year 2002-03. Even with imports, India has not able to meet the domestic demand for pulses. The per capita net availability of pulses in the country, after factoring in for imports and exports, has declined from 18.15 kg during 1965-70 to 15.4 kg during 2011-14. In India, pulses are mainly grown under rain-fed and low input compared to cereal crops (i.e., wheat, maize, rice, barley, sorghum and millet), Also, compared to cereal crops, pulse are grown in marginal areas where water is a scarce resource. Moreover, in our countries, because, pulses are considered as secondary crops, they do not receive investment resources and policy attention from governments, as do cereal crops (e.g., maize, rice, wheat), which are often considered food security crops and thus receive priority attention from the research and policy making communities (Byerlee and White, 2000). Consequently, the productivity of pulses is one of the lowest among staple crops.

Rajasthan, with a geographical area of 3.42 lakh sq. km. is the largest state of the country, covering 10.4 percent of the total geographical area of India and it accounts for 5.5 percent of the population of India. Agriculture plays an important role in Rajasthan economy. About 70 per cent of the total population depends on agriculture and allied activities for their livelihood and around 30 percent of the state income is generated by it. Agriculture in the state is essentially rain fed which is susceptible and vulnerable of the vagaries of the monsoon. The northwest region of the state comprising 61 percent of the total area is either desert or semi desert which absolutely depends on rains for crop pattern. In view of the importance of agriculture sector in state economy several attempts have been made to study the trends in area and production of pulses crops which reveal the growth performance. The normal statistical procedures are obtained as a measure of growth of output over the period of a series is to postulate a hypothetical function which would be adequately described the series of the outputs over time and to estimate its parameters which would offer a measure of growth of output over the period. The analysis of growth is usually used in economic studies to find out the trend of a particular variable over a period of time and used for making policy decisions. Fitting a trend to raw data and calculating coefficient of variation of residuals from the fitted trend apparently take note of the both the trend and fluctuations. Though, normally it may be an adequate procedure but it may not be workable when fluctuations are huge and frequent. This is because the estimation of trend is distorted by fluctuations and neither the trend nor the fluctuations derived here may adequately reflect the reality involved (Rao *et al.*, 1980). For this purpose, the study has been carried out to on for the years1979–80 to 2011-12. The paper is divided in two sections. It begins with an examination of growth and trend in area of cultivation and production of pulse crops in Rajasthan. And, secondly association of productivity of pulses across districts in Rajasthan.

Materials and Methods

Statistical tools and techniques

Type and sources of data

To study the growth, trend in area and production and association of productivity of pulses crops across districts in Rajasthan during pre and post WTO periods, a reliable source of secondary data is very essential to get the real picture. The study was based on secondary data. The time series data on area and production of pulses crop was available from 1979-80 onwards.

The period of study is 1979–80 to 2011-12 which is characterized by wider technology dissemination. The entire study was split into two sub periods. The sub period was framed as period I- 1979-80 to 1994-95, (pre WTO) period II- 1995-96 to 2011-12 (post WTO). Data used for the study was collected from various published sources, like Directorate of Economics & Statistics, Rajasthan and Revenue records of area, production and yield of crops.

Compound annual growth rates

The growth in the area and production under pulses were estimated using the compound growth function of the form:

$Y_t = ab^t e^{ut}$

Where, Y_t = Dependent variable in period t, a = Intercept, b = Regression coefficient= (1+g) t = Years and u_t = Disturbance term for the year t

The equation was transformed into log linear form for estimation purpose. The compound growth rate (g) in percentage was then computed using the relationship g = (10^b - 1)*100 (Veena, 1996).

Trend analysis

The distribution-free test for trend used in the present procedure is the Mann-Kendall test (Mann 1945 and Kendall 1975). This will detect presence of negative or positive trends in time series data set better than the Spearman's rho and have similar power (Yue *et al.*, 2002). This method is based on sign difference of random variables rather than their direct values therefore this method is less affected by outliers. Mann-Kendall test for trend coupled with the Sen's method for slope estimation used for identification and estimation of Trends.

Sen's slope

This test computes both the slope (i.e. linear rate of change) and intercept according to Sen's method (Hipel 1994). First, a set of linear slopes is calculated as follows:

$$d_k = \frac{X_j - X_i}{j - i}$$

for $(1 \leq i < j \leq n)$, where d is the slope, X denotes the variable, n is the number of data, and i, j are indices. Sen's slope is then calculated as the median from all slopes: b = Median d_k. The intercepts are computed for each time step t as given by

$a_t = X_t - b * t$

and the corresponding intercept is as well the median of all intercepts

Mann-Kendall statistic (S)

This method is also called as Kendall's Tau. Tau measures the strength of relationship between variable X and Y. In other words, Tau value tells about how X and Y are correlated. There are two advantages of using this test. First, it is a non parametric test and does not require the data to be normally distributed. Second, the test has low sensitivity to abrupt breaks due to inhomogeneous time series. According to this test, the null hypothesis H_0 assumes that there is no trend (the data is independent and randomly ordered) and this is tested against the alternative hypothesis H_1, which assumes that there is a trend.

The Mann-Kendall S Statistic is computed as follows:

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \text{sign}(T_j - T_i)$$

Sing $(T_j = T_i)$ = 1 if $T_j - T_i > 0$
0 if $T_j - T_i = 0$
-1 if $T_j - T_i < 0$

Where
T_j and T_i are the annual values in years j and i, j > i, respectively.
If n < 10, the value of |S| is compared directly to the theoretical distribution of S derived by Mann and Kendall.

For $n \geq 10$, the statistic S is approximately normally distributed with the mean and Variance as follows:

$E(S) = 0$

The variance (σ^2) for the S-statistic is defined by:

$$\sigma^2 = \frac{n(n-1)(2n+5) - \sum t_j(i)(i-1)(2i+5)}{18}$$

In which t_i denotes the number of ties to extent i. The summation term in the numerator is used only if the data series contains tied values. The standard test statistic Z_s is calculated as follows:

$Z_s = \frac{s-1}{\sigma}$ for S>0

0 for S=0

$\frac{s+1}{\sigma}$ for S<0

In order to consider the effect of autocorrelation, Hamed and Rao (1998) suggest a modified Mann-Kendall test, which calculates the autocorrelation between the ranks of the data after removing the apparent trend. The adjusted variance is given by:

$$\mathrm{Var}(S) = \frac{1}{18}[N(N-1)(2N+5)]\frac{N}{NS}$$

$$\frac{N}{NS} = 1 + \frac{2}{N(N-1)N-2}\sum_{i=1}^{p}(N-I)(N-i-1)(N-i-2)P_s(i)$$

Where, N = number of observations in the sample, NS = effective number of observations to account for autocorrelation in the data and P_s = autocorrelation between ranks of the observations for lag i, and p is the maximum time lag under consideration.

Correspondence analysis

Correspondence analysis is a graphical technique to show which rows or columns of a frequency table have similar patterns of counts. In the correspondence analysis plot, there is a point for each row and for each column. Use Correspondence Analysis when you have many levels, making it difficult to derive useful information from the mosaic plot. The row profile can be defined as the set of row wise rates, or in other words, the counts in a row divided by the total count for that row. If two rows have very similar row profiles, their points in the correspondence analysis plot are close together. Squared distances between row points are approximately proportional to Chi-square distances that test the homogeneity between the pair of rows.

Algebraic development of correspondence analysis

Let 'X' be a matrix, with elements X_{ij}. Which is represented as a table of I×J unsealed frequencies or counts. Here the number of rows I >J and assume that 'X' is of full column rank J. The rows and columns of the contingency table 'X' correspond to different categories of two different characteristics.

If 'n' is the total of the frequencies in the data matrix X. A matrix of proportion P = (P_{ij}) is constructed by dividing each element of X by number.

Hence,

$P_{ij} = \frac{x_{ij}}{n}$ $i = 1, 2,$ ---------, I

$P_{I,J} = \frac{1}{n}X_{I,J}$ $j = 1, 2,$ ---------, J

The matrix 'P' is called the 'correspondence matrix'. The vectors of row and column sums are defined as 'r' and 'c' respectively. Then, the diagonal matrices D_r and D_c with elements of 'r' and 'c' on the diagonals are formed. Then the elements r_i of D_r are

$$r_i = \sum_{j=l}^{J} P_{ij} = \sum_{j=l}^{J} \frac{x_{ij}}{n} \quad i = 1,2,------,I$$

And the elements of c_j of D_c are given by

$$c_j = \sum_{i=l}^{l} P_{ij} = \sum_{i=l}^{l} \frac{x_{ij}}{n} \quad j = 1,2,------,J$$

$D_r = diag(r_1, r_2, --------, r_I)$
$D_c = diag(c_1, c_2, ---------, c_J)$

The scaled version of the matrix is obtained by,

$$A = D_r^{-1/2}\,(p - \hat{p})D_c^{-1/2}$$

Where, $\hat{p} = rc^1$

$$D_r^{1/2} = diag\,(\sqrt{r_1}, \dots, \sqrt{r_I})$$
$$D_c^{1/2} = diag\,(\sqrt{c_1}, \dots, \sqrt{c_J})$$
$$D_r^{-1/2} = diag(\frac{1}{\sqrt{r_1}}, \dots, \frac{1}{\sqrt{r_I}})$$
$$D_c^{-1/2} = diag(\frac{1}{\sqrt{c_1}}, \dots, \frac{1}{\sqrt{c_J}})$$

Results and Discussion

Compound annual growth rate

Analyzing the growth rate trends in the agricultural area and production across space and time have remained issues of significant concern for researchers as well as policy makers. It has been argued that analysis of the growth rate trends help us to identifying the changing pattern of crops and land use pattern under different crop and rate of change in area and production of a crop and further help in designing the appropriate agricultural policy for the state. The compound annual growth rate in area and production of pulses crops during the period 1979-80 to 1995-96 and 1996-97 to 2011-2012 listed in table 1. In the first period area under pulses crops had showed highly negative growth rates in Nagaur district (-5.78%) followed by Jaipur and Bharatpur districts. During the second period area under crops showing highly positive growth rate in Nagaur (5.56%), followed by Barmer (5.13%) and Jalore districts (3.84%). In the first period table 1 show that Banswara district (3.15%) have highly positive growth rate followed by Jhalawar (2.86%). During the second period under pulses crops had showed highly positive Nagaur district of 4.01 per cent, followed by Jhunjhunu district of 3.43 per cent growth rate of production. If we see the state as a whole, growth rate of pulses are showed positivity growth in both under area and production (8.07&7.19) respectively. There are posivte changes in both area and production growth rate from first study to second study period. This change might also be due to the efforts of the research projects at the national and state level in improving productivity of pulses over years; availability of good quality seeds that minimize the incidence of soil borne diseases and availability of improved package of practices. Similar results were found by Acharya *et al.*, (2012) in their study.

Identification of trend in area and production

Area under pulses

The result established in the table 2 indicated the Tau statistic results from the Mann Kendall test for the pulses crop area of all districts. In the first period four district viz., Banswara, Bharatpur, Chittogarh and Jhalawar districts showing statistically significant increasing trend under cropped area. Further, only two districts namely Nagaur and Swai Madhopur districts had a statistically significant decreasing trend in area. In remaining districts, eight districts showing increasing trend as compared to twelve districts which showing decreasing trend in pulses area. In the first period (1979-80 to 1995-96) the analysis of trend in area of pulses indicates that four districts significant positive slope coefficients, which indicates increase in area at Banswara, Bharatpur, Chittorgarh and Jhalawar districts. In other hand significant negative slope coefficient at Nagaur and Swai Madhopur districts indicates decrease in area.

In the second stuady period (1996-97 to 2011-12) seven districts viz Ajmer, Bikaner, Jaisalmer, Jalore, Jodhpur, Nagaur and Pali showing statistically significantly increasing trend in area. Further, only eight districts Alwar, Banswara, Bharatpur, Chittorgarh, jhalawar, Kota, Sirohi and Udaipur had a statistically significant decreasing trend in area. In remaining district, five districts showing increasing trend as compared to six districts showing decreasing trend in pulses area. Ajmer, Bikaner, Jaisalmer, Jalore, Jodhpur, Nagaur and Pali show significant positively slope coefficients that is indicate increase in area. In case of Alwar, Banswara, Bharatpur, Chittorgarh, Jhalawar, Kota, Sirohi and Udaipur district showed decrease in area due to significant negative slope coefficients. The possible reason of increase in area in some pulses producing districts may be due to risk taking ability of farmers, i.e. low risk pulses vs high risk crops in other seasons and high market prices of produces in last some years. These results were conformity to the results of studies conducted by the Parathasarathy 1984.

Production of pulses

The result presented in the table 3 indicated the tau statistic results from the Mann Kendall test for the production of all districts for the study period.

In the first period four districts viz Bundi, Chittorgarh, Dungarpur and Jhunjhunu shows statistically significant increasing trend in production. Further, only two districts Bharatpur and Sawai Madhopur had a statistically significant decreasing trend in production. In remaining nineteen districts, ten districts showing increasing trend as a compared to nine districts showed decreasing trend in pulses production indicating non-significant for the first period. In this period the analysis of trend in production indicate increase in production at Bundi, Chittorgarh, Dungarpur and Jhunjhunu and Bharatpur and Swai Madhopur shows decreasing trend in production. During the second study period Bikaner, Jaisalmer, Jhunjhunu and kota districts showing statistically significant increasing trend and production. Further, five districts viz Alwar, Banswara, Bharatpur, chittorgarh and Kota had a statistically significant decreasing trend in production. In remaining seventeen districts, ten districts showed increasing trend as a compared to seven districts shows decreasing trend in pulses production indicating non-significant for the second period.

Correspondence analysis

The association between the different levels of crop yield and different districts, correspondence analysis is attempted in table 4. The chi-square test for independence indicated significant association between two kinds of classification.

The table 4 indicates the mass association and its inertia of each district and different level of pulses productivity. From the result, it is seen that 70.14 per cent and 78.15 per cent of association can be explained by dimension-1 in first and second period respectively. As a result all districts are equally contributed to the total inertia. The contribution is more in first period 0.052 Compare to second period 0.046. However, the medium productivity with mass 0.502 for first period and 0.471 for second period indicates greater contribution among all others. Further, the chi-square test reveals the statistical significance. The association between two kinds of classification of pulses is shown in Figure 1 and 2. Figure 1 shows that Kota, Bundi, Jhalawer, Sawai Madhopur and Ganganagar districts are tends to be associated with medium productivity and Jodhpur are associated with low productivity. Bharatpur district is tends to be associated with high productivity in first study period. In second study period Figure 2 indicate that Jhunjhunu district is trends to be associated with highest productivity. Sirohi district associated with lowest productivity, whenever Nagaur, Bhilwara and Pali are trends to be associated with medium productivity.

Table.1 Compound annual growth rates of area and production of major district of Rajasthan in India

District	Period-I (1979-80 to 1995-96)		Period-II (1996-97 to 2011-2012)	
	Area	Production	Area	Production
Ajmer	3.97	2.35	4.21*	3.38
Alwar	-5.50*	-5.11	-4.91*	-4.66*
Banswara	3.67*	3.15*	-4.60*	-4.18*
Barmer	3.43	-1.87	5.13*	2.91
Bharatpur	-5.57*	-5.42*	-4.43*	-4.64*
Bhilwara	3.38	2.29	4.10	3.54
Bikaner	5.58	3.24	5.55	3.84
Bundi	-3.86*	3.19	3.24	3.04
Chittogarh	3.93*	3.07	-4.80*	-4.32*
Churu	6.17	4.21	6.10	4.42
Dungarpur	3.17	2.46	-3.82*	-3.30
Ganganagar	-6.33	5.57	-6.08	-5.29
Jaipur	-5.60*	4.58	4.92	-4.46
Jaisalmer	6.50	-3.09	-1.49*	-2.19*
Jalore	3.52	2.23	3.84*	1.67
Jhalawar	3.66*	2.86*	-4.49*	-3.78
Jhunjhunu	-5.29*	3.25	4.83	3.43*
Jodhpur	-5.44	-2.77	5.27	3.16
Kota	4.73	4.12	-4.59*	-4.17*
Nagaur	-5.78*	-4.15	5.56*	4.01*
Pali	-3.80	-2.55	3.80*	2.97
Sawai Madhopur	-5.13*	-4.61	-4.41*	-4.24
Sikar	-5.18*	-3.58	4.88	3.90
Sirohi	-3.39	-1.92	-3.13*	-2.13
Tonk	-4.31	-3.50	4.19	-3.70
Udaipur	3.78	3.07	-4.22*	-3.60
Total	**-8.23**	**-7.20**	**8.07**	**7.19**

* Significant at 5% level of significance;

Table.2 Mann-Kendall trend results for area under pulses in Rajasthan

District	Period-I (1979-80 to 1995-96)				Period-II (1996-97 to 2011-2012)			
	Mann-Kendall's statistic (S)	S. E.	Mann-Kendall's statistic (S)	S. E.	Mann-Kendall's statistic (S)	S. E.	Mann-Kendall's statistic (S)	S. E.
Ajmer	-11.00	0.634	-0.046	-0.0476	99.00	1.413	4.095	0.4286*
Alwar	-87.00	1.577	-4.749	-0.3766	-155.00	0.832	-4.731	-0.6710*
Banswara	141.00	0.361	1.959	0.6104*	-161.00	0.345	-2.850	-0.6970*
Barmer	67.00	1.785	2.262	0.2900	87.00	1.632	5.584	0.3756
Bharatpur	-137.00	1.143	-5.866	0.5931*	-129.00	0.716	-2.738	-0.5584*
Bhilwara	35.00	0.286	0.447	0.1515	75.00	0.670	1.440	0.3247
Bikaner	45.00	1.634	1.115	0.1948	111.00	2.692	9.842	0.4805*
Bundi	-75.00	0.149	-0.364	-0.3247	29.00	0.424	0.421	0.1255
Chittogarh	102.00	0.885	2.712	0.4416*	-153.00	0.594	-3.654	-0.6623*
Churu	59.00	2.303	0.662	0.2554	25.00	5.862	4.015	0.1022
Dungarpur	59.00	0.259	0.404	0.2554	-82.00	0.272	-1.008	-0.3550
Ganganagar	15.00	3.871	-1.699	0.0649	-47.00	4.182	-6.871	-0.2035
Jaipur	-91.00	1.391	-5.139	-0.3939	-9.00	1.671	0.585	-0.0390
Jaisalmer	-8.00	0.007	-0.002	-0.0346	217.00	0.618	4.494	0.9394*
Jalore	3.00	0.820	-0.128	0.0130	153.00	0.643	4.533	0.6623*
Jhalawar	141.00	0.436	2.498	0.6104*	-113.00	0.522	-2.599	-0.4892*
Jhunjhunu	-90.00	1.345	-3.777	-0.3896	-1.00	1.291	-0.123	-0.0043
Jodhpur	-77.00	1.550	-2.971	-0.3333	101.00	1.981	3.084	0.4372*
Kota	57.00	0.525	0.762	0.2468	-161.00	0.535	-3.930	-0.6970*
Nagaur	-99.00	1.557	-5.125	-0.4286*	151.00	2.020	13.540	0.6537*
Pali	-15.00	0.648	-0.318	-0.0649	119.00	0.900	3.866	0.5152*
Sawai Madhopur	-149.00	0.664	-4.141	-0.6450*	-91.00	0.735	-2.366	-0.3939
Sikar	-85.00	0.927	-2.589	-0.3680	-1.00	0.765	-0.25	-0.0043
Sirohi	-3.00	0.370	-0.102	-0.0130	-103.00	0.145	-0.536	-0.4459*
Tonk	-91.00	0.374	-0.954	-0.3939	51.00	1.194	1.734	0.2208
Udaipur	-3.00	0.516	0.212	-0.0130	-107.00	0.415	-1.976	-0.4632*
Total	**-31.00**	**18.580**	**-24.937**	**-0.1342**	**39.00**	**24.061**	**23.824**	**0.1688**

* Significant at 5% level of significance

Table.3 Mann-Kendall trend results for production of pulses in Rajasthan

District	Period-I (1979-80 to 1995-96)				Period-II (1996-97 to 2011-2012)			
	Mann-Kendall's statistic (S)	S. E.	Mann-Kendall's statistic (S)	S. E.	Mann-Kendall's statistic (S)	S. E.	Mann-Kendall's statistic (S)	S. E.
Ajmer	19.00	0.468	0.251	0.0823	21.00	1.276	1.894	0.0909
Alwar	-33.00	2.349	-2.159	-0.1429	-109.00	1.025	-4.233	-0.4719*
Banswara	100.00	0.336	1.186	0.4338	-103.00	0.442	-2.126	-0.4459*
Barmer	-14.00	0.967	-0.470	-0.0606	27.00	2.290	1.818	0.1169
Bharatpur	-73.00	1.549	-4.486	-0.3160*	-111.00	1.252	-3.947	-0.4805*
Bhilwara	62.00	0.239	0.498	0.2684	9.00	0.804	0.510	0.0390
Bikaner	32.00	1.379	0.360	0.1385	115.00	2.189	8.188	0.4978*
Bundi	71.00	0.153	0.264	0.3087*	13.00	0.391	0.324	0.0563
Chittogarh	89.00	0.428	0.981	0.3904*	-117.00	0.691	-2.532	-0.5065*
Churu	11.00	1.613	1.279	0.0476	25.00	3.649	2.658	0.1082
Dungarpur	71.00	0.257	0.494	0.3074*	-45.00	0.418	-0.739	-0.1948
Ganganagar	35.00	3.843	2.807	0.1515	-7.00	3.453	-2.491	-0.0303
Jaipur	-31.00	1.318	-1.399	-0.1342	1.00	2.043	1.436	0.0043
Jaisalmer	24.00	0.002	0.002	0.1264	212.00	0.466	2.725	0.9177*
Jalore	-38.00	0.323	-0.434	-0.1645	73.00	0.781	2.358	0.3160
Jhalawar	91.00	0.297	0.915	0.3957	-39.00	0.492	-0.774	-0.1688
Jhunjhunu	9.00	1.140	0.252	0.0390*	107.00	1.266	3.419	0.4632*
Jodhpur	0.00	1.041	-0.109	0.00	33.00	1.693	2.449	0.1429
Kota	39.00	0.767	1.072	0.1688	-141.00	0.432	-2.514	-0.6104*
Nagaur	-55.00	1.169	-1.125	-0.2381	99.00	2.493	9.159	0.4286*
Pali	-25.00	0.355	-0.356	-0.1082	21.00	0.900	1.181	0.0909
Sawai Madhopur	-76.00	0.808	-1.862	-0.3297*	-57.00	1.024	-1.883	-0.2468
Sikar	-29.00	0.818	-0.432	-0.1255	59.00	1.293	1.665	0.2554
Sirohi	-11.00	0.147	-0.054	-0.0476	-31.00	0.266	-0.299	-0.1342
Tonk	-33.00	0.411	-0.352	-0.1429	-5.00	0.995	0.398	-0.0216
Udaipur	12.00	0.443	0.218	0.0519	-69.00	0.439	-1.017	-0.2987
Total	**-1.00**	**15.653**	**-2.658**	**-0.0043**	**15.00**	**24.070**	**17.624**	**0.0649**

* Significant at 5% level of significance

Table.4 Summary statistics for row and column points for Pulses in Rajasthan

Particulars/ Districts	Period-I (1979-80 to 1995-96)				Period-II (1996-97 to 2011-2012)			
	Mass	**Relative Inertia**	**Mass**	**Relative Inertia**	**Mass**	**Relative Inertia**	**Mass**	**Relative Inertia**
Ajmer	0.052	0.046	0.075	0.000	0.046	0.030	0.015	0.000
Alwar	0.052	0.053	0.053	0.000	0.046	0.019	0.014	0.000
Banswara	0.052	0.021	0.039	0.000	0.046	0.018	0.009	0.000
Bharatpur	0.052	0.036	0.041	0.000	0.046	0.108	0.033	0.000
Bhilwara	0.052	0.012	0.034	0.000	0.046	0.030	0.009	0.000
Bikaner	0.052	0.083	0.148	0.000	0.046	0.041	0.011	0.000
Bundi	0.052	0.033	0.046	0.000	0.046	0.045	0.014	0.000
Chittorgarh	0.052	0.028	0.053	0.000	0.046	0.017	0.013	0.000
Churu	0.052	0.029	0.086	0.000	0.046	0.049	0.013	0.000
Dungarpur	0.052	0.026	0.043	0.000	0.046	0.037	0.013	0.000
Ganganagar	0.052	0.017	0.035	0.000	0.046	0.021	0.010	0.000
Jaipur	0.052	0.008	0.028	0.000	0.046	0.034	0.015	0.000
Jhalawar	0.052	0.031	0.055	0.000	0.046	0.030	0.013	0.000
Jhunjhunu	0.052	0.079	0.112	0.000	0.046	0.056	0.011	0.000
Jodhpur	0.052	0.121	0.183	0.000	0.046	0.068	0.012	0.000
Kota	0.052	0.036	0.050	0.000	0.046	0.040	0.009	0.000
Nagaur	0.052	0.068	0.131	0.000	0.046	0.030	0.011	0.000
Pali	0.052	0.065	0.098	0.000	0.046	0.066	0.012	0.000
SawaiMadhopur	0.052	0.024	0.038	0.000	0.046	0.038	0.018	0.000
Sikar	0.052	0.069	0.107	0.000	0.046	0.038	0.015	0.000
Sirohi	0.052	0.059	0.098	0.000	0.046	0.116	0.011	0.000
Tonk	0.052	0.033	0.053	0.000	0.046	0.036	0.015	0.000
Udaipur	0.052	0.021	0.040	0.000	0.046	0.028	0.014	0.000
High	0.312	0.100	0.000	0.000	0.304	0.100	0.00	0.000
Medium	0.502	0.260	0.110	0.000	0.471	0.261	0.020	0.00
Low	0.189	0.670	0.312	0.000	0.208	0.706	0.089	0.00
	Singular value	**Principal inertia**	**Chi-Square**	**Percent**	**Singular value**	**Principal inertia**	**Chi-Square**	**Per cent**
Dim1	0.068	0.005	70.83	70.14	0.093	0.009	72.09	78.15
Dim2	0.045	0.002	75.37	29.8	0.049	0.002	70.75	21.48

Fig.1 Pulses perceptual map from correspondence analysis Period I (1979-80 to 1995-96)

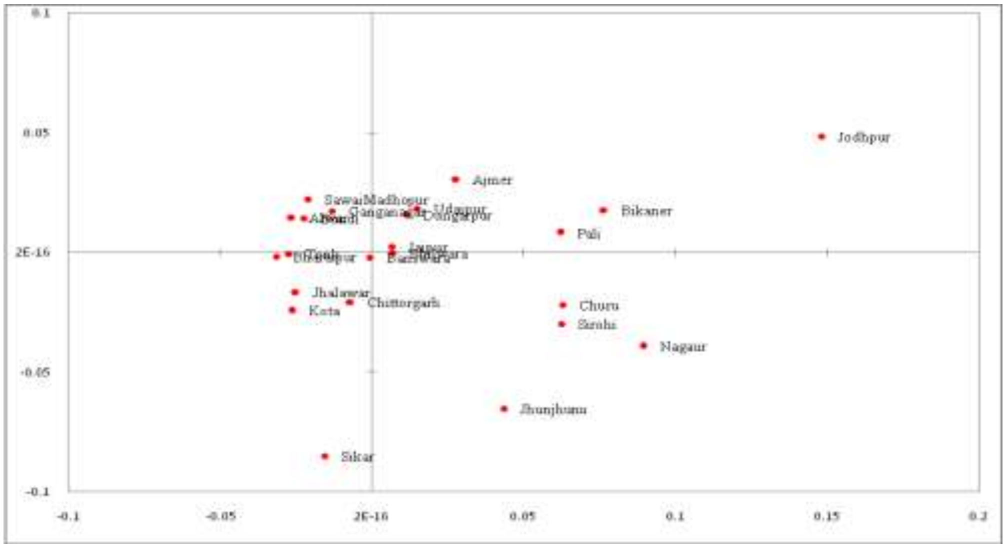
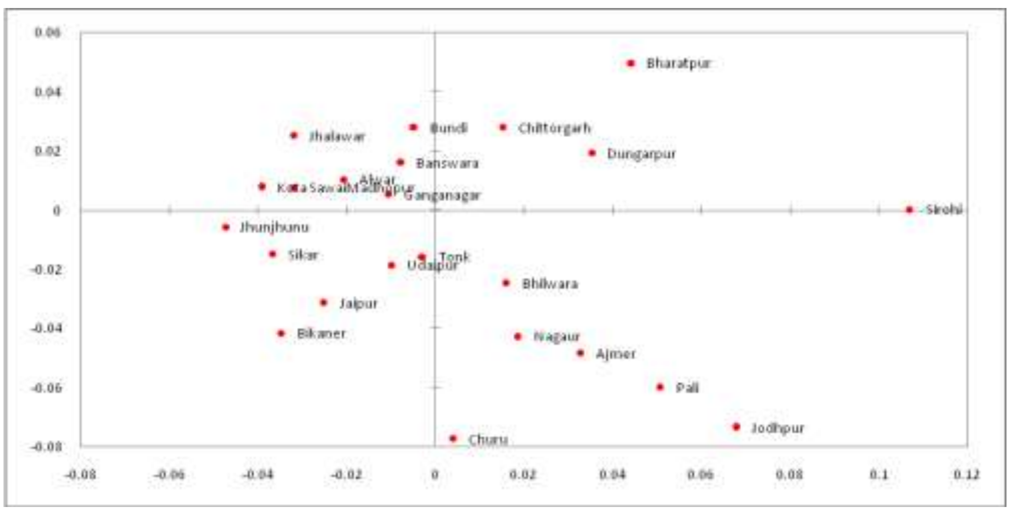


Fig.2 Pulses perceptual map from correspondence analysis Period II (1996-97 to 2011-12)



In conclusion this paper analyzed trends in annual precipitation in the Rajasthan state over the 32-year study period (1979–80 to 2011-12) which was divided as Pre and Post WTO. A mix of positive and negative trends was observed at various districts. In the first period only four districts shows statistically significant increasing trend in production. In the second steady period seven districts showing statistically significantly increasing trend in area. Further, only eight districts had a statistically significant decreasing trend in area. The possible reason of increase in area in some pulses producing districts may be due to risk taking ability of farmers, i.e. low risk pulses vs high risk crops in other seasons and high market prices/MSP of produces in last some years. Correspondence analysis shows that Kota, Bundi, Jhalawer, Sawai Madhopur and Ganganagar districts are tends to be associated with medium productivity and Jodhpur are associated with low productivity.

Bharatpur district is tends to be associated with high productivity in first study period. In second study period Figure 2 indicate that Jhunjhunu district is trends to be associated with highest productivity. The results obtained with the Mann-Kendall (MK) and Sen's tests showed agreement in their assessments of annual precipitation trends. The variability of negative and positive trends in various districts shows that there are needs for more detailed studies on the pluses crop of this state.

Policy implications

To improve yields, measures need to be taken to control pests and diseases, introduce better variety of seeds, no-till cultivation in rain-fed areas to retain moisture and soil fertility.

Supporting weather-based price insurance for pulses, the relevant insurance policy needs to be 'more effective' since the climate risks faced by farmers are very high with erratic rainfall that adversely impacts pulse cultivation.

With the view to inform farmers about the modern techniques of agriculture, publicize agriculture schemes in rural areas and to provide agriculture inputs to the farmers, camps are organized at the gram panchayat level before crop sowing season.

Keeping in view the conservation of water in the state, sprinkler, mini-sprinklers and drip irrigation schemes are promoted.

Government to procure all pulses at minimum support price not only moong and Urd.

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