

<https://doi.org/10.48047/AFJBS.6.14.2024.12579-12588>



African Journal of Biological Sciences

Journal homepage: <http://www.afjbs.com>



Research Paper

Open Access

## Assessment of Growth Rate and Instability of Pearl Millet in Selected States of India

Shiv Kumar Rana<sup>1</sup>, Manish Kumar\*<sup>1</sup>, Alok Kumar Singh<sup>2</sup>, R.R Kushwaha<sup>3</sup>,  
K.K. Maurya<sup>1</sup>, Gyan Prakash<sup>1</sup>

<sup>1</sup>Department of Agricultural Statistics, Acharya Narendra Deva University of Agriculture & Technology, Ayodhya, INDIA

<sup>2</sup>Department of Crop Physiology, Acharya Narendra Deva University of Agriculture & Technology, Ayodhya, INDIA

<sup>3</sup>Department of Agricultural Economics, Acharya Narendra Deva University of Agriculture & Technology, Ayodhya, INDIA

\*Corresponding author\* Email Address: [manishstats88@gmail.com](mailto:manishstats88@gmail.com)

Volume 6, Issue 14, Sep 2024

Received: 15 July 2024

Accepted: 25 Aug 2024

Published: 05 Sep 2024

doi: [10.48047/AFJBS.6.14.2024.12579-12588](https://doi.org/10.48047/AFJBS.6.14.2024.12579-12588)

### ABSTRACT

The present study deals with the statistical analysis of growth and instability in production, sown area, and yield of pearl millet in some specific states of India. The assessment is carried out using compound growth rate (CGR) and Cuddy-Della Valle (CDV) instability index for the time series data pertaining to the period 2007-2021. Furthermore, statistical coefficients viz. coefficient of variation (CV) and coefficient of determination ( $R^2$ ) have been evaluated for pearl millet production, area and yield in the concerned states. The values of  $R^2$  have been obtained on fitting linear models to the respective time series data for pearl millet in the concerned states.

**Keywords:** Coefficient of variation, Coefficient of determination, Instability index, Compound growth rate

## 1. INTRODUCTION

The agriculture sector is regarded as a significant sector for food security and for contributing towards the economic advancement of a nation. Pearl millet (*Pennisetum glaucum* L.), commonly known as bajra, belongs to Poaceae family and is one of the most significant staple food crop in India. The crop grows well in regions with adverse climatic conditions, and can be intercropped with other crops. It serves a dual purpose for consumption as a food grain and also fodder for livestock. Pearl millet is rich in nutritional composition and also has medicinal benefits, for instance, see Malik [1] and Balkrishna et al. [2].

India is the largest producer of pearl millet. In India, pearl millet is primarily grown in Rajasthan, Uttar Pradesh, Gujarat, Maharashtra and some other states as well. The leading state in the production of pearl millet was Rajasthan (3.75 million tons) during the year 2021-22, followed by Uttar Pradesh (1.95 million tons), Haryana (1.12 million tons), and Gujarat (1.06 million tons). In India, the total area under pearl millet cultivation was 6.70 million hectares with an overall production of 9.62 million tons. (Source: Directorate of Economics & Statistics, DAC&FW, Govt. of India [3]).

In the past few years, there has been a substantial increase in the production of food grains due to notable advancements in the agricultural sector and the emergence of high-yielding seed varieties. Bhargavi and Umesha C. [4] conducted a field experiment using randomized block design (RBD) to analyze the effect of plant growth regulators and zinc on growth and yield of pearl millet. Sreekala et al. [5] investigated the trend of millet production and consumption in India, and suggested measures for enhancing the production in short period through popularization of new varieties, expansion of certified seed distribution and improving crop management practices.

The time series analysis plays a crucial role for predicting the future growth and trend pattern of crops on the basis of existing trend, which is indispensable for food security and formulation of policy regarding management of inventory, fixation of price, and transportation of crops. Considering the given fact, various scientists and researchers utilized statistical models for trend analysis of crops. Nireesha et al. [6] analyzed the trends of area, production, and productivity of pearl millet in the state Andhra Pradesh of India, on applying linear, non-linear, ARIMA and exponential smoothing models. Handral and Sethy [7] examined the growth pattern

and instability in production and productivity of jowar and bajra crops on utilizing compound annual growth rate and coefficient of variation. Dharmaraja et al. [8] utilized linear regression and time-series models for prediction of crop yield in India. Gandhi et al. [9] forecasted the prices and production of pearl millet in the state Rajasthan of India, on using ARIMA and SARIMA models. Some other noteworthy works related to time series analysis of crops have been made by Patil and Yeledhalli [10], Arti and Rai [11], Joshi et al. [12], Kumar and Menon [13], Rana and Kumar [14] and Kumar et al. [15].

The time series analysis of crops has significant role for predicting the long-term trend of the crop, which is an essential requirement for attaining the global food demand, enhancing the agricultural productivity and policy formulation for import and export. Moreover, in recent years, the demand and consumption of pearl millet is increasing at a rapid rate. Hence, considering the given fact, an attempt has been made in the present paper is to analyze the growth rate and instability in production, area, and yield of pearl millet in some selected states of India. The analysis is carried out using statistical measures viz., compound growth rate (CGR) and Cuddy-Della Valle (CDV) instability index.

## **2. MATERIALS AND METHODS**

### **Source of Data**

The present study deals with the analysis of secondary time series data pertaining to the period (2007-2021) on pearl millet production, area and yield in some specific states of India. The time series data is obtained from the records of Directorate of Economics & Statistics, DAC&FW, Govt. of India.

### **Terminologies and Notations**

In the present analysis, three pearl millet growing states of India, viz. Uttar Pradesh (S1), Gujarat (S2) and Maharashtra (S3) are considered. These states exhibit significant variations in production, area and yield of pearl millet during the concerned period of study. These variations are measured using Cuddy-Della Valle (CDV) instability index, compound growth rate, and other statistical coefficients which are elaborated in the subsequent sections.

### **Statistical Coefficients and Measures**

#### **(a) Coefficient of Variation (CV)**

The coefficient of variation (CV) measures the relative variability in a dataset. A lower value of CV indicates consistency whereas a higher value of CV indicates irregularity (or inconsistency). The coefficient of variation (CV) is expressed as:

$$CV(Y) = \frac{SD(Y)}{\bar{Y}} \times 100,$$

Where, SD(Y) denotes the standard deviation of the variable Y (which may be either of area, production, or yield, as the case may be). Also,  $\bar{Y}$  denotes the mean value of the variable Y.

**(b) Instability Index**

The level of instability in production, area and yield of pearl millet for the states S1, S2 and S3 are measured using Cuddy-Della Valle instability index (*I*), which is mentioned below:

$$I = CV\sqrt{1 - R^2}$$

where  $R^2$  denotes the coefficient of determination, which is obtained on fitting linear model to the concerned time series data on production, area and yield of pearl millet in the concerned states. Also, CV represents the coefficient of variation.

**(c) Compound Growth Rate (CGR)**

The compound growth rate (CGR) in production, area and yield of pearl millet is obtained on using the following function:

$$y_t = a(1 + r)^t \dots\dots\dots (1)$$

where  $y_t$  is the observed value of production, area or yield (as the case may be) of pearl millet at time  $t$ . Also, ‘ $a$ ’ is a statistical constant, and ‘ $r$ ’ denotes the compound growth rate.

From (1), we have

$$\log y_t = \log a + t\{\log(1 + r)\}$$

$$i.e., Y_t = A + Rt \dots\dots\dots (2)$$

where  $Y_t = \log y_t$ ,  $A = \log a$ , and  $R = \log (1 + r)$ .

The normal equations for estimating ‘ $A$ ’ and ‘ $R$ ’ are:

$$\sum Y_t = nA + R \sum t \dots\dots\dots (3)$$

$$\sum tY_t = A \sum t + R \sum t^2 \dots\dots\dots (4)$$

Finally, on solving (3) and (4), the estimated values of ‘ $a$ ’ and ‘ $r$ ’ are obtained as follows:

$$\hat{a} = \text{antilog}(A)$$

$$\hat{r} = \text{antilog}(R) - 1$$

Here,  $\hat{r}$  denotes the compound growth rate (CGR), and is generally expressed in terms of percentage as follows:

$$\hat{r} = [\text{antilog}(R) - 1] \times 100$$

### 3. RESULTS AND DISCUSSION

The secondary time series data on production, area and yield of pearl millet in the states S1, S2 and S3 of India is elaborated in Table 1. The values of various statistical measures, i.e., mean, variance and standard deviation (SD), for production, area and yield of pearl millet in the states S1, S2 and S3 are summarized in Table 2. Moreover, the values of various statistical coefficients, i.e., coefficient of variation (CV), coefficient of determination ( $R^2$ ), and Cuddy-Della Valle instability index (I) for production, area and yield of pearl millet in the concerned states are elaborated in Table 3. The values of  $R^2$ , for production, area and yield of pearl millet, are measured by fitting a linear model to the time series data on pearl millet in the concerned states. Moreover, the compound growth rates (CGRs) for production, area and yield of pearl millet in the concerned states are computed and the findings are presented in Table 4.

**Table 1.** Time series data on production, area and yield of pearl millet in the selected states of India

Year	Production, area and yield of pearl millet in the states								
	S1			S2			S3		
	P	A	Y	P	A	Y	P	A	Y
2007	1.34	0.88	1520	1.31	0.92	1419	1.13	1.28	878
2008	1.30	0.81	1609	0.96	0.70	1365	0.66	0.87	765
2009	1.39	0.85	1638	0.83	0.67	1232	0.77	1.03	741
2010	1.56	0.94	1660	1.09	0.87	1253	1.12	1.04	1077
2011	1.63	0.89	1839	1.42	0.80	1771	0.84	0.84	1000
2012	1.76	0.90	1951	1.04	0.60	1743	0.50	0.79	637
2013	1.87	0.92	2033	1.21	0.69	1742	0.79	0.76	1034
2014	1.81	0.95	1899	0.77	0.46	1677	0.94	0.87	622
2015	1.78	0.98	1821	0.79	0.39	2004	0.33	0.80	416
2016	1.74	0.91	1914	0.93	0.43	2160	0.80	0.84	955
2017	1.79	0.93	1940	0.96	0.40	2430	0.67	0.79	849
2018	1.78	0.88	2029	0.83	0.40	2101	0.31	0.50	623
2019	1.94	0.92	2115	0.91	0.44	2098	0.51	0.67	761
2020	2.01	0.91	2221	1.01	0.46	2192	0.66	0.69	955
2021	1.95	0.90	2156	1.06	0.45	2368	0.48	0.53	903

**Note:** P = Production (in million tons), A = Area (in million hectares), Y = Yield (in Kg / hectare).

**Source:** Directorate of Economics & Statistics, DAC&FW, Govt. of India.

**Table 2.** Values of various statistical measures for production, area and yield of pearl millet

States	Production			Area			Yield		
	Mean	Variance	SD	Mean	Variance	SD	Mean	Variance	SD
S1	1.71	0.05	0.22	0.90	0.001	0.04	1889.67	44086.81	209.97
S2	1.01	0.04	0.19	0.58	0.03	0.18	1837	155826.6	394.80
S3	0.70	0.06	0.25	0.82	0.04	0.20	814.4	34198.83	184.93

**Table 3.** Values of various statistical coefficients for production, area and yield of pearl millet

States	Production			Area			Yield		
	CV	$R^2$	$I$	CV	$R^2$	$I$	CV	$R^2$	$I$
S1	13.00	0.81	5.70	4.53	0.17	4.14	11.11	0.83	4.53
S2	18.75	0.12	17.58	31.72	0.70	17.44	21.49	0.82	9.09
S3	35.76	0.36	28.53	23.99	0.70	13.15	22.71	0.01	22.65

The Table 3 exhibits the following results:

- (i). Among the states S1, S2 and S3, the instability in production, area and yield of pearl millet is observed to be the least in the state S1.
- (ii). The instability in production is observed to be the highest in the state S3 (i.e., 28.53 %) followed by the states S2 (i.e., 17.58 %), and S1 (i.e., 5.70 %). A similar pattern of instability is observed in the yield of pearl millet for the respective states.
- (iii). The instability in area under pearl millet cultivation is observed to be the highest in the state S2 (i.e., 17.44 %) followed by the state S3 (i.e., 13.15 %), and S1 (i.e., 4.14 %).

Hence, the production and yield of pearl millet in the state S3 is comparatively more instable as compared to the states S2 and S1. However, highest level of instability in area of pearl millet is revealed in the state S2 in comparison to the other states S3 and S1.

**Table 4.** CGR (in percentage) for production, area and yield of pearl millet

States	Compound Growth Rate (in percentage)		
	Production	Area	Yield
S1	2.77	0.43	2.34
S2	-1.29	-5.57	4.63
S3	-4.81	-4.42	-0.40

The Table 4 reveals the following results:

- (i) A significant growth rate in production of pearl millet is observed in the state S1. However, the state S2 recorded a significant growth in the yield of pearl millet. A positive and steady growth in area under pearl millet cultivation is observed in the state S1.
- (ii) In state S2, there is a rapid decline in area and a slight decline in production of pearl millet. Moreover, the state S3 witnessed a rapid decline in both production and area of pearl millet.
- (iii) The state S1 revealed a slight positive growth in the yield of pearl millet, whereas a slight negative growth in the yield is observed for the state S3.

#### 4. CONCLUSION

In the present paper, the assessment of growth rate and instability in production, area and yield of pearl millet in some pearl millet growing states of India, namely, Uttar Pradesh (S1), Gujarat (S2) and Maharashtra (S3). The analysis has been made by considering secondary time series data pertaining to the period 2007-2021.

The results of the analysis reveal that the state Uttar Pradesh exhibits a consistent trend pattern in production, area and yield of pearl millet as the values of coefficient of variation are observed to be the least for production, area and yield of pearl millet in the state Uttar Pradesh as compared to the other states, i.e., Gujarat and Maharashtra. Moreover, the instability in production as well as yield of pearl millet is observed to be the highest in the state Maharashtra, whereas the instability in area under pearl millet cultivation is observed to be highest in the state Gujarat.

The state Uttar Pradesh exhibits significant positive growth rates in production and yield of pearl millet, whereas it reveals a steady growth in area under pearl millet cultivation. Moreover, a rapid growth in the yield of pearl millet, and negative growth rates in production as well as area of pearl millet are observed in Gujarat. Furthermore, the state Maharashtra reveals negative growth in production, area, and yield of pearl millet.

The present study explores the scenario of growth rate and instability of pearl millet in the states Uttar Pradesh, Gujarat, and Maharashtra. The study could be extended further for some other states of India as well. Since pearl millet is a prominent staple food crop with a rich source of vital nutrients and a significant source for enhancing of farmers' income, hence the potential farmers could be motivated for its cultivation.

### **CONFLICT OF INTEREST**

The authors declare that they have no conflict of interest.

### **REFERENCES**

1. Malik S (2015) Pearl millet-nutritional value and medicinal uses. *International Journal of Advance Research and Innovative Ideas in Education* 1(3):414-418
2. Balkrishna A, Shankar R, Prajapati UB, Srivastava A, Joshi RA, Tripathi P (2024) A review on Bajra/ Pearl millet (*Cenchrus americanus* (L.) Morrone). *Journal of Scientific and Innovative Research* 13(1):1-8
3. Anonymous (2021). *Agricultural Statistics at a Glance*. Directorate of Economics & Statistics, DAC&FW, Govt. of India, New Delhi.
4. Bhargavi G, Umesha C (2024) Effect of plant growth regulators and zinc on growth and yield of pearl millet. *International Journal of Research in Agronomy* 7(3):22-25
5. Sreekala ADS, Anbukkani P, Singh A, Rao BD, Jha GK (2022) Millet production and consumption in India: where do we stand and where do we go? *National Academy Science Letters* 46(1):65-70
6. Nireesha V, Rao VS, Rao DVS, Reddy GR (2016) A study on forecasting of area, production and productivity of pearl millet in Andhra Pradesh. *J.Res. ANGRAU* 44(3&4):119-126

7. Handral AR, Sethy JP, (2017) Trends in production and productivity of Jowar and Bajra in India. *Internat. Res. J. Agric. Eco. & Stat* 8(2):243-249
8. Dharmaraja S, Jain V, Anjoy P, Chandra H (2020) Empirical analysis for crop yield forecasting in India. *Agricultural Research* 9:132-138.
9. Gandhi T, Saravanakumar V, Chandrakumar M, Divya K, Senthilnathan S (2023) Forecasting pearl millet production and prices in Rajasthan, India: An ARIMA approach. *International Journal of Statistics and Applied Mathematics* 8(5):307-314
10. Patil NA, Yeledhalli RA (2016) Growth and instability in area, production and productivity of different crops in Bengaluru division. *International Journal of Agriculture, Environment and Biotechnology* 9(4):599-611
11. Arti, Rai CK (2017) Growth rate of area, production and productivity of sugarcane crop in Uttar Pradesh. *Research Journal of Agricultural Sciences* 8(2):423-425
12. Joshi P, Gautam P, Wagle P (2021) Growth and instability analysis of major crops in Nepal. *Journal of Agriculture and Food Research* 6:1-6
13. Kumar M, Menon SV (2022) Statistical modeling and trend analysis of jackfruit production in the districts of Kerala in India. *International Journal of Agriculture, Environment and Biotechnology* 15(03):745-752
14. Rana SK, Kumar M (2022) Growth rate and instability analysis of sugarcane in selected states of India. *International Journal of Agriculture, Environment and Biotechnology* 15(4):837-843
15. Kumar M, Prakash G, Rana SK (2024) Statistical modeling for analysis of growth and trend pattern of wheat production in selected states of India. *Asian Journal of Research in Crop Science* 9(1):66-75