

International Journal of Agriculture Extension and Social Development

Volume 8; Issue 5; May 2025; Page No. 797-802

Received: 18-02-2025
Accepted: 26-03-2025

Indexed Journal
Peer Reviewed Journal

Assessment of growth rate and instability analysis of rice cultivation in some selected states of India

¹Sukhi Gowda KE, ¹Manish Kumar, ¹Gyan Prakash, ²Sandeep Gautam and ³Rajnish

¹Department of Agricultural Statistics, Acharya Narendra Deva University of Agriculture & Technology, Ayodhya, Uttar Pradesh, India

²Department of Agricultural Economics, Acharya Narendra Deva University of Agriculture & Technology, Ayodhya, Uttar Pradesh, India

³Department of Extension Education, Acharya Narendra Deva University of Agriculture & Technology, Collage of Agriculture Kotwa, Azamgarh, Uttar Pradesh, India

DOI: <https://www.doi.org/10.33545/26180723.2025.v8.i5k.1980>

Corresponding Author: Gyan Prakash

Abstract

In the present paper, the assessment of growth rate and instability analysis in production, area and yield of rice for some rice cultivating states of India. In the analysis, compound growth rate (CGR) and Cuddy-Della Valle (CDV) instability index are computed on utilizing secondary time series data on of rice regarding to the period 2011-2022 in the concerned states of India. The percentage change in production, area, and yield of rice is investigated by considering the base year as 2011. Moreover, the percentage share of production, area, and yield of rice for the year 2022 is displayed graphically.

Keywords: Compound growth rate. Instability index, percentage change, percentage share, coefficient of variation, coefficient of determination

1. Introduction

Rice (*Oryza sativa* L.) is an important and widely consumed staple food grain crop, which is rich in carbohydrates, and several other vital nutrients. It holds an eminent position in the diet of Indian subcontinent. Kumar *et al.* (2025)^[5]. It is most important and widely consumed staple food crop in the Poaceae family and its native is South India. is commonly grown in the foothills of the far Eastern Himalayas. Rice is rich in carbohydrates, source of protein and it contains various vitamins, such as thiamin, niacin and minerals. It is a highly nutritious cereal comprising of carbohydrate, protein, fiber and other vital nutrients. In India, it is mainly grown in kharif season. More than 80 percent of people in Asia eat rice. India is also the second largest producer and consumer of rice in the world. Sunandini *et al.* (2020)^[14].

India is the second-largest producer of rice in the world, after China with a production of 135.76million tons, area 47.83 million hectares and yield 2.84 tons/hectare of rice during the year 2022-23. Moreover, the largest producing state of rice in India was Uttar-Pradesh (16.14 million tons) during the concerned year followed by Telangana (15.88 million tons), West Bengal (15.48 million tons), Punjab (12.99 million tons), Chhattisgarh (9.81 million tons), Odisha (8.25 million tons) and Andhra Pradesh (7.94 million tons) during the concerned year (Source: Economics, Statistics and Evaluation Division, DA&FW, Govt. of India).

The largest area of rice in India was Uttar-Pradesh (5.90 million tons) during the year 2022-23, followed by West Bengal (5.07 million hectares), Telangana (4.66 million hectares), Odisha (4.06 million hectares), Chhattisgarh (3.77 million hectares), Punjab (3.10 million hectares), and Andhra Pradesh (2.13 million hectares) during the concerned year (Source: Economics, Statistics and Evaluation Division, DA&FW, Govt. of India).

The rice crop plays a vital role in global trade and significantly contributes to national economic growth. As a result, many scientists have concentrated their research efforts on studying rice cultivation. Lekshmi and Venkataramana (2020)^[7] conducted a study on the growth and instability of paddy cultivation in Kerala, focusing on area, production, and productivity. They employed an exponential growth model for forecasting purposes. Sunandini *et al.* (2020)^[14] analyzed the trends, growth patterns, and instability in the area, production, and productivity of rice in Andhra Pradesh. They applied the compound growth rate and coefficient of variation to calculate the annual growth rate and measure instability. Mishra *et al.* (2021)^[8] employed both simple ARIMA and ARIMAX models incorporating crop inputs into the ARIMA framework to forecast rice production. The ARIMAX model outperformed the simple ARIMA in terms of accuracy. The study highlighted future trends in rice production and identified key factors influencing

productivity. Nazir *et al.* (2021) ^[9] estimated rice yield at different phenological stages using hyper-temporal vegetation indices derived from time-series Sentinel-II satellite imagery. Various vegetation indices were employed to predict paddy yield, and the accuracy of the predictions was assessed using RMSE and MAPE statistical methods. Several other noteworthy contributions towards time series analysis of crops, other than rice have been made by Arti and Rai (2017) ^[2], Sanjay *et al.* (2018) ^[12], Kalidas *et al.* (2020) ^[3], Wasnik *et al.* (2022) ^[15], Singh *et al.* (2021) ^[13], Kumar and Menon (2022) ^[4], Rana and Kumar (2022) ^[11], Kumar *et al.* (2024) ^[6] and Prakash *et al.* (2025) ^[10].

In recent years, time series analysis of agricultural crops has become essential for examining long-term trends in harvest patterns and for shaping policies related to bulk storage, price setting, transportation, crop insurance, and food security. With this context in mind, the present paper aims to analyze the growth rate and variability in the production, area, and yield of rice in various states of India.

The objective of the present paper is to carry out comparative assessment of the instability and growth rate in production, area and yield of rice in India. The analysis is made by computing statistical measures viz., Cuddy-Della Valle (CDV) instability indices and compound growth rates (CGRs) concerning periods (2011-2022).

2. Data and methodology

2.1 Source of Data

For the objectives of present investigation secondary time series data on rice, belonging to the period 2011-12 to 2022-23, for the states of India are examined. The time series data is collected from the records of Economics, Statistics and Evaluation Division, DA&FW, Govt. of India.

2.2 Terminologies and Notations

In India. Also, in most of the states we observe various growth patterns of rice production, namely, increasing growth pattern, decreasing growth pattern, and constant growth pattern. For the present investigation, we have considered three rice producing states of India, viz. Punjab (S1), Andhra Pradesh (S2) and Uttar Pradesh (S3). In these states, the above-mentioned cases of growth pattern are observed.

2.3 Statistical Measures and Coefficients

a) Percentage change in Production, Area and Yield of Rice

1) Percentage change in production is obtained as follows:

$$\text{Percentage Change in Production} = \frac{\text{Production in CY} - \text{Production in BY}}{\text{Production in BY}} \times 100$$

2) Percentage change in area is obtained as follows:

$$\text{Percentage Change in Area} = \frac{\text{Area in CY} - \text{Area in BY}}{\text{Area in BY}} \times 100$$

3) Percentage change in yield is obtained as follows:

$$\text{Percentage Change in Yield} = \frac{\text{Yield in CY} - \text{Yield in BY}}{\text{Yield in BY}} \times 100$$

where CY represents the current year and BY represents the base year.

b) Percentage share of Production, Area, and yield of Rice in India

1) Percentage share of production in state S_i is obtained as follows:

$$\% \text{ share of production in } S_i = \frac{\text{Production in } S_i}{\text{Total production of all the states}} \times 100$$

2) Percentage share of area under cultivation in state S_i is obtained as follows:

$$\% \text{ share of area in } S_i = \frac{\text{Area in } S_i}{\text{Total area of all the states}} \times 100$$

3) Percentage share of yield in state S_i is obtained as follows:

$$\% \text{ share of yield in } S_i = \frac{\text{Yield in } S_i}{\text{Total yield of all the states}} \times 100$$

where $(i = 1, 2, \dots, 28)$ as the India consists of a total of 28 states.

c) Coefficient of Variation (CV)

The coefficient of variation (CV) is a standardized measure of dispersion, and is a unit free quantity. It is generally expressed in terms of percentage as follows:

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

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

d) Instability Index

The Cuddy-Della Valle (CDV) instability index is computed to measure the level of instability in production, area and yield of rice for the states S1, S2 and S3 of India. The instability index is obtained on using the following formula:

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

Where, R^2 represents the coefficient of determination, rice is obtained on fitting linear model to the concerned time series data on production, area and yield of rice for the respective states. Also, CV represents the coefficient of variation.

e) Compound Growth Rate (CGR)

The CGR in production, area and yield of rice is obtained on using the following formula:

$$y_t = y_0 (1 + r)^t$$

where,

y_t = observed value of production, area or yield of rice crops at time t .

y_0 = initial time series value of production, area or yield.

r = compound growth rate.

The compound growth rate (r) is generally expressed in terms of percentage as follows:

$$r = \left[\left(\frac{y_t}{y_0} \right)^{1/t} - 1 \right] \times 100$$

3. Data analysis and results

The secondary time series data on the production, area and yield of rice in states S1, S2, and S3 of India are demonstrated in Tables 1, 2, and 3 respectively. Moreover, the percentage change in production, area and yield of rice for the selected states of India are described in Tables 4, 5 and 6 respectively.

Table 1: Time series data on production of rice in selected states of India

Year	*Production (in million tons) for the states		
	S1	S2	S3
2011	10.54	12.90	14.02
2012	11.37	11.51	14.42
2013	11.27	12.72	14.64
2014	11.11	7.23	12.17
2015	11.82	7.49	12.50
2016	11.59	7.45	13.75
2017	13.28	8.17	13.27
2018	12.82	8.23	15.55
2019	11.78	8.66	15.52
2020	12.18	7.89	15.66
2021	12.89	7.76	15.27
2022	12.99	7.94	16.14

(*Source: Economics, Statistics and Evaluation Division, DA&FW, Govt. of India)

Table 2: Time series data on area under rice cultivation in selected states of India

Year	* Area under cultivation (in '000 hectares) of the states		
	S1	S2	S3
2011	2.82	4.10	5.95
2012	2.85	3.63	5.86
2013	2.85	4.36	5.98
2014	2.89	2.39	5.87
2015	2.98	2.16	5.86
2016	2.90	2.11	5.99
2017	3.07	2.16	5.81
2018	3.10	2.21	5.75
2019	2.92	2.30	5.74
2020	2.79	2.32	5.68
2021	2.97	2.29	5.70
2022	3.10	2.13	5.90

(*Source: Economics, Statistics and Evaluation Division, DA&FW, Govt. of India.)

Table 3: Time series data on yield of rice in selected states of India

Year	* Yield (in quintal/hectare) for the states		
	S1	S2	S3
2011	37.38	31.46	23.56
2012	39.98	31.73	24.60
2013	39.53	29.20	24.47
2014	38.38	30.22	20.72
2015	39.74	34.65	21.33
2016	39.98	35.40	22.95
2017	43.66	37.88	22.83
2018	41.32	37.29	27.04
2019	40.34	37.65	27.05
2020	43.66	33.95	27.59
2021	43.40	33.92	26.78
2022	41.93	37.30	27.37

(*Source: Economics, Statistics and Evaluation Division, DA&FW, Govt. of India.)

Table 4: Percentage change in rice production for selected states of India

Year	Percentage change (%) in production for the states		
	S1	S2	S3
2011	---	---	---
2012	7.87	-10.78	2.85
2013	6.93	-1.40	4.42
2014	5.41	-43.95	-13.20
2015	12.14	-41.94	-10.84
2016	9.96	-42.25	-1.93
2017	26.00	-36.67	-5.35
2018	21.63	-36.20	10.91
2019	11.76	-32.87	10.70
2020	15.56	-38.84	11.70
2021	22.30	-39.84	8.92
2022	23.24	-38.45	15.12

Table 5: Percentage change in area under rice cultivation for selected states of India

Year	Percentage change (%) in area for the states		
	S1	S2	S3
2011	---	---	---
2012	1.06	-11.46	-1.51
2013	1.06	6.34	0.50
2014	2.48	-41.71	-1.34
2015	5.67	-47.32	-1.51
2016	2.84	-48.54	0.67
2017	8.87	-47.32	-2.35
2018	9.93	-46.10	-3.36
2019	3.55	-43.90	-3.53
2020	-1.06	-43.41	-4.54
2021	5.32	-44.15	-4.20
2022	9.93	-48.05	-0.84

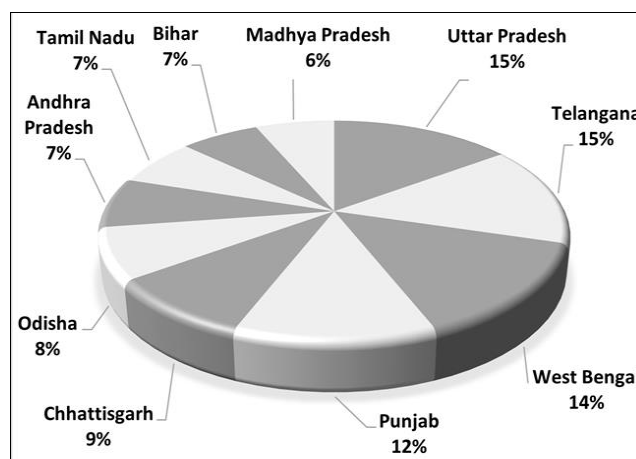
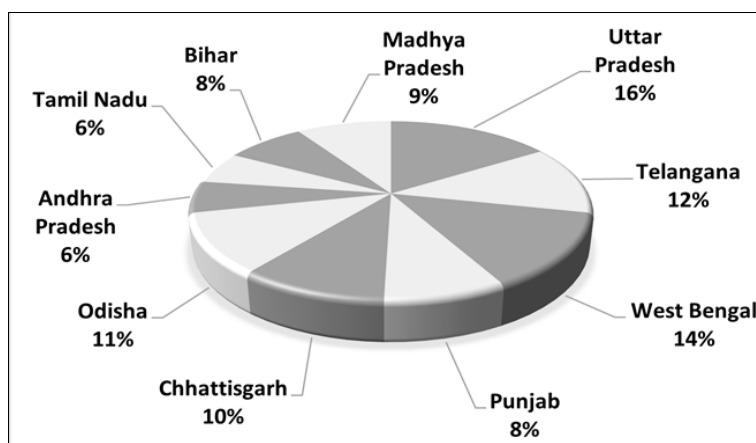
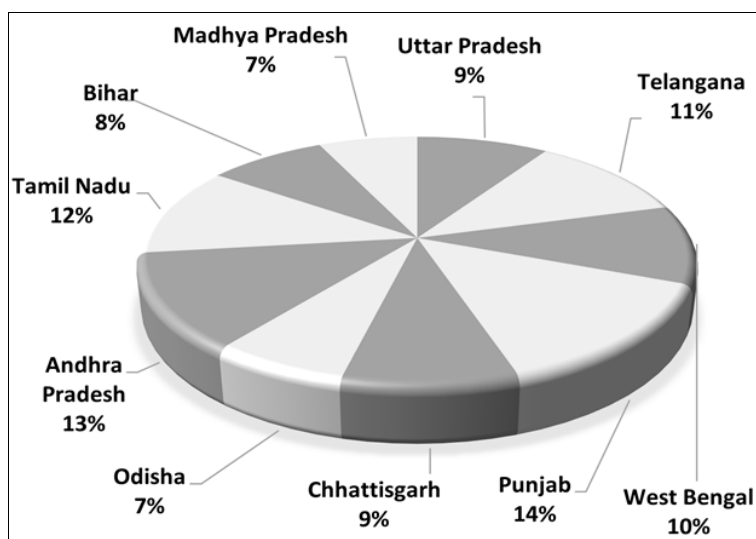
Table 6: Percentage change in rice yield for selected states of India

Year	Percentage change (%) in yield for the states		
	S1	S2	S3
2011	---	---	---
2012	6.96	0.86	4.41
2013	5.75	-7.18	3.86
2014	2.68	-3.94	-12.05
2015	6.31	10.14	-9.47
2016	6.96	12.52	-2.59
2017	16.80	20.41	-3.10
2018	10.54	18.53	14.77
2019	7.92	19.68	14.81
2020	16.80	7.91	17.11
2021	16.10	7.82	13.67
2022	12.17	18.56	16.17

It is observed from Table 4, 5, 6, it is revealed that for the year 2022, the percentage change in production of rice is more for the state S1 (i.e., 23.24%) as compared to the state S3 (i.e., 15.12%). However, the percentage change in production is negatively high for the state S2 (i.e., -38.45%). Moreover, the percentage change in area under rice cultivation is positively for the state S1 (i.e., 9.93%), However, the percentage change in area is negatively high for the state S2 (i.e., - 48.05%) and S1 (i.e., - 0.84%). However, the percentage change in area is negatively high

for the state S2 (i.e., - 48.05%) and S1 (i.e., - 0.84%). From Table 6, it is revealed that for the year 2022, the percentage change in yield of rice is more for the state S2 (i.e., 18.56%) as compared to the states S3 (i.e., 16.17%) and S1 (i.e., 12.17%).

The percentage share of production, area and yield of rice for the year 2022 in various rice producing states of India are depicted graphically in Figures 1, 2, and 3 respectively.

**Fig 1:** Percentage (%) share of rice production in the year 2022**Fig 2:** Percentage (%) share of rice area in the year 2022**Fig 3:** Percentage (%) share of rice yield in the year 2022

From Fig. 1, it is observed that the state Uttar Pradesh (S3), and Telangana exhibits highest percentage share for rice production (i.e., 15%), followed by West Bengal (i.e., 14%), Punjab (S1) (i.e., 12%), Chhattisgarh (i.e., 9%), Odisha (i.e., 8%), Andhra Pradesh (S3), Tamil Nadu, Bihar (i.e., 7%), and Madhya Pradesh exhibit the least percentage share for rice production (i.e., 6%). From Fig. 2, it is observed that the state Uttar Pradesh (S3) exhibits the highest percentage share for area under rice cultivation (i.e., 16%), followed by West Bengal (i.e., 14%), Telangana (i.e., 12%), Odisha (i.e., 11%), Chhattisgarh (i.e., 10%), Madhya Pradesh (i.e., 9%),

Punjab (S1) (i.e., 8%) and Andhra Pradesh (S2), exhibit the least percentage share for area of rice (i.e., 6%). From Fig. 3, it is revealed that the state Punjab (S1) exhibits the highest percentage share for rice yield (i.e., 14%) as compared to the other states, whereas the least percentage share for rice yield is observed in the state Madhya Pradesh and Odisha (i.e., 7%).

The values of various statistical measures, i.e., mean, variance and standard deviation (SD), for production, area and yield of rice in the state S1, S2, and S3 of India, are summarized in Table 7.

Table 7: Values of various statistical measures for production, area and yield of rice in the selected states of India

States	Production			Area			Yield		
	Mean	Variance	SD	Mean	Variance	SD	Mean	Variance	SD
S1	11.97	0.75	0.86	2.94	0.01	0.11	40.78	4.23	2.06
S2	9.00	4.40	2.10	2.68	0.69	0.83	34.22	9.17	3.02
S3	14.15	1.68	1.29	5.84	0.01	0.11	24.69	5.99	2.45

The values of several 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 rice in the concerned states are summarized in the Table 8. In order to calculate the values of R^2 for production, area and yield of rice in the concerned states, a cubic model is fitted to the time series data on rice.

Table 8: Values of various statistical coefficients for production, area and yield of rice in the selected states of India

States	Production			Area			Yield		
	CV	R^2	I	CV	R^2	I	CV	R^2	I
S1	7.22	0.67	4.13	3.67	0.35	2.95	5.04	0.64	3.03
S2	24.32	0.73	12.67	32.01	32.01	15.24	9.34	9.34	2.74
S3	8.82	0.60	5.58	1.80	0.72	1.14	9.94	0.70	5.43

The compound growth rates (CGRs) for production, area and yield of rice in the concerned states of India, are computed and the findings are presented in Table 9.

Table 9: CGR (in percentage) for production, area and yield of rice in selected states of India

States	Production	Area	Yield
S1	1.92	0.86	1.05
S2	- 4.32	- 5.78	1.56
S3	1.29	- 0.08	1.37

From Table 9, we conclude that:

1. In state S1, there is a steady growth in production and yield of rice during the period 2011-2022. Furthermore, a slight growth in the area under rice cultivation has been observed.
2. In state S2, there is a rapid decline in production and area under rice cultivation, and a steady growth in the yield of rice has been observed.
3. In state S3, a slight decline in area under cultivation has been observed, whereas a steady growth in production and yield has been observed.

4. Conclusion

In the present paper, the assessment of growth rate and instability in production, area, and yield of rice is carried out

for some rice growing states S1 (Punjab), S2 (Andhra Pradesh), and S3 (Uttar Pradesh) of India is considered. The secondary time series data pertaining to the period 2011-2022 is considered for the study.

The percentage change in production, area and yield of rice has been evaluated, by considering the base year as 2011. It is revealed from Section 3 that among all the three states, the percentage change in production, and area of rice is positively high for the state Punjab. Moreover, the percentage change yield of rice is positively high for the state Punjab, Andhra Pradesh in the year 2022.

The percentage share of production, area and yield of rice for the year 2022 in various rice growing states of India are elaborated in Section 3. It is revealed that among all the three considered states, the percentage share of production and area of rice is highest in the state Uttar Pradesh, followed by the states Punjab and Andhra Pradesh. Moreover, the percentage share of yield of rice is highest in the state Punjab, followed by the states Andhra Pradesh and Uttar Pradesh.

The level of instability in production, area and yield of rice is measured for the concerned states by using Cuddy-Della Valle (CDV) instability index. It is observed from the results of Section 3 that the production of rice in the state Andhra Pradesh is comparatively more instable as compared to the states Uttar Pradesh and Punjab. Moreover, the area of rice in the state Andhra Pradesh is comparatively more instable as compared to the states Punjab and Uttar Pradesh. However, the yield of rice in the state Uttar Pradesh is comparatively more instable as compared to the states Punjab and Andhra Pradesh.

In Section 3, the compound growth rates (CGRs) in production, area and yield of rice are examined for the states considered under study. It is revealed that for state Punjab, the compound growth rates (CGRs) for production, area and yield are positive. Moreover, the state Andhra Pradesh, the compound growth rates (CGRs) for yield is positive, whereas there is a negative growth rate in area and production under rice cultivation. However, the state Uttar Pradesh, the compound growth rates (CGRs) for production and yield of rice are positive, whereas there is a negative growth rate in area under rice cultivation.

The findings of the study provide important information on

the growth rate scenario of rice in Punjab, Andhra Pradesh and Uttar Pradesh. The study can be further extended to some other states of India. Since rice occupies a prominent place in the human diet and has nutritional benefits, potential farmers can maximize their income through rice cultivation as well as integrated farming practices.

5. References

1. Anonymous. Agricultural Statistics at a Glance. Economics, Statistics and Evaluation (ESE) Division, DA&FW, Govt. of India. 2023.
2. Arti, Rai CK. Growth rate of area, production and productivity of sugarcane crop in Uttar Pradesh. *Res J Agric Sci*. 2017;8(2):423-5.
3. Kalidas K, Mahendran K, Akila K. Growth, Instability and Decomposition Analysis of Coconut in India and Tamil Nadu, Western Tamil Nadu, India: A Time Series Comparative Approach. *J Econ Manag Trade*. 2020;26(3):59-66.
4. Kumar M, Menon SV. Statistical modeling and trend analysis of jackfruit production in the districts of Kerala in India. *Int J Agric Environ Biotechnol*. 2022;15(3):745-52.
5. Kumar M, Gowda KES, Prakash G, Menon SV. Assessment of Trend Pattern of Rice Production in Some Rice Growing States of India. *J Exp Agric Int*. 2025;47(1):582-91.
6. Kumar M, Prakash G, Rana SK. Statistical Modeling for Analysis of Growth and Trend Pattern of Wheat Production in Selected States of India. *Asian J Res Crop Sci*. 2024;9(1):66-75.
7. Lekshmi UD, Venkataramana MN. Growth and Instability Analysis of Area, Production and Productivity of Paddy in Kerala, with Special Reference to The Kerala Conservation of Paddy Land and Wetland Act, 2008. *Int J Agric Environ Biotechnol*. 2020;13(1):93-8.
8. Mishra P, Sahu PK, Devi M, Fatih C, Williams AJ. Forecasting of Rice Production using the Meteorological Factor in Major States in India and its Role in Food Security. 2021;51-62.
9. Nazir A, Ullah S, Saqib ZA, Abbas A, Ali A, Iqbal MS, *et al*. Estimation and forecasting of rice yield using phenology-based algorithm and linear regression model on sentinel-ii satellite data. *Agriculture*. 2021;11(10):1026.
10. Prakash G, Kumar M, Rana SK, Gowda KES. A statistical approach for assessment of growth rate and instability of wheat in selected states of India. *J Mod Appl Stat Methods*. 2025;24(1):76-89.
11. Rana SK, Kumar M. Growth rate and instability analysis of sugarcane in selected states of India. *Int J Agric Environ Biotechnol*. 2022;15(4):837-43.
12. Sanjay, Seidu M, Kundu KK. Growth and Instability in Cotton Cultivation in Northern India. *Econ Aff*. 2018;63(2):443-40.
13. Singh B, Sharma P, Arya CK, Singh A, Kumar J. Spatial growth and instability analysis of area, production and yield of sugarcane in India. *Econ Aff*. 2021;66(2):245-52.
14. Sunandini GP, Paul K, Irugu SD. Analysis of Trends, Growth and Instability in Rice Production in Andhra Pradesh. *Curr J Appl Sci Technol*. 2020;39(42):40-6.
15. Wasnik SB, Suryawanshi SN, Pandey S. Economics of growth performance, instability and decomposition analysis of tobacco in India. *Econ Aff*. 2022;67(2):87-94.