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Statistical Study on Growth and Instability of Area, Production and Productivity of Selected Cereal, Millet and Oilseed Crop of Odisha

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ABSTRACT

Background : The growth rate in agriculture refers to the increase in agricultural productivity over a specific period of time where as Instability is the fluctuations and uncertainties in various factors that affect the agricultural sector which creates major challenges for farmers and the farming industry. The present study is conducted to examine the growth and instability in area, production and productivity of selected cereal, millet and oilseed crop of Odisha.

Methods: The whole study period is divided into two subperiod, period I (1970-71 to 1994-95) and Period II (1995-96 to 2019-20). The Cuddy Della Valle Instability Index (CDVI), Coppock's Instability Index (CII) and coefficient of variation (CV) are used to measure the instability in the area, production and productivity of maize, jowar and sesamum. Whereas the compound annual growth rate (CAGR) is used to measure the growth rates.

Result: For whole study period, the CAGR showed a rise in the area and production of both sesame and maize over time. Highest value of CAGR is found in maize production for both the period- I and period-II. The CAGR for the productivity of jowar is found to be significantly negative for the whole period. The largest value of the Cuddy Della Valle volatility Index was observed in maize productivity, indicating the higher degree of instability.maximum instability observed in production of maize due to the lowest value of CII and CV. Productivity of jowar is found to be more stable and consistent followed by the productivity of sesame due to the lowest value of the coefficient of variation.

Key words: CAGR, CII, CV, Growth, Instability.

INTRODUCTION

The primary industry for the people of Odisha is agriculture. The importance of agriculture to Odisha's economy may be seen in the 15% of GDP that it contributes to the state's revenue. Approximately 60% of the State's workforce finds employment in agriculture, in addition to providing food for the populace. Approximately 70% of people in our population work in agriculture either directly or indirectly. Numerous obstacles, such as weather variations and natural disasters, result in significant losses in agricultural yield in the state leads to decrease in growth rates and more instability (Dash *et al.,* 2017).

In this study, we have considered the important cereal crop (maize), millet (jowar or sorghum), oil seed crop (sesamum) for the growth and instability analysis. As the above mentioned crop are grown in large areas in the state of Odisha and contribute a lot to the State Agricultural production (Five decades of Odisha Agriculture Statistics 2020). The growth rate in agriculture refers to the increase or improvement in agricultural productivity over a specific period of time. It is a crucial metric that measures the pace at which agricultural output, such as crop yields or livestock production, is expanding (Rajanbabu *et al.,* 2022; Singh *et al.,* 2015). The importance of growth rate in agriculture can be understood through several key aspects like food security and environmental sustainability. Instability in agriculture refers to fluctuations and uncertainties in various factors that affect the agricultural sector, such as climate conditions, market prices, input costs and policy changes (Buragohain and Borah, 2022; Dhaka *et al.,* 2019). While instability can pose challenges for farmers and the agricultural industry as a whole, it is also important to understand its significance. Instability is important for risk management, economic implications, environmental consideration and food security (Bhalla and Singh, 2009; Dudhat *et al.,* 2021). The major producing district of maize, jowar and Sesame are highlighted and presented in Fig 1.

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MATERIALS AND METHODS

Data sources

The area, production and productivity data of the selected crop such as maize, jowar and sesame from 1970-71 to 2019-20 has been collected from Department of Agriculture and Food Production, Govt of Odisha (Odisha Agriculture Statistics). The research has been carried out in Department of Agricultural Statistics, Institute of Agriculture (Palli Siksha Bhavana), Visva-Bharati, Sriniketan. The year of experiment is from 2021-24. The secondary data from 1970-71 and 2019-20 has been used for the research purpose.

Compound annual growth rate (CAGR)

Data on the area, productivityand production were computed by fitting the exponential functions. The following formula was used to compute the CAGR for Period I (1970–71 to 1994-95), Period II (1995–96 to 2019–20)and the entire period (1970–71 to 2019–20).

$$Y_t = ab^t$$

Whereas,
Y_t = Crop area/prod/productivity.
t = Time (1, 2, 3,... n).
Intercept (a) and regression coefficient (b)

$$\ln Y_t = \ln a + \ln b$$

$$Y_t^1 = A^1 + B^1 t$$

$$A = (\sum_{t=1}^{n} Y_t^1 - B.\sum_{t=1}^{n} t)/n$$

$$\text{Given } \ln a = A^1,\ a = e^{A1}$$

$$\ln b = B^1,\ b = e\ B^1$$

Then, compound annual growth rate (CAGR) = (b-1) ×100 or (antilog B-1)×100 (Dash *et al* 2017) (Dhakre and Sharma, 2010).

The significance of the average growth rate for the different periods and for the whole period is tested by using student's t-statistic.

The null hypothesis H_0: GR = 0
Alternate hypothesis H_1: GR ≠ 0

$$\text{Test Statistic } (t) = \frac{GR}{SE\ (GR)}, \text{ which follows a t-distribution}$$

with (n-2) d.f.
Where,
n= No. of observations.

$$\text{S.E. (CAGR)} = \frac{\ln(b) \times SE(\ln b)}{\ln 10}$$

To test the significance of difference of growth rate in two periods we used t- test.
The null hypothesis H_0: ΔGR = 0 is tested against the Alternate hypothesis H_1: ΔGR ≠ 0

$$\text{Test statistics } (t) = \frac{\Delta GR}{SE\ (\Delta GR)}$$

If the calculated value of t is greater than or equal to tabulated value of at α level of significance and $n_1 + n_2 - 2$ degree of freedom, then t is consider to be significant otherwise non significant. Where, n_1 and n_2 are the number of observations in period I and II respectively (Kumar *et al.,* 2018; Mathew, 2020).

Cuddy della valle instability index (CDVI)

The instability in the area, production and productivity of the different crops was examined by using the Cuddy-Della valle instability index, which was given by John Cuddy and Della Valle in 1978. (Cuddy and Della Valle, 1978) This index is referred to be the best measure to find the instability in agricultural production (Dash and Prusty, 2020).

$$CDVI = CV \times \sqrt{1 - Adj\ R^2}$$

Where,
CV= Coefficient of variation (SD/Mean)×100.
R^2= Coefficient of determination from a time trend regression adjusted for its degree of freedom.

$$\text{Adjusted } R^2 = 1 - (1 - R^2) \times \left(\frac{(n-1)}{(n-p)}\right)$$

Where,
n= No. of observations.
p= No. of parameters observed in the model.

The ranges of CDVI are given as follows (Rakesh Sihmar, 2014):
Low instability= 0-15.
Medium instability= 15-30.
High instability= More than 30.

Coppock's instability index (CII)

It is a close approximation of the average year to year percentage variation adjusted for trend and the advantages is that it measures the instability in relation to the trend of area, production and productivity (Dash *et al.,* 2017).

$$CII = \text{Antilog } (\sqrt{\log V} - 1) \times 100$$

$$(\log V = \sqrt[2]{\left(\sum_{t=1}^{n} \log \frac{X_{t+1}}{X_t} - m\right)}$$

Where ,
log V= log variance.

$$m = \sum_{t=1}^{n} \log \frac{X_{t+1}}{X_t}$$

x= Area/production/productivity.
m= Mean value of successive differences of log values (Anjum and Madhulika, 2018).

Coefficient of variations (CV)

It is one of the simplest measures of instability, usually it overestimates the instability level in long-term time series data (Prajnesu, 2005).

$$CV\ (\%) = \frac{\text{Standard deviation}}{\text{Mean}} \times 100$$

RESULTS AND DISCUSSION

The compound growth rates were estimated to examine the changes in area, production and productivity of given crops in Odisha. From the Table 1, it has been found that the CAGR for area, production and productivity of maize for the whole period is positive, where as negative growth rate is found in area, production and productivity jowar. The CAGR for the productivity of jowar is significantly negative at 1% level of significance. Significantly positive growth rate found in area under sesame but its productivity shows significantly negative trend at 1% level of significance for whole period. In both Period-I and II, CAGR of production of

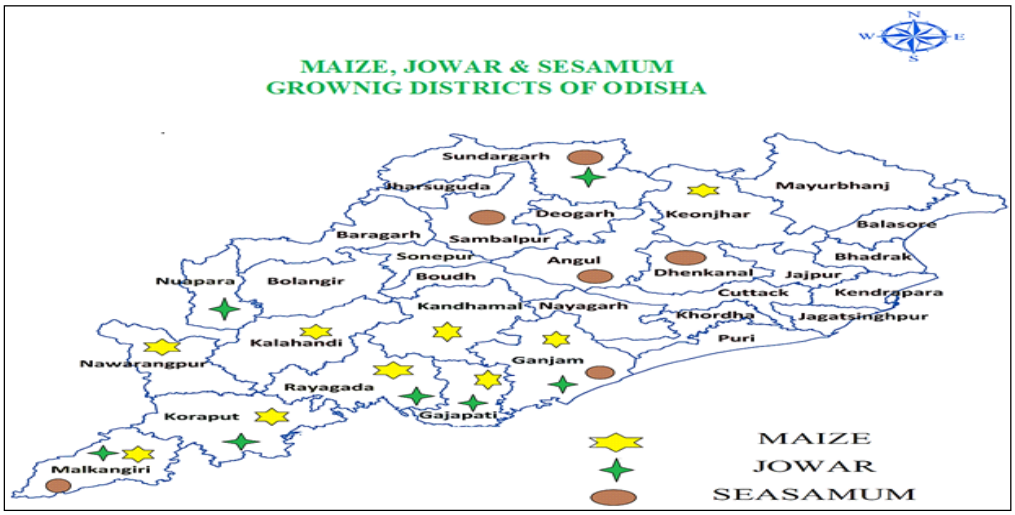


Fig 1: Maize, jowar and sesame growing district of Odisha.

Table 1: CAGR of area, production and productivity of maize, jowar and sesame in Odisha.

Name of crop		GR whole period	GR1 period I	GR2 period II	ΔGR GR2-GR1
Maize	Area	2.024	3.596	2.568	-1.03
	Production	4.886	5.262	7.773	2.51
	Productivity	2.80	1.60	5.07	3.47
Jowar	Area	-3.59	0.53	-4.56	-5.09
	Production	-3.98	0.98	-4.10	-5.08
	Productivity	-0.40**	0.44*	0.48	0.04
Sesame	Area	1.33**	6.86	-1.54**	-8.4
	Production	0.69	7.03	-0.57	-7.6
	Productivity	-0.62**	0.15*	0.98	0.83

(** Significant at 1% level, * Significant at 5% level).

Table 2: Different measures of instability (CDVI, CII and CV) of area, production and productivity of Maize, Jowar and Sesame in Odisha.

		Cuddy Della valle instability index (CDVI)(CII)	Coppock's instability index (CV)	Coefficient of variation
Maize	Area	12.66	51.21	29.76
	Production	38.32	77.36	77.75
	Productivity	49.60	57.43	24.35
Jowar	Area	31.58	67.55	54.40
	Production	45.70	74.15	66.81
	Productivity	14.82	42.74	16.16
Sesame	Area	30.95	54.97	33.51
	Production	40.92	56.48	41.14
	Productivity	17.06	45.17	19.50

maize is maximum. In Period -I, Productivity of jowar and sesame shows a significant positive growth rate at 5% level of significance but in case of Period-II, the CAGR for the area under sesame is found to be significantly negative. During Period I, the area under maize exhibited a positive yet non-significant growth rate, where as the difference in growth rate experience negative and non-significant. Difference in growth rate (ΔGR) exhibits positive growth rate for production of maize and productivity of maize, jowar and sesame, however negative growth rate exhibited by area under maize, jowar, sesame and production of jowar, sesame.

From Table 2, It has been observed that the CDV Instability index is highest in productivity of maize in Odisha. This lower instability is found in area under maize. But in case of CII and CV, higher order of instability found in maize production, which is due to the interaction effect of area and yield. Lesser instability found in jowar productivity due to the lower degree of variation in CII and CV. Productivity of jowar is found to be more stable and consistent followed by the sesame productivity.

CONCLUSION

The present study depicted that maximum growth rate was observed in production of maize for whole period and sub-period, *i.e.* period I and II as compare to other crops. Significant positive growth rate was observed in area under sesame in the whole period, where as negative significant growth rate was observed in productivity of jowar and sesame. Negative growth rate was found in area and production of jowar for the whole period. In instability analysis, the CDVI is higher in Productivity of maize where as the maximum instabilityobserved in Production of Maize due to the lowest value of CII and CV. Productivity of jowar is found to be more stable and consistent followed by the sesame productivity due to the lowest value of the coefficient of variation.

Author contributions

Conceptualization-Subrat Kumar Mahapatra, methodology-Debasis Bhattacharya, Kader Ali Sarkar, software- Subrat Kumar Mahapatra, Digvijay Singh Dhakre, validation and formal analysis- Subrat Kumar Mahapatra, Digvijay Singh Dhakre, writing-original draft preparation and editing-Subrat Kumar Mahapatra, Digvijay Singh Dhakre, Debasis Bhattacharya, Kader Ali Sarkar.

Author consent

All authors have read and agreed to the published this manuscript.

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Research involving human and/or animals

Not applicable.

Data availability statement

The dataset used and analyzed during the study is available from the corresponding authors on reasonable request.

Conflict of interest

The authors declare no conflict of interest.

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