Growth, Decomposition and Instability Analysis of Major Rabi Pulse Crops in Madhya Pradesh (India)

Abstract

The purpose of the study was to analyze the growth, decomposition and instability in area, production and productivity of rabi pulse crops viz., gram and lentil in Madhya Pradesh. The study was based on secondary time series data. The time series data of area, production and productivity of rabi pulse crops viz., gram and lentil have been taken for 30 years from 1992-93 to 2021-22. The study period (1992-93 to 2021-22) was divided into four periods i.e. period-I (1992-93 to 2001-02), period-II (2002-03 to 2011-12), period- III (2012-13 to 2021-22) and overall period (1992-93 to 2021-22). Three different analyses had been carried out in the study viz. (a) Compound annual growth rate by fitting exponential function, (b) Decomposition analysis by Minhas and Vaidyanthan, (1965) model and (c) Instability analysis by Cuddy- Della Valle index. The findings of study observed that during entire study period, the area under chickpea inclined at the rate of 0.32 per cent per annum while the production and productivity had significantly increased at the rate of 2.20, 1.88 per cent, respectively per annum in Madhya Pradesh. The production of gram in Madhya Pradesh might have increased due to significant growth in the productivity. In the same time, the area, production and productivity of lentil recorded positive and significant growth rate at the rate of 3.07, 2.52 and 0.54 respectively, in Madhya Pradesh. During overall period, yield effect was more responsible for the growth in gram and lentil production. The highest instability was observed in the production of gram and lentil crop during period – I, II, III and overall in the Madhya Pradesh.

Highlights

- The highest growth was noticed in production of gram during period – II in Madhya Pradesh
- The yield effect was most powerful instrument to increase the production of crops
- The highest instability was founded in production of gram and lentil pulse crop

Keywords: Gram, Lentil, growth, decomposition and instability

Introduction:

Pulses are basic ingredient in diet of a vast majority in Indian livelihood. The country grows a wide variety of pulse crops such as gram, lentil, pigeon pea, green gram black gram, cowpea under rain-fed conditions, which have poor fertility and moisture stress (Bairwa *et al.* 2020). These pulses are an important commodity group of crops that provide high quality protein with complementing cereal proteins for pre-dominantly substantial population of the country. Pulses are popularly known as "Poor man's meat" and "rich man's vegetable" as a result of being a major source of proteins, vitamins and minerals especially for vegetarian diets in India. To make the public aware of the nutritional benefits of pulses as part of sustainable food production aimed at food security and nutrition, The United Nations declared 2016 as "International year of pulses (IYP) (Balai *et. al.*, 2021). These are vital gift of nature as they nourish mankind with highly nutritive food and traditionally important constituents of our cropping system. Being leguminous in nature, these improve soil fertility by fixing atmospheric nitrogen and making soil more porous due to their invasive tap root system. Pulses are an integral part of sustainable crop production as they have low water requirement and capacity to withstand abnormal weather conditions. The results from household consumption survey revealed that decline in pulses consumption lead to increase in malnutrition due to decline in protein intake (Shalendra *et al.*, 2013).

The pulse crops were cultivated over 85.40 million hectares along with 87.40 million tonnes production and 1023 kg/ha productivity. Among all the major pulses cultivated globally, performance of lentil has been good at the productivity level (1152 kg/ha). Chickpea, pigeon pea and lentil are major contributing crops in total world pulses production with the share of 16.69, 10.40 and l 7.72 percent respectively (Anonymous, 2018).

India has secured the top position in area and production with 35 percent and 29 percent in the world respectively. Madhya Pradesh occupied the first rank in production with more than 25 per cent production followed by Rajasthan and Maharashtra with 16 per cent each and Karnataka at 11 per cent (Anonymous, 2018).

Considering decomposition analysis in agricultural output, it has remained an important part of interest to researchers and policy makers. A breakdown of growth into various component of area and yield facilitates in output projection with alternative targets and policies. Thus, decomposition of agricultural growth among its constituent forces is of great importance. The paper is divided in three sections. It begins with examinations of growth in area, production

and productivity of rabi pulse crops in Madhya Pradesh, secondly it measures the contribution of area, yield and their interaction effect to produce the output of rabi pulse crops i.e. gram and lentil in Madhya Pradesh. And thirdly measures the instability in area, production and productivity of major rabi pulse crops in Madhya Pradesh. There are many studies such Balai *et al.*, 2021a, 2021b, 2021c, 2021d, 2023, and Bairwa *et al.*, 2020a,2020b, 2021a, 2021b, 2021c, 2022, Meena *et al.* 2022, Babita *et al.*, 2023 Shalini *et al,.* 2023a, 2023b and Joshi et al., 2023a, 2023b

The major challenges in Madhya Pradesh is to provide an improved production technology for achieving sustained production of pulse crops. The present study has been conducted to answer the research questions whether there was significant growth in Madhya Pradesh in area, production and productivity of pulse crops over the period, per cent contribution of area and yield towards change in total pulses production in Madhya Pradesh and instability in area, production and productivity of major pulse crops in Madhya Pradesh.

Material and methods

The study was based on secondary data collected from different sources i.e. Directorate of Economics and Statistics, GOI, Directorate of pulses development Bhopal, various issues of Agriculture Statistical Year Book and Agriculture Statistics at a Glance, etc. The time series data of area, production and productivity of selected pulse crops have been taken for 30 years from 1992-93 to 2021-22. The study period (1992-93 to 2021-22) was divided into four periods i.e. period-I (1992-93 to 2001-02), period-II (2002-03 to 2011-12), period- III (2012-13 to 2021-22) and overall period (1992-93 to 2021-22). Three different analyses had been carried out in the study viz. (a) Compound annual growth rates was calculated period wise to study the growth in area, production and yield of selected pulses, (b) Decomposition analysis and (c) Instability analysis. Compound growth rates (CGR) of area, production and productivity of selected pulse were worked out for different periods as well as for entire period of analysis by fitting exponential function. To measure the relative contribution of area and yield towards the total output change with respect of individual pulse crop, Minhas and Vaidyanthan, (1965) model had been used. Instability in area, production and productivity of selected pulse were worked out for entire period of analysis by Cuddy- Della Valle index. The study was restricted to major rabi pulse crops i.e. Pigeon pea, green gram and black gram. the selected kharif pulse crops

accounted more than 55.53 and 27.56 per cent of total pulse crops cropped area and production in Madhya Pradesh.

Compound Growth Rate

Compound annual growth rates was estimated to know the growth pattern on area, production and productivity of major rabi pulse crops in Madhya Pradesh. The growth rate was estimated by using exponential trend model (Balai, *et al*., 2021a, 2024 and Bairwa, *et al.* 2022).

Exponential trend equation: $Y = ab^t$

The compound growth rate was obtained for the logarithmic form of the equation as below:

$$\text{Log } Y = \log a + t \log b$$

Where,

Y = area/production/yield

a = Intercept

b = regression coefficient / (1 + r)

t = Year

r = Compound growth rate / (Antilog b) -1

The percent compound growth rate (r) will be as,

$$r = [(\text{Anti log of } b) - 1] \times 100$$

Student't' test was used for testing significance level of growth in area, production and productivity of selected rabi pulse crops (Shalini *et al.*, 2023).

$$t = \frac{CGR}{SE\ (CGR)}$$

Where,

't' = Student 't' test

CGR = Compound growth rate

SE (CGR) = Standard error of Compound growth rate

Standard error of Compound growth rate is calculated by using following formula (Bairwa, *et al.*, 2020a).

$$\text{SE (CGR)} = \frac{100\text{b}}{\ln 10} \text{x SE (ln b)}$$

Decomposition Analysis

To study the contribution of area, yield and the interaction of area and yield towards increasing the pulses production in Madhya Pradesh, a decomposition analysis was used as expressed below (Minhas and Vaidyanthan, 1965):

$$\Delta P = AB*\Delta Y + YB*\Delta A + \Delta A*\Delta Y$$

$$= \text{(Yield effect)} + \text{(Area effect)} + \text{(Interaction effect)}$$

Where,

$\Delta A = AC - AB$

$\Delta P = PC - PB$

$\Delta Y = YC - YB$

AB, PB and YB are the area, production and yield of pulses for the base year.

AC, PC and YC are the area, production and yield of pulses for the current year.

ΔA = Change in area

ΔP = Change in production

ΔY = Change in yield

Instability

Instability index was calculated by using of Cuddy- Della Valle index (Cuddy and Della, 1978).

$$\text{Instability Index} = \text{CV} * \sqrt{(1 - \text{R}^2)}$$

$$C.V.= \frac{\text{Standard Deviation}}{\text{Arithmetic Mean}} \times 100$$

R^2= ESS/TSS i.e. ratio of explained variation to total variation.

Where, CV is Coefficient of Variation

R^2 is the Coefficient of Determination

ESS = Variation explained by explanatory variable.

TSS = Total Variation.

The ranges of instability are as follows(Balai *et al*., 2021a):

Low instability	=	Between 0 to 15
Median instability	=	Greater than 15 and lower than 30
High instability	=	Greater than 30

Results and Discussion

Compound Annual Growth Rate: The growth rate in area, production and productivity of rabi crops i.e. gram and lentil for the study period from 1992-93 to 2021-22 were calculated. The result of compound annual growth rate for gram and lentil of Madhya Pradesh were presented in the table 1 and 2.

Gram:

The results of growth rate in area, production and productivity of gram were presented in the Table 1. It was revealed from the table that during entire study period, the area under chickpea inclined at the rate of 0.32 per cent per annum while the production and productivity had significantly increased at the rate of 2.20, 1.88 per cent, respectively per annum in Madhya Pradesh. The production of gram in Madhya Pradesh might have increased due to significant growth in the productivity. During period-1(1992-93 to 2001-02) the area under chickpea declined at the rate of -0.43 per cent per annum while the production and productivity had non-significantly increased at the rate of 1.42 and 1.86 per cent, respectively per annum in Madhya

Pradesh. The production of gram in Rajasthan might have increased due to significant growth in the productivity. In the mean time, the area under gram might have decreased due to increase in area of its competitive crop lentil. During period-II (2002-03 to 2011-12) the area and production of gram significantly increased at the rate of 2.16 and 4.71 per cent per annum, respectively. In period-II, the production could have increased due to significant upward growth in area and non-significant augmentation in productivity of gram at the rate of 2.49 per cent per annum in Madhya Pradesh .During period-III (2012-13 to 2021-22) the area and production of gram decreased at the rate of -5.17 and -1.31 per cent per annum, respectively. In the mean time, productivity of gram significantly increased with the magnitude of 4.06 per cent per annum. In the same period, the production could have decreased due to significant downward growth in area of gram. Shalini *et al.*, (2023a) observed similar findings in area, production and productivity of gram in Madhya Pradesh during 1991-92 to 2020-21.

Table 1: Compound annual growth rate in area production and productivity of Gram in Madhya Pradesh

(CAGR in Per cent)

Aspects/ Periods	Period – I (1992-93 to 2001-02)	Period – II (2002-03 to 2011-12)	Period – III (2012-13 to 2021-22)	Overall Period (1992-93 to 2021-22)
Area	-0.43 (0.011)	2.16** (0.008)	-5.17** (0.019)	0.32 (0.003)
Production	1.42 (0.018)	4.71** (0.020)	-1.31 (0.018)	2.20* (0.004)
Productivity	1.86 (0.010)	2.49 (0.015)	4.06** (0.009)	1.88* (0.003)

Source: Authors own computation from compiled time series data.

Note: Figures in parenthesis are standard error of selected growth model.

* Significant at 1 per cent level of significance and ** significant at 5 per cent level of significance.

Lentil:

Table 2 is showed the estimation of growth rates in area, production and productivity of lentil in Madhya Pradesh. It was observed from the table that during overall period, the area,

production and productivity of lentil recorded positive and significant growth rate in Madhya Pradesh. In this period, the reported growth rate was 3.07 per cent in production followed by 2.52 per cent in productivity and 0.54 per cent in area of lentil. In the study period, the production of lentil in Madhya Pradesh was increased; it might be due to positive and significant growth in area and productivity of lentil. In the period-I, the area and production were significantly increased with the extent of 3.17 and 2.98 per cent annually, respectively. In the mean time, growth of productivity was declined with the magnitude of -0.15 per cent per annum. In the same time, significant growth was recorded in production of lentil; it could be due to positive and significant growth in area of lentil. Whereas, growth in the area and production of lentil during period-II were inclined at the rate of 2.55 and 0.18 per cent per year, respectively. At the same time, the productivity under lentil was declined non-significantly at the rate of -2.32 per cent annually. The growth in production of lentil crop increased in the Madhya Pradesh; it may have increased due to positive growth in area of lentil crop. During period-III, the positive growth rate was recorded in production of lentil with the magnitude 3.02 per cent. In the same time, area and productivity were observed negative growth at the rate of -2.55 per cent per annum. Shalini *et al.*, (2023b) observed similar findings in area, production and productivity of green gram in Madhya Pradesh during 1991-92 to 2020-21.

Table 2: Compound annual growth rate in area production and productivity of Lentil in Madhya Pradesh

(CAGR in Per cent)

Aspects/ Periods	Period – I (1992-93 to 2001-02)	Period – II (2002-03 to 2011-12)	Period – III (2012-13 to 2021-22)	Overall Period (1992-93 to 2021-22)
Area	3.17* (0.009)	2.55* (0.007)	-2.55 (0.015)	0.54** (0.003)
Production	2.98** (0.012)	0.18 (0.020)	3.02 (0.030)	3.07* (0.005)
Productivity	-0.15 (0.007)	-2.32 (0.020)	-2.55 (0.015)	2.52* (0.005)

Source: Authors own computation from compiled time series data.

Note: Figures in parenthesis are standard error of selected growth model.

* Significant at 1 per cent level of significance and ** significant at 5 per cent level of significance.

Decomposition:

To appraise the sources of output growth for major rabi pulses crops, the change in production has been divided in to three effects i.e., area effect, yield effect and interaction effect. The relative contribution of area, yield and their interaction to changes in production of rabi crops was presented in the table 3 and 4.

Gram:

The relative contribution of yield, area and their interaction to change in production of gram in Madhya Pradesh are presented in Table 3. It could be seen from the table that during overall period, yield effect and (168.18%) interaction effect (27.89) were responsible for the growth in gram production. During period-I, highest contribution was made by yield effect (58.44%) followed by interaction effect (27.98 per cent) and area effect (13.57 per cent) to boost up the gram production. During period-II, yield effect was more dominant than area and interaction effect. In this period the output of gram was increased by 63.45 per cent due to of yield effect and 24.74 per cent 11.80 per cent due to increased area and rest of growth by interaction effect. During period-III, interaction effect (100.08%) accounted highest effect on production of gram in Madhya Pradesh than the yield and area effect. Similar findings were reported by Joshi *et al*. (2023a) in area effect, yield effect and their interaction effect of gram in Gujarat state during 1991-92 to 2020-21 in Uttar Pradesh

Table 3: Percent contribution of area, yield and their interaction on production of Gram in Madhya Pradesh

Aspects/ Periods	Period - I (1992-93 to 2001-02)	Period - II (2002-03 to 2011-12)	Period - III (2012-13 to 2021-22)	Overall Period (1992-93 to 2021-22)
Yield effect	58.44	63.45	0.08	168.18
Area effect	13.57	24.74	-0.17	-96.07
Interaction effect	27.98	11.80	100.08	27.89

Source: Authors own computation from compiled time series data.

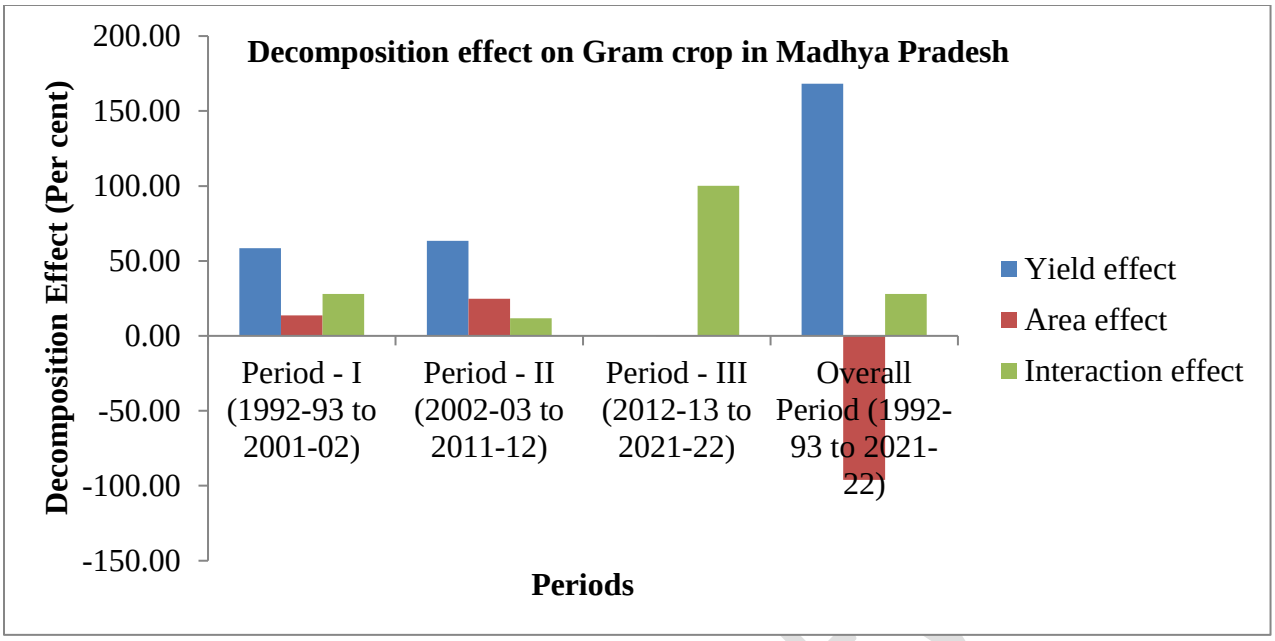

Figure 1: Decomposition effect on Gram in Madhya Pradesh

Lentil:

Results of decomposition of growth of lentil output has been presented in the table 4. During entire study period, yield effect accounted 66.07 per cent of the total output growth while contribution of interaction effect was 31.64 per cent and the area effect with magnitude 2.29 per cent.

During period-I, area expansion was comparatively more instrumental in increasing in production of lentil while interaction effect and its yield effect were next in order with 13.12 per cent and 0.53 per cent contribution to the output growth of lentil. Area effect accounted 86.34 per cent of the output growth. During period-II, area effect again more responsible for the output growth of lentil accounting for 296.20 per cent of the total output growth of lentil in Madhya Pradesh. During period-III, the interaction effect (136.15%) was more dominant to uplifted in the production of lentil in the Madhya Pradesh, followed by yield effect (86.62%) and area effect (-122.77%). Similar results were reported by Balai *et al.* (2021a) in area effect, yield effect and their interaction effect of lentil in India during 1988-89 to 2017-18.

Table 4: Percent contribution of area, yield and their interaction on production of Lentil in Madhya Pradesh

Aspects/ Periods	Period - I (1992-93 to 2001-02)	Period - II (2002-03 to 2011-12)	Period - III (2012-13 to 2021-22)	Overall Period (1992-93 to 2021-22)
Yield effect	0.53	-86.63	86.62	66.07
Area effect	86.34	296.20	-122.77	2.29
Interaction effect	13.12	-109.58	136.15	31.64

Source: Authors own computation from compiled time series data.

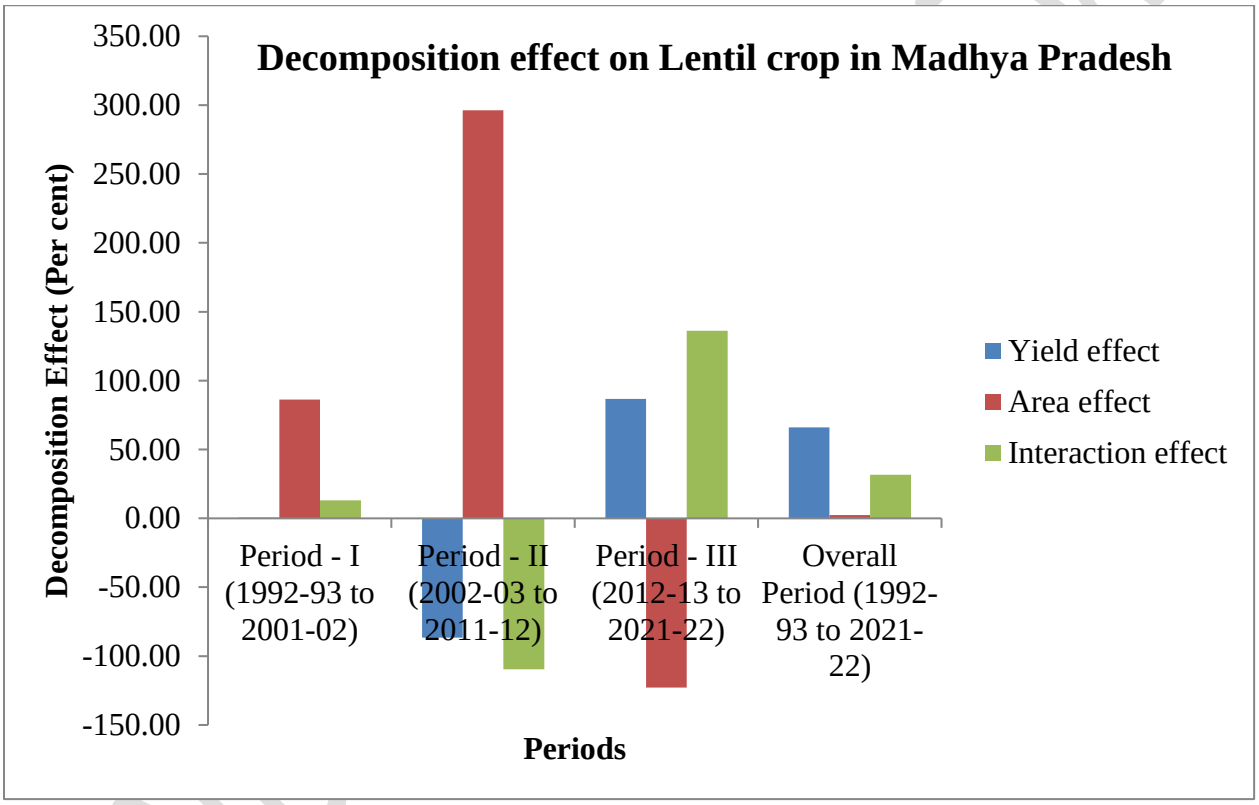

Figure 2: Decomposition effect on Lentil crop in Madhya Pradesh

Instability:

The instability in area, production and productivity of gram and lentil crops for the study period from 1992-93 to 2021-22 were calculated. The result of instability for selected pulse crops of Madhya Pradesh were presented in the table 5 to 6.

Gram:

The instability in area, production and productivity of gram in Madhya Pradesh are presented in the Table 5. It was revealed from the table that during entire study period, maximum variability was observed in production (17.80%) followed by area (14.81%) and productivity (12.69%). During period – I, the highest instability was noticed in production (14.74%) and the lowest instability was observed in productivity (8.49%). In the period – II, the highest instability was noticed in production (16.57%) and the lowest instability was observed in area (7.12%). During period – III, the highest instability was noticed in production (15.83%) and the lowest instability was observed in productivity (7.47%). Similar findings were also presented by Joshi *et al.* (2023b) in wheat and rice crop in Madhya Pradesh during 1991-92 to 2020-21.

Table 5: Instability in area, production and productivity of Gram crop in Madhya Pradesh

(In Per cent)

Periods/ Aspects	Area	Production	Productivity
Period - I (1992-93 to 2001-02)	8.85	14.74	8.49
Period - II (2002-03 to 2011-12)	7.12	16.57	12.42
Period - III (2012-13 to 2021-22)	14.77	15.83	7.47
Overall Period (1992-93 to 2021-22)	14.81	17.80	12.69

Source: Authors own computation from compiled time series data.

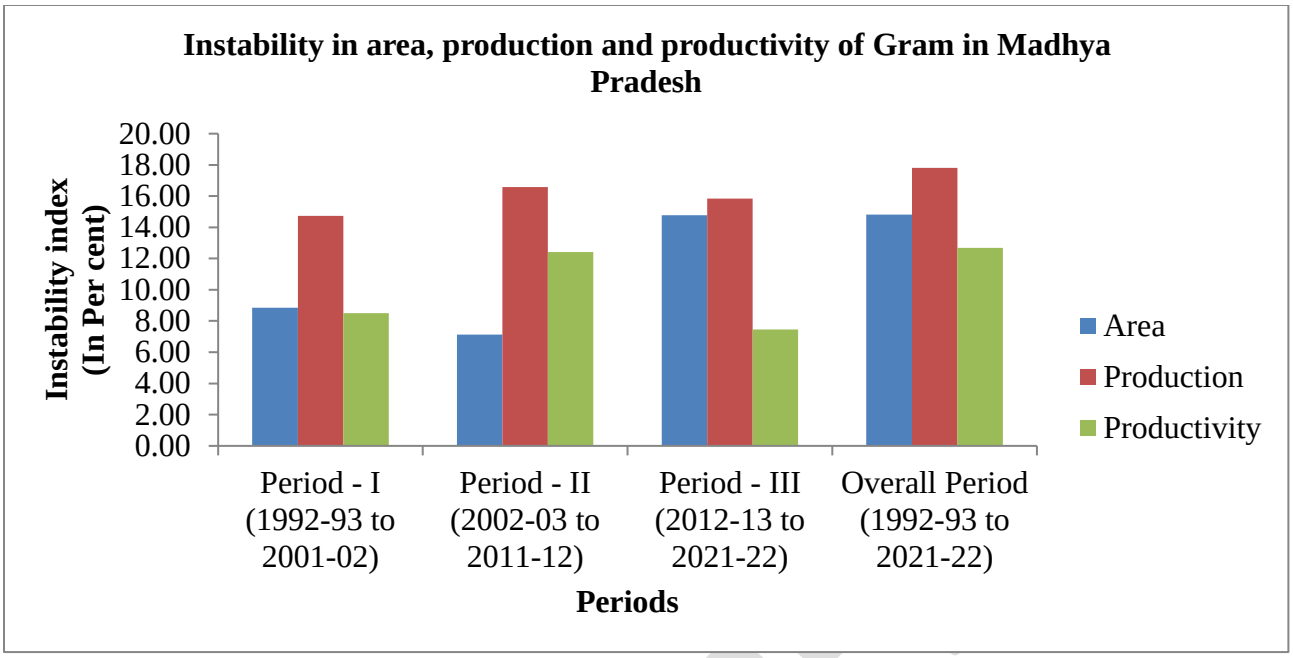

Figure 3: Instability in area, production and productivity of Gram crop in Madhya Pradesh

Lentil:

The instability in area, production and productivity of lentil in Madhya Pradesh are presented in the Table 6. It was revealed from the table that during entire study period, maximum variability was observed in production (26.51%) followed by productivity (25.63%) and area (11.70%). During period – I, the highest instability was noticed in production (10.56%) and the lowest instability was observed in productivity (6.00%). In the period – II, the highest instability was noticed in production (16.57%) and the lowest instability was observed in area (6.22%). During period – III, the highest instability was noticed in production (27.90%) and the lowest instability was observed in productivity (12.11%). Similar findings were also presented by Balai *et al.* (2021c) in gram, lentil, green gram and black gram during 1988-89 to 2017-18 of Rajasthan.

Table 6: Instability in area, production and productivity of Lentil crop in Madhya Pradesh

(In Per cent)

Periods/ Aspects	Area	Production	Productivity
Period – I (1992-93 to 2001-02)	6.93	10.56	6.00
Period - II (2002-03 to 2011-12)	6.22	16.57	15.42
Period - III (2012-13 to 2021-22)	12.11	27.90	20.03
Overall Period (1992-93 to 2021-22)	11.70	26.51	25.63

Source: Authors own computation from compiled time series data.

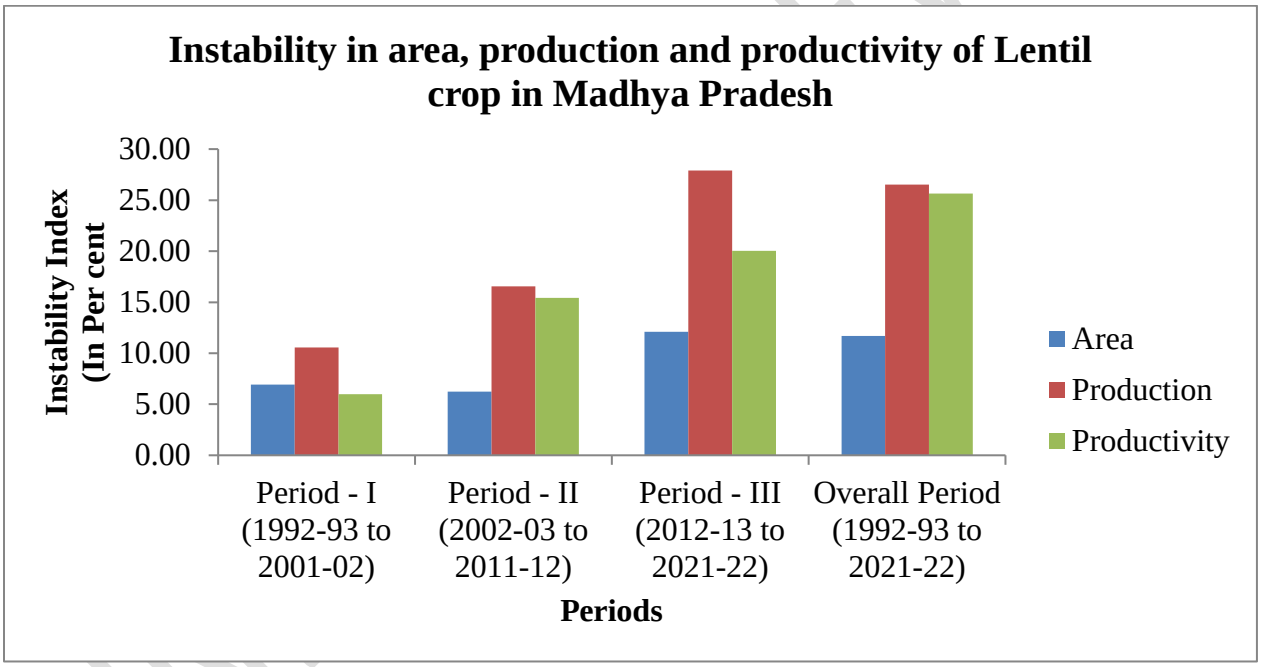

Figure 4: Instability in area, production and productivity of Lentil crop in Madhya Pradesh

Conclusions:

It could be concluded from the study that during overall period, positive growth was noticed in area production and productivity of gram and lentil crops in Madhya Pradesh. During period – I, declined growth was observed in area and production of the gram crop while positive growth was observed in production and productivity of gram crop in Madhya Pradesh. In the

same time positive and significant growth was found in area and production of lentil crop over the year. During period – II, augmented growth was noticed in area, production and productivity of gram in Madhya Pradesh. In the same study period, positive growth was found in area and production of lentil crop, while negative growth was noticed in productivity of lentil crop. During period – III, area and production of gram crop decreased over the time, while productivity was increase significantly. In the mean time, growth in area and productivity of lentil found downward, while growth in production was observed positive in production of lentil crop in Madhya Pradesh.

Thus it could be summarized from the above analysis that yield effect is more powerful instrument to increase the production of gram crop in the Madhya Pradesh during period – I, II and overall. During period – III, interaction effect was prime contributor to increase the production of gram crop. Area effect was most powerful instrument to increase the production of lentil during period- I and II. Interaction effect was more effective during period – III and yield effect was more dominant during overall period to increase the production of lentil in Madhya Pradesh.

The study revealed that the highest instability was noticed in production in gram and lentil crops during period – I,II, III and overall in the Madhya Pradesh.

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