Decadal Performance of Major Kharif Pulse Crops in Madhya Pradesh: In Context of Growth, Decomposition and Instability Analysis

Abstract

The study purpose examined the growth, decomposition and instability of major kharif pulses i. e. pigeon pea, green gram and black gram in Madhya Pradesh. The study was based on secondary data.The 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 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, (b) Decomposition analysis and (c) Instability analysis. It was revealed from the outcomes that during the entire study period,a mixed growth pattern was observed in the area, production and productivity of pigeon pea and green gram while significant and positive growth was noticed in area, production and productivity of black gram with the magnitude of 4.31, 6.19 and 1.80 percent, respectively in Madhya Pradesh. During overall study period, area expansion was major instrument to increase the production of pigeon pea and black gram. The highest variability was noticed production of all selected crops during period – I, II, III and entire study period.

Key words: Growth, Decomposition, Instability, Pigeon pea, Green gram and Black gram.

Introduction

The cereal-centric diet is based on wheat, rice and maize seems unsustainable in the long run and poses a significant challenge in ensuring food and nutritional security throughout the world (Devi, *et al.,* 2024). About 60% of the calorie intake is provided by three cereals namely rice, wheat, and maize (Potaka *et al.* 2021), whereas 50 percent of the human beings suffering from hidden hunger lives in India (Ritchie *et al.* 2018). The major crops contributing to unsustainable portion of blue water footprint globally are wheat (27%), rice (17%) and maize (5.9%) and around 31% of the global unsustainable blue water foot print is located in India (Mekonnen and Hoekstra, 2020). One of the most important parts of agriculture after cereals and oilseeds is pulses. Pulses production in India is categorized by the diversity of crops and their

regional specificity based on adaptation to prevailing agro-climatic conditions. Pulses are an important source of proteins for poor as well as vegetarians which constituent major population of country. These pulses mainly include chickpea, lentil, pigeon pea, green gram, black gram and field pea (Balai, *et al.,* 2021e). The split grains of pulses known as dalare excellent source of high-quality protein, essential amino acid, fatty acids, fibers, minerals and vitamins. Almost fifty percent of world pulses output concentrated in Asia, twenty-two percent concentrated in Africa, nineteen percent in America and nine percent in Europe (Balai, *et al.,* 2021e). India is the largest producer as well as consumer of pulses, and is the largest importer in the world. Pulses were cultivated over 29 million hectare area, 27.30 million tones production with productivity of 888 kg/ha Among the all the states, Madhya Pradesh hold first position both in area (5.35 million hectare) and production (5.69 million tones) (Anonymous, 2021-22). The study has attempted to determine the peak or trough in the cultivation of pulse crops in the past. As we all know, Indian farmers are in a bad way these days, so this information useful to policymakers in developing new measures to increase the area, production, and yield of pulse spices in the state of Rajasthan. With the aforementioned facts in mind, a study on the growth and instability in the area, production, and productivity of major pulse crops in Rajasthan. Instability in pulse crop area, production and productivity over the years indicated that the large variation of production and the major reasons i.e.(1) highly sensitive to environmental fluctuation, (2) being rainfed crop, pulses experience drought at critical growth stages, (3) highly sensitive to abiotic stresses (temperature extremities, excessive moisture and salinity), (4) vulnerable to large number of disease and emergence of new race of pathogens, (5) prone to attract by insect – pests and (6) unpredictable nature of host - pest relationship due to dynamic changes of the pest behavior under changing climates (Anonymous, 2015). With the aforementioned facts in mind, a decadal growth, instability and decomposition performance of major kharif pulse crops in Madhya Pradesh was selected for present study.

Methodology

The present study was completely based on secondary information collected from different published sources namely Directorate of Economics and Statistics, GOI, Directorate of Pulses Development Bhopal, various issues of Agriculture Statistical Year Book and Agriculture Statistics at a Glance. The time series data on area, production and productivity of selected pulse crops were collected and compiled for 30 years from 1992-93 to 2021-22. Further, for drawing

meaningful interpretation about growth, instability and decomposition in area, production and productivity of selected pulse crops, the study period (1992-93 to 2021-22) was divided into four sub-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). The pre-decided time series data on area, production and productivity were compiled and analyzed logically with following statistical techniques (a) exponential growth model, (b) Minhas and Vaidyanthan decomposition model and (c) Cuddy- Della Valle instability index. Data analysis part of MS Excel were used computing CGAR, instability and resource contribution.

Compound Growth Rate: Compound annual growth rates were estimated to know the growth pattern in 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, 2021b, 2021c, 2021d, 2023 and Bairwa, et al. 2021a,2021b,2021c and 2022).

$$Y = ab^t$$

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 of i^{th} pulse crop

a = Intercept

b = regression coefficient / (1 + r)

t = Year

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

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

Based on Student‘t’ test values, the level of significant was computed for growth in area, production and productivity of selected rabi pulse crops (Mishra,*et al.*, 2023a, 2023b).

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

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, 2020b).

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

Decomposition Analysis: To study the contribution of area, yield and their combined 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

Result and Discussion:

Pigeon pea: Compound annual growth rate in area, production and productivity in pigeon pea in Madhya Pradesh depicted in the Table – 1. During overall study period, compound annual growth rate in area, production and productivity reported at the rate of -0.03, 0.69 and 0.72 percent, respectively in Madhya Pradesh. In the mean time growth in state production might be increased due to positive growth in the productivity. Similar findings were reported by Baghel, *et al.,* 2023. During period – I, declined growth was noticed in area production and productivity with the magnitude of -3.33, -4.95and -1.68 percent, respectively. In mean time, production might be decreased due to downward growth in area and productivity of pigeon pea in the state. During period – II, positive growth was noticed in area and production at the rate of 5.37 and 1.98 percent, respectively. In the same time,production growth was upward due to augmented growth in area. During Period – III, negative growth in area and production were observed with the magnitude of -11.28 and -7.76 percent, respectively, while in productivity affirmative growth was noticed at the rate of 3.94 percent. In this period, production of pigeon pea was increased in Madhya Pradesh; it might be due to declined growth in area.Similar outcomes were noticed by Bairwa, *et al.* 2021a.

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

(CAGR in percent)

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	-3.33* (0.008)	5.37* (0.014)	-11.28 (0.38)	-0.03 (0.070)
Production	-4.95* (0.015)	1.98 (0.024)	-7.76 (0.58)	0.69 (0.008)
Productivity	-1.68 (0.011)	-3.23 (0.029)	3.94 (0.024)	0.72 (0.005)

Source: Authors own computation from compiled time series data.

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

* Significant at 1 percent level of significance and ** significant at a 5 percent level of significance.

Green Gram:

The findings of growth rates in area, production and productivity of green gram were noticed in the Table 2. During overall period, affirmative growth was observed in production and productivity with the magnitude of 0.82 and 1.08 percent, respectively whereas growth in area was declined at the rate of -0.23 percent in Madhya Pradesh. The state production under green gram could be increased due to positive growth in productivity. During period – I, negative growth in area, production and productivity were reported with the magnitude of -4.86, -5.90 and -1.23 percent, respectively. In the period – II, area and production increased at the rate 0.31 and 0.04 percent, respectively whereas growth in productivity was reported negative at the rate of -0.16 percent. At the same time, production was increase due to positive growth in area of green gram pulse crop. During period – III, area, production and productivity were decreased at the rate of -5.79, -9.27 and -3.65 percent, respectively. In the mean time, production of green gram declined in Madhya Pradesh; it might be due to downward growth in area and productivity.Similar outcomes were noticed by Joshi, *et al.* 2021a.

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

(CAGR in Percent)

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	-4.86* (0.005)	0.31 (0.009)	-5.79 (0.060)	-0.23 (0.007)
Production	-5.90* (0.014)	0.04 (0.016)	-9.27 (0.078)	0.82 (0.011)
Productivity	-1.23 (0.010)	-0.16 (0.013)	-3.65 (0.021)	1.08* (0.008)

Source: Authors own computation from compiled time series data.
Note: Figures in parenthesis are standard error of selected growth model.
* Significant at 1 percent level of significance and ** significant at 5 percent level of significance.

Black gram:

Table 3 depicted the results in area, production and productivity of black gram in Madhya Pradesh. During entire study period, area production and productivity were significantly increased of black gram with the magnitude of 4.31, 6.19 and 1.80 percent, respectively. In this period, production of black gram could be increased due to upward growth in area and productivity. During period – I, the compound annual growth was reported negative in area and production at the rate of -1.54 and -1.31 percent, respectively whereas growth in productivity was noticed positive with the magnitude of 0.23 percent. In the same time, declined growth in production founded due to negative growth in area of black gram. During period – II, positive and non significant growth was observed in production and productivity of the black gram at the rate of 0.32 and 0.38 percent, respectively while negative and non significant growth in area was reported at the rate of 0.06 percent. In the mean time, production of black gram might be increased due to positive and non significant growth in productivity of black gram. During period – III, augmented growth in area and production were reported with the magnitude of 12.99 and 8.67 percent, respectively whereas negative growth in productivity was reported at the rate of -3.83 percent. At the same time, production of black gram might be increased due to remarkable growth in area of the same crop. Similar outcomes were noticed by Meena, *et al.* 2022.

Table 3: Compound annual growth rate of area production and productivity of Black gram in Madhya Pradesh

(CAGR in Percent)

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	-1.54 (0.010)	-0.06 (0.014)	12.99* (0.033)	4.31* (0.007)
Production	-1.31 (0.020)	0.32 (0.020)	8.67 (0.056)	6.19* (0.009)
Productivity	0.23 (0.015)	0.38 (0.015)	-3.83 (0.036)	1.80* (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 percent level of significance and ** significant at 5 percent level of significance.

Decomposition:

The growth in output of pigeon pea, green gram and black gram pulse crops were therefore allocated to the various factors by breaking the change in output in three effects i.e. yield effect, area effect and their interaction effect

Pigeon pea:

The relative contribution in yield, area and interaction to change in output of pigeon pea in Madhya Pradesh were presented in the Table 4. During overall period, area expansion comparatively more instrumental in increasing the output of pigeon pea at the rate of 223.41 percent. During period – I, area effect was mainly responsible to increase the production of the crop with the magnitude of 103.41 percent and yield effect had very small contribution to extend of 11.08 percent to total output growth of pigeon pea in Madhya Pradesh while interaction effect on production was negative accounting -14.49 percent. Area effect was most dominant in period – II and III with the magnitude of 114.75and 268.44 percent. Similar outcomes were noticed by Balai, *et al.* 2021a.

Table 4: Percent contribution of area, yield and their interaction on production of Pigeon pea 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	11.08	17.52	-36.81	-17.93
Area effect	103.41	114.75	268.44	223.41
Interaction effect	-14.49	-32.27	-131.63	-105.48

Source: Authors own computation from compiled time series data.

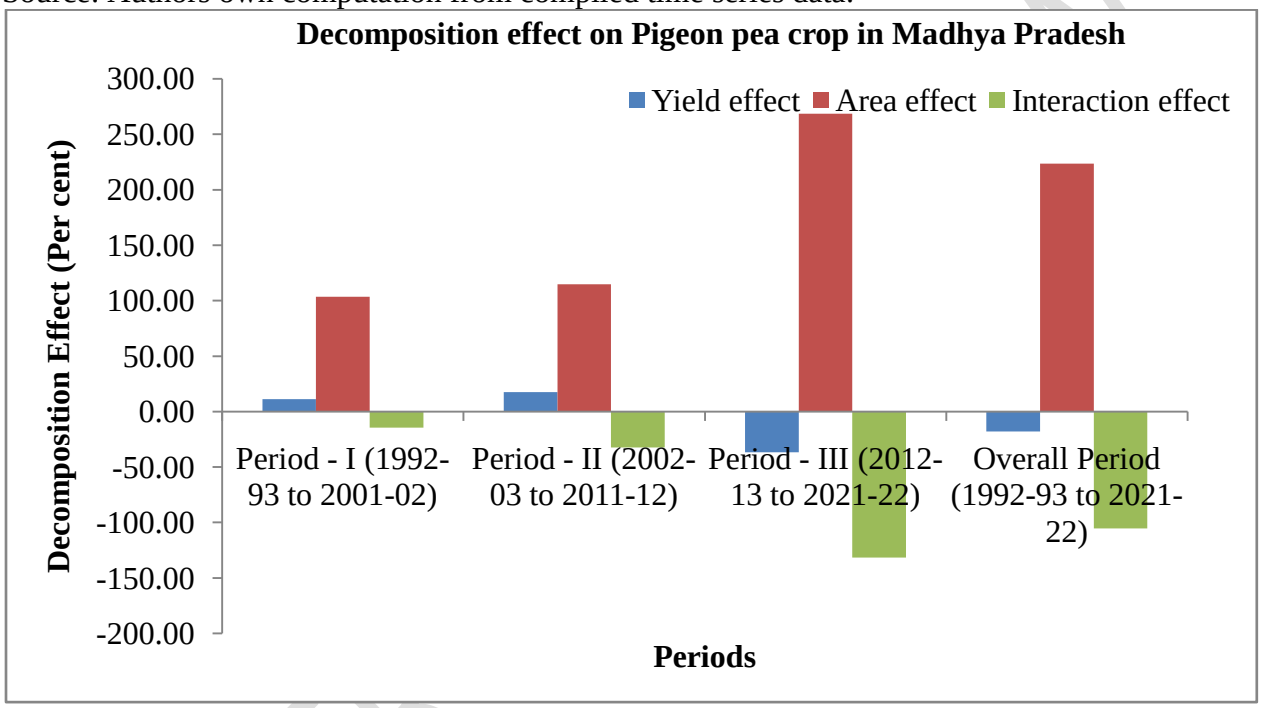

Figure 1: Decomposition effect on Pigeon pea crop in Madhya Pradesh

Green gram:

Decomposition of output growth in its into its constitutes forces for green gram in Madhya Pradesh was presented in the Table 5. It was revealed from the table that during overall period and period – III area effect was mainly responsible to uplift growth of output with the magnitude of 260.77 and 286.27 percent. During period – I, area effect was more dominant than yield effect at the rate of 93.86 and 11.96 percent, respectively, while yield effect wasthe most powerful instrument to increase the output of green gram in Madhya Pradesh at the rate of 221.48 percent during period – II.Similar outcomes were noticed by Joshi, *et al.* 2023b.

Table 5: Percent contribution of area, yield and their interaction on production of Green 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	11.96	221.48	285.40	96.14
Area effect	93.86	-3.32	286.27	260.77
Interaction effect	-5.82	-118.16	-471.67	-256.91

Source: Authors own computation from compiled time series data.

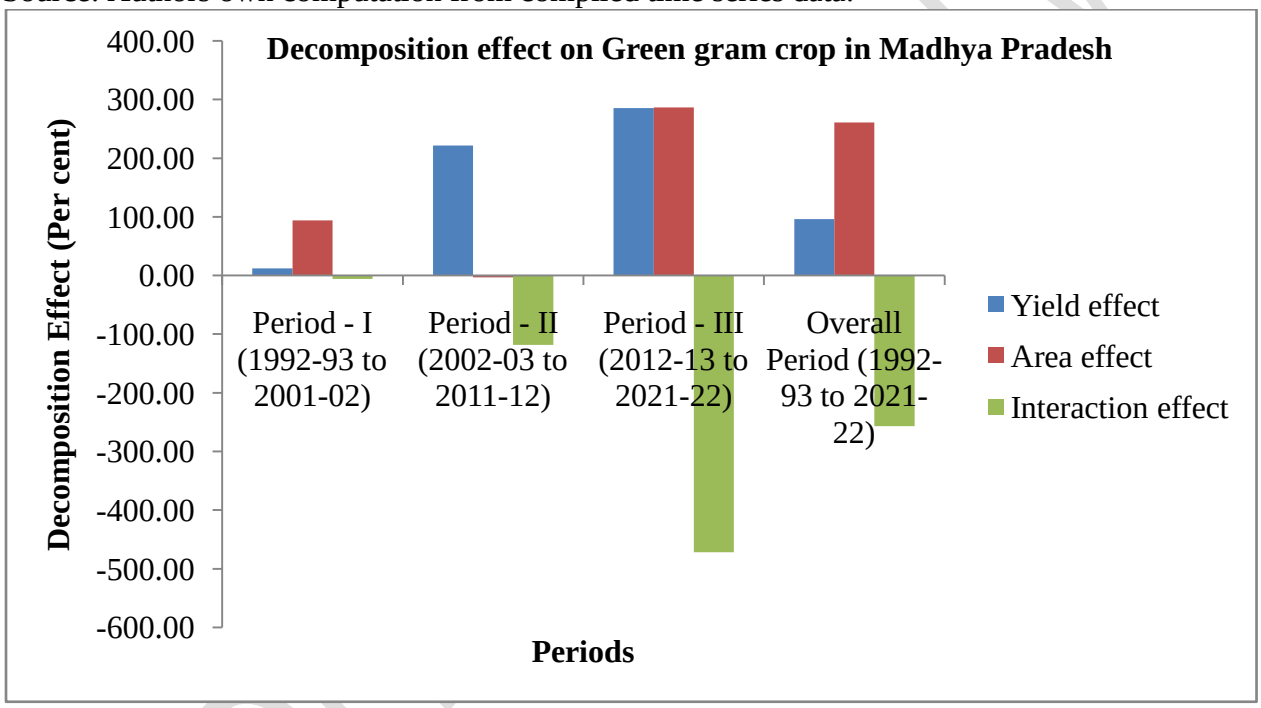

Figure 2: Decomposition effect on Green gram crop in Madhya Pradesh

Black gram:

The Table 6 represented the contribution of area, yield and their interaction to the output growth of black gram in Madhya Pradesh. During overall period, however area effect turned out to be the most powerful factor in the growth of production of black gram with 126.91 percent. During period – I, growth in production of black gram was mainly achieved through area alone, while yield and interaction effect had negative effect on change of production. In the mean time, the area effect contributed as high 628.16 percent while yield and interaction effect had negative contribution to the extent of -297.02 and 231.14 percent respectively. During period – II,

increment in the output was due to interaction effect (479.37%) and area effect (130.72%) while yield effect observed negative (-510.09%). During period – III, change in production was observed by the area effect and interaction effect to the extend of 191.86 and 28.79 percent, respectively whereas yield effect founded negative to change in the output at the rate of -120.65 percent.Similar findings were reported by Bairwa, *et al.* 2021c.

Table 6: Percent contribution of area, yield and their interaction on production of Black 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	-297.02	-510.09	-120.65	-53.57
Area effect	628.16	130.72	191.86	126.91
Interaction effect	-231.14	479.37	28.79	26.65

Source: Authors own computation from compiled time series data.

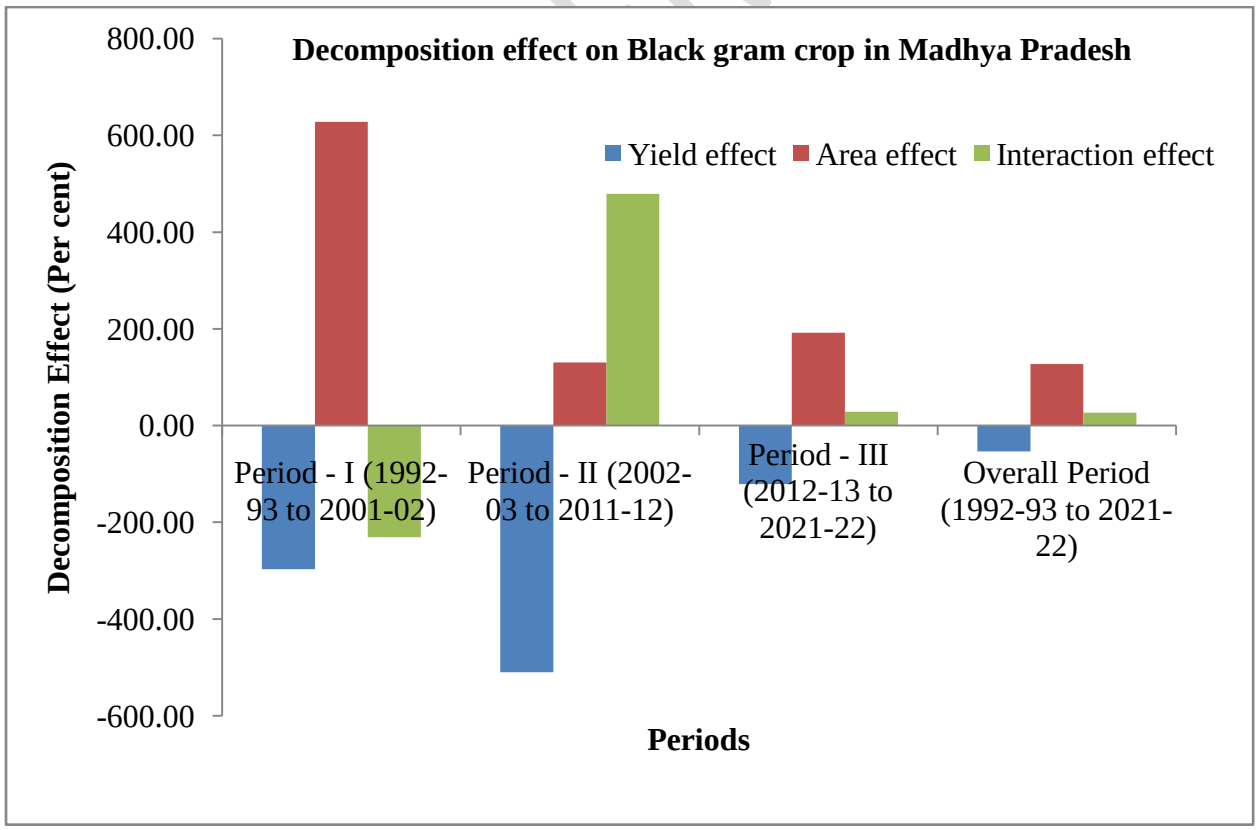

Figure 3: Decomposition effect on Black gram crop in Madhya Pradesh

Instability: The instability is serious concern for the farmers. It is directly related to inconsistent earnings. It causes the barrier between the total demand and actual supply of the commodity. The instability in area, production and productivity of major kharif pulse crops in Rajasthan is an important to understand whether there is stable in growth performance of pigeon pea, green gram and black gram pulse crops. The instability analysis helps to find out which crops performed well in the region in terms of area, production and productivity. Similar results were observed by Mishra, *et al.* 2023a.

Pigeon pea: Instability in area, production and productivity of pigeon pea is presented in the Table 7. It was revealed from the table that the highest instability was found in production (48.99%) followed by area (31.51%) and productivity (23.41%) during entire study period. The maximum instability was observed in production during period – I, II and III with the magnitude of 12.72, 20.09 and 49.99 percent, respectively. Similar outcomes were noticed by Balaia, *et al.* 2021d.

Table 7: Instability in area, production and productivity of Pigeon pea crop in Madhya Pradesh

(In Percent)

Periods/ Aspects	Area	Production	Productivity
Period - I (1992-93 to 2001-02)	6.69	12.72	8.80
Period - II (2002-03 to 2011-12)	13.28	20.09	19.95
Period - III (2012-13 to 2021-22)	29.32	49.09	19.68
Overall Period (1992-93 to 2021-22)	31.51	48.99	23.41

Source: Authors own computation from compiled time series data.

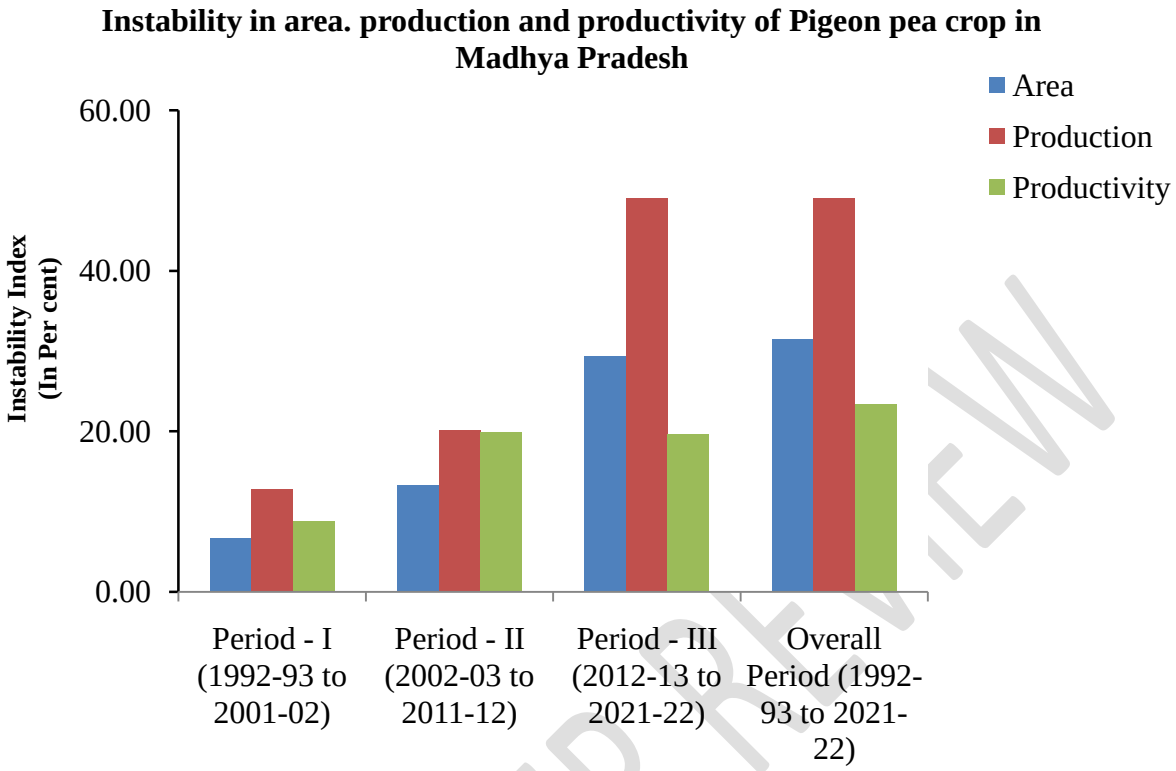

Figure 4: Instability in area, production and productivity of Pigeon pea crop in Madhya Pradesh

Green gram: The variability in area, production and productivity of green gram is presented in the Table 8. It was revealed from the table that during the entire study period, the variability was observed the highest in production of green gram was observed the highest (69.16%) followed by area (40.53%) and productivity (19.53%) in Madhya Pradesh. During period – III, same pattern of instability was followed as overall study period. During period – I, the highest instability was found in production followed by productivity area at the rate of 11.20, 8.27 and 3.94 percent, respectively. During period – II, same pattern of variability was followed as period – I. Similar outcomes were noticed by Bairwa, *et al.* 2021a.

Table 8: Instability in area, production and productivity of Green gram crop in Madhya Pradesh

(In Percent)

Periods/ Aspects	Area	Production	Productivity

Period - I (1992-93 to 2001-02)	3.94	11.20	8.27
Period - II (2002-03 to 2011-12)	7.77	14.24	10.75
Period - III (2012-13 to 2021-22)	50.10	65.98	18.70
Overall Period (1992-93 to 2021-22)	40.53	69.16	19.53

Source: Authors own computation from compiled time series data.

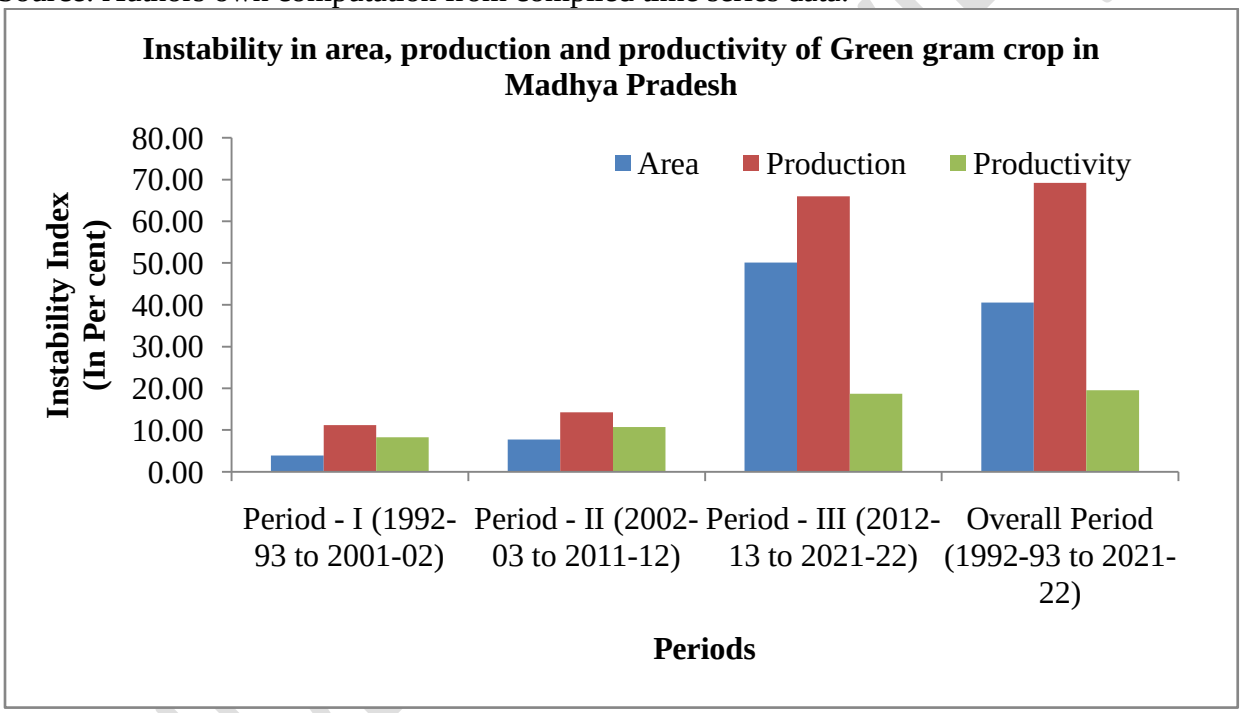

Figure 5: Instability in area, production and productivity of Green gram crop in Madhya Pradesh

Black gram: Instability in area, production and productivity of black gram in Madhya Pradesh is presented in the Table 9. It was revealed from the table that the highest instability in production was noticed with the magnitude 57.41 percent followed by area and productivity 42.46 and 25.70 percent, respectively. During period – I, II and III, the highest instability was observed in production followed by productivity and area of black gram in Madhya Pradesh.Similar outcomes were noticed by Bairwa, *et al.* 2020a.

Table 9: Instability in area, production and productivity of Black gram crop in Madhya Pradesh

(In Percent)

Periods/ Aspects	Area	Production	Productivity
Period - I (1992-93 to 2001-02)	8.27	15.53	12.10
Period - II (2002-03 to 2011-12)	11.78	17.28	11.84
Period - III (2012-13 to 2021-22)	27.41	48.17	27.95
Overall Period (1992-93 to 2021-22)	42.46	57.41	25.70

Source: Authors own computation from compiled time series data.

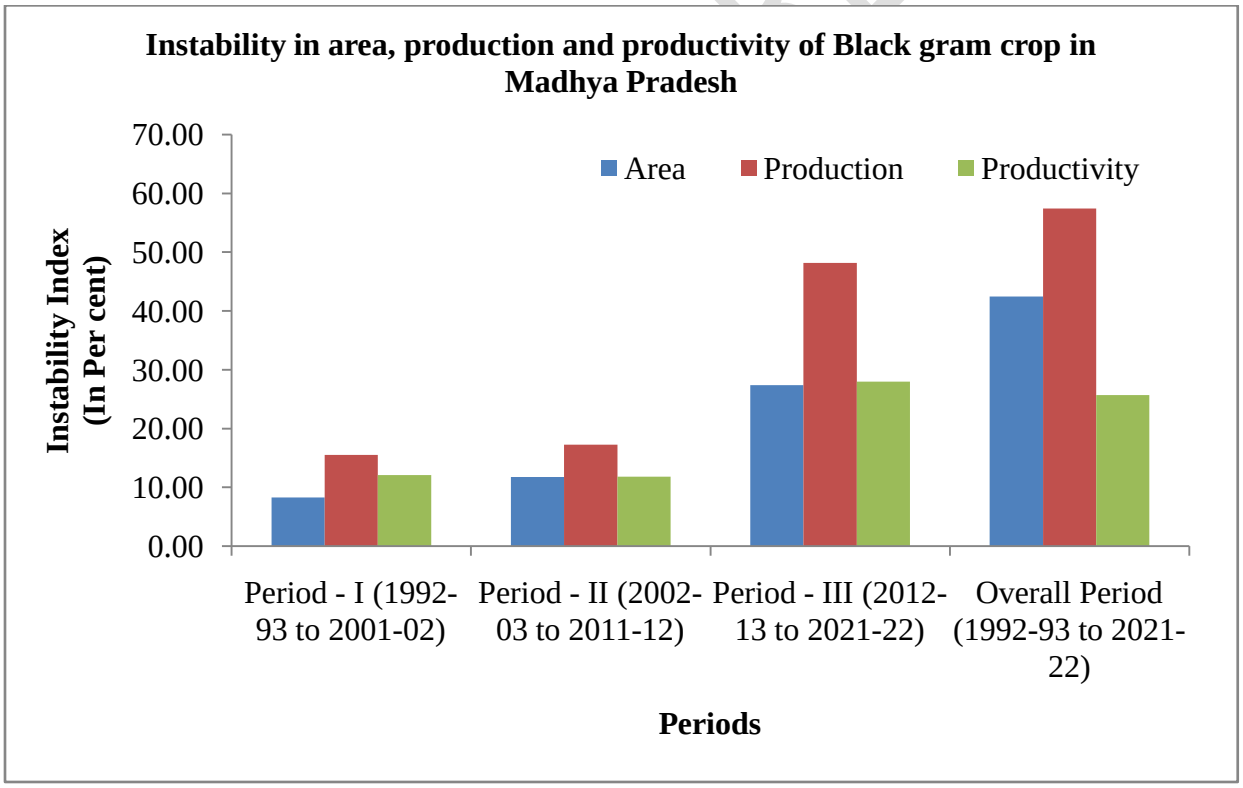

Figure 6: Instability in area, production and productivity of Black gram crop in Madhya Pradesh

Conclusions

Therefore, it can be concluded from the analysis that during entire study period, mixed growth pattern was observed in area, production and productivity of pigeon pea and green gram while significant and positive growth was noticed in area, production and productivity of black gram with the magnitude of 4.31, 6.19 and 1.80 percent, respectively in Madhya Pradesh. During period –I, II, III and overall study period, area expansion was major instrument to increase the production of pigeon pea and black gram. During period- I, III and overall study period area effect was more responsible to uplift the output of green gram while yield effect was most powerful instrument to increase the production of green gram in Madhya Pradesh during period – II. The highest variability was noticed production of pigeon pea, green gram and black gram during period – I, II, III and entire study period.

Highlights:

- The highest growth was observed in area of black gram in Madhya Pradesh During entire study period.
- The area effect was mainly responsible to increase the production of pigeon pea, green gram and black gram.
- The highest variability was found in production of pigeon pea, green gram and black gram during period – I, II, III and entire study period.

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